Scientific American

JUNE
1944

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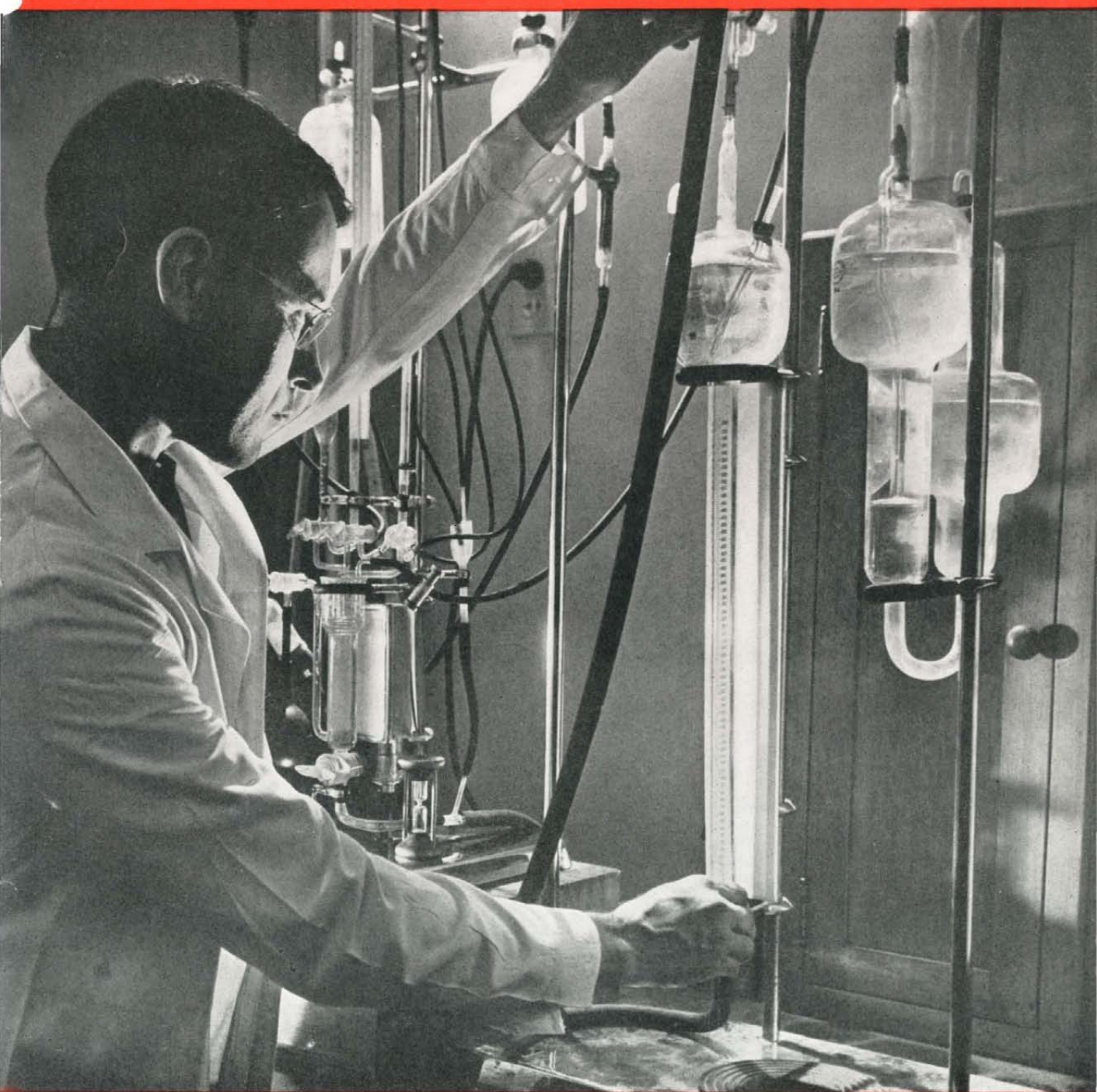
EPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



Raw-Materials Testing Assures Quality . . . See page 241

KEEPING UP WITH *Electricity*

BROADCASTING TIN. "Flowing" tin plate by induction heating is now accepted practice in the industry. Frequency used in the first installation was 200,000 cycles per second—and the equipment was salvaged from a discarded broadcasting unit! Incidentally, this first installation is still in daily use.

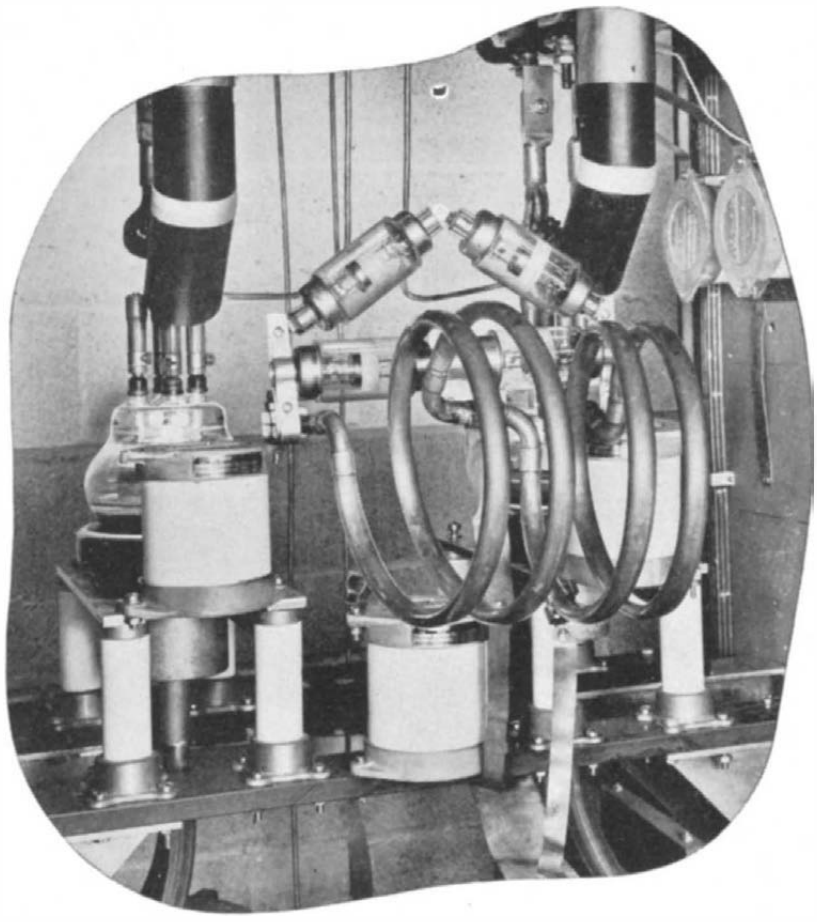
IT'S A MATTER OF SPEED. Radium gives out 1,200,000 times as much energy as the same weight of coal burned with oxygen. Even if we had plenty, however, it would probably be a poor substitute for coal, since it releases energy only one-eightieth as rapidly. Nothing that scientists have been able to do has had the slightest effect in speeding up the process.

THE SUN IS STILL SLOWER, releasing energy by a process which involves the transmutation of elements and takes between six and seven million years.

WOMAN'S WEAPON. One reason that electric irons aren't being made is that the thermostats used to control their temperature are busy on land, sea and air. They're guarding against motor trouble in tanks, fire danger in planes, overheating in gun equipment on battleships.

PEAK FLATTENERS. Resistance welders have speeded up production in thousands of war plants, but they have imposed enormous on and off single-phase loads on power circuits, often building up impossible peak demands. Capacitors are proving to be the answer, correcting the power factor to approximate unity.

THE HIGHER, THE FEWER no longer applies in radio vibrators. At high altitudes, vibrator contacts literally "boiled away" in ten hours, hence this type of radio was seldom used in airplanes. New-type vibrator, using Westinghouse-developed materials and techniques, has a life expectancy equal to that of the plane.



Plastics, plywood and electronics

This is a Westinghouse laboratory set-up for research in dielectri heating—internal heating by high-frequency radio waves. Togethe with induction heating—surface heating of metals by high-frequency radio waves—this process is daily finding new applications in industry

One outstanding use of the principle of high-frequency heating i the Westinghouse development of flowing of tin on steel strip. Othe important applications are in the bonding of plywood and the curing of plastics.

Dielectric and induction heating effect important savings in time and materials with attendant benefits of better control and more uniform results.

High-frequency heating is an example of electronics at work, anothe phase of Westinghouse leadership in electricity. Westinghouse Electric & Manufacturing Co., Pittsburgh 30, Pa.

WESTINGHOUSE PRESENTS: *John Charles Thomas, Sunday, 2:30 p.m., E.W.T. NBC. "Top of the Evening," Mon. Wed. Fri. 10:15 p.m., E.W.T., Blue Network*

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CONTENTS • JUNE 1944

COVER: In the manufacture of even such small and apparently unimportant items as nuts, it is necessary that exact control be maintained over the materials used if the resulting product is to be of uniform high standard. Shown in our front cover illustration is part of the chemical testing laboratory in one of the plants of the Elastic Stop Nut Corporation of America. Here all incoming raw materials are tested for conformance to rigid specifications before they are processed.

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Previews of the Industrial Horizon

By A. P. Peck

TRANSMUTED WOOD

POPLAR that is as hard as hard maple, hard maple that is hard as ebony, commercial uses of wood formerly unfit for such applications because of inherent deficiencies in strength or grain structure, are some of the possibilities that arise from a new wood treatment process developed by Du Pont. Add to these qualities of increased hardness and strength the fact that the treated wood will not swell or warp under changes in humidity, and the industrial applications of "transmuted" wood broaden tremendously.

Briefly, the transmutation process consists of impregnating the wood structure with resin-forming chemicals capable of reacting with the wood cellulose. This reaction profoundly alters the properties of the wood. It becomes harder—much harder, stronger, stiffer, and the grain will not rise on wetting. The wood so treated can be more smoothly worked and highly polished without the further use of surface finishes. Its tendency to shred or splinter during working or later use is vastly reduced. An an added feature of the process, color can be introduced during the impregnating process, resulting in wood that is colored throughout its structure.

Wood treated by this methylolurea process is no longer wood in the commonly accepted sense. It is transmuted to a product in which the wood structure carries a hard resin. All the beauty of the wood grain is retained, however, with added beauty gained through the polish which can be achieved.

Within reasonable limits, it appears that the possibilities of wood transmutation with methylolurea are virtually boundless. Furniture made with treated wood will retain its shape, drawers will not stick; veneers can be made harder, and self-bonding if the base is also treated; doors and jambs, window sashes and frames, will not swell or shrink; wooden parts subjected to wear—loom shuttles, for example—can be given greatly extended life.

Not the least important feature of the transmuted wood is the surface finish. Scratches in furniture and the like can easily be removed by simple sanding and repolishing of the affected area; it is unnecessary to refinish the entire surface, since the finish is "built in" through the entire thickness of the wood.

From the commercial angle, it should be noted that the process is inexpensive, both as to materials and treating equipment. In fact, it might be said that it will be, in some cases, "costless" because it decreases waste, makes rejected wood available for use, prevents shrinkage, and reduces finishing operations.

Indications so far are that treated woods require slower rates of sawing, cutting, and turning and that different tool settings and harder tools or more frequent sharpening are necessary than with untreated wood. More power is needed for drilling or for inserting screws, but the holding power of screws and nails seems to be improved.

GASOLINE TOMORROW

PERHAPS no war-necessitated rationing has given birth to more discussion—and more misconceptions—than that applied to gasoline. Forcefully has it been driven home that this is a petroleum war, a war in which motor fuel is as vital a fluid as the very life blood of the men who are doing the actual fighting.

From this dependence upon petroleum products have come, of course, technological developments in motor fuels that foreshadow important news for the motorist. Much of the present work is still in the hush-hush stage, but enough of it can be talked about to furnish a glimpse of the horizon. Thus Dr. Alexander Klemin looks over the motor fuel situation, from the standpoint of aviation, in the article on page 262 of this issue; on page 268 Thomas H. Risk views it as an oil-refinery technologist; D. H. Killeffer considers it, on page 247, as a problem to be tackled by the chemical industry.

Here is a truly complicated industrial problem, one which presents so many facets that at the moment much of the thinking about the future must be considered as factually-based speculation. Two of the aspects will have to work themselves out as time rolls on: What will be the source of gasoline tomorrow? What will be done with the high-octane gasoline refining equipment already in use and that under construction?

Some answers are fairly clear today, and they all sit squarely in the lap of industry. First, the chemical industry must make itself responsible for increasing efficiency of gasoline manufacture and for developing new fuel sources. Then the automotive engineers must take it upon themselves to make possible the utilization of the maximum power of this fuel. The growing aviation industry also comes into the picture, with a share in the development of still better power plants and expansion of commercial air transportation.

If nothing else comes out of the building of huge gasoline production facilities two things are sure: The world is learning how to make the most efficient use of irreplaceable oil reserves; other methods of obtaining liquid fuels than from crude petroleum are being vigorously investigated and developed.

TELEVISION FILMS

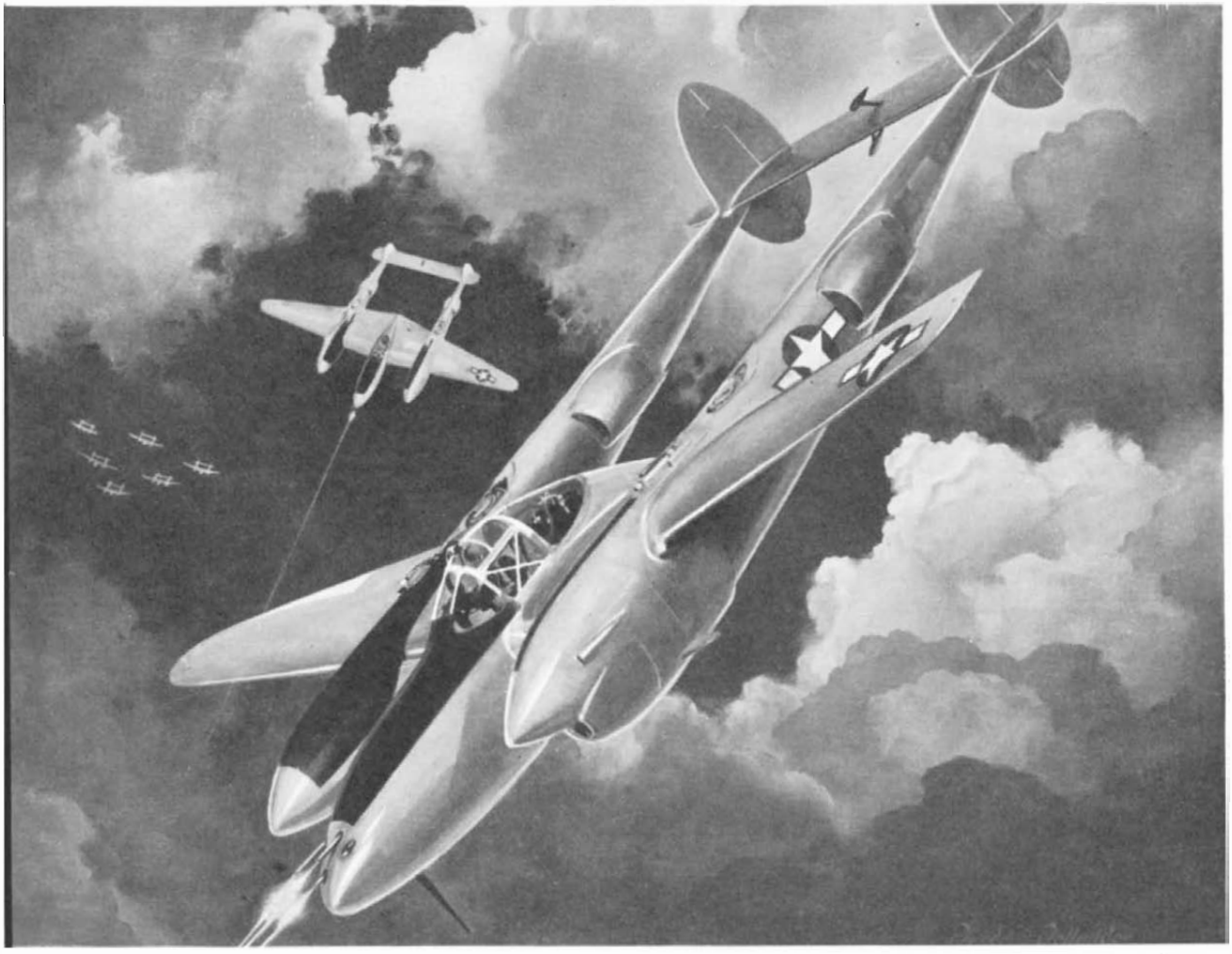
LOOK TO television to make great demands on the film industry when it once gets under way. While "live" programs will undoubtedly be largely used in video broadcasts, mainstay will probably be movie films. As the number of television stations increases—and G.E. estimates that there will be 100 active stations within five years after the war—there will be need for an enormous number of movies to fill the requirements for anything like consistent television service.

OFFICE EFFICIENCY

ALL TOO little realized is the fact that office work can be speeded up, made more efficient, by the very same methods as have so successfully been applied to shop operations. Time and motion studies have shown startling facts about routine office procedures. Steps taken as a result of such studies have been highly productive in increasing output, reducing waste, and making office employees happier, once they are shown that the steps are for their own benefit as well as that of the firm.

FOR FUTURE REFERENCE

BUSINESSES that are now lining up customers for goods to be delivered as rapidly after the war as conditions permit will be the ones to get in on the peace-time ground floor. . . Neoprene, oldest and most versatile of the synthtic rubbers, is now almost as scarce as natural rubber. But the varied uses to which it is being put, because of that versatility, are making it ready for great post-war applications. . . Over 70 percent of the metals industry of the United States can convert to peace-time operations almost overnight. . . Post-war products, in limited fields, are already making experimental models of magnesium, studying the advantages and disadvantages of this light metal. . . Greater travel comfort for railroad patrons is foreseen in research now going on in such matters as seats, luggage racks, wash rooms, window shades, and so on.



8 MILES UP—THE *P-38* GETS FINGER-TIP CONTROL

No matter *how much speed* a fighter-pilot has *he must also have maneuverability*—be able to get in fast and get out quickly.

Now, even with the P-38's phenomenally increased speed, he can do just that. For Lockheed engineers, by installing aileron boosters actuated by the revolutionary Hycon "Stratopower" hydraulic pump, have given him "finger-tip control" over speed faster than sound. The application of these boosters, made practical for the first time, provides faster response of control surfaces, and as a result the Lockheed *Lightning* now outmaneuvers many single-engined ships—and fights higher than ever before in the thin air eight miles up.

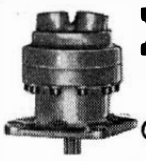
To speed the day of Victory, we are using to the limit every facility at our command in the production of Hycon "Stratopower" pumps, and all of them are reserved for the planes of our armed forces.

LET'S ALL BACK THE ATTACK—BUY MORE WAR BONDS

And after the war—for peacetime

Because of its compactness and phenomenally high pressure, furnishing *variable volume up to 3000 pounds per square inch*, the Hycon "Stratopower" pump will do a great many hydraulic jobs *better*.

Today there are available other Hycon Pumps and Valves in the 3000-pound range for commercial applications to control or actuate machine tools, giant presses, dump truck lifts, materials-handling mechanisms and remote control circuits. They will operate brakes, clutches and steering devices of heavy vehicles; test high-pressure apparatus; and solve a wide variety of other hydraulic problems. For immediate delivery. Write for full information.



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50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of June, 1894)

AUTOMATIC PILOT — "An interesting device by Mr. Bersier is described in *L'Ind. Elec.* The object is to operate the rudder of large vessels automatically by the compass directly without the use of the usual seaman. . . The standard compass is used and a current from a Ruhmkorff coil is passed from the pivot of the needle to the north pole extremity, whence sparks of 3 millimeters' length pass to one of two semicircular pieces of aluminum insulated from each other, the gap between them being set to the desired sailing direction. When the spark passes to one of these the current, by means of a relay, starts a motor in one direction, which in turn operates the rudder, while if the spark passes to the other piece, it moves the rudder in the other direction."

ENGINEER-ARCHITECTS — "The profession of architect as relating to the designing of buildings has occupied a position intermediate between that of a profession and of an art. . . But of recent years a new function has to be called in, in the construction of modern city buildings, which function is the work of the modern civil engineer. . . Steel has now invaded the architect's realm, and the last few years have seen a new type of city building evolved, one which would be impossible without steel, and in which the modern engineer asserts his presence."

MATCHES — "The lucifer match has attained its present high state of perfection by a long series of inventions of various degrees of merit, the most important of which resulted from the progress of chemical science."

SUEZ — "Three thousand three hundred and forty-one ships, of 7,659,000 tons, passed through the Suez Canal in 1893, yielding sixty-eight millions in dues."

INSANITY — "Great intellectual effort requires high nervous tension. It is ability to stand this tension which makes greatness, and the vanity of greatness is merely the symptom of reaction—of breaking down, of the insanity which is the result of nervous tension uncontrolled by will."

COMMERCIAL FISHING — "The commercial fisheries of the country give employment to 182,407 persons, represent an investment in vessels, boats, fishing gear, buildings, wharves and other property of $58,355,000, and yield products of the annual value of $45,000,000 in first hands. The cost to the consumer is probably about $130,000,000, and it is thought that the fisheries of the whole United States furnish support to over 1,000,000."

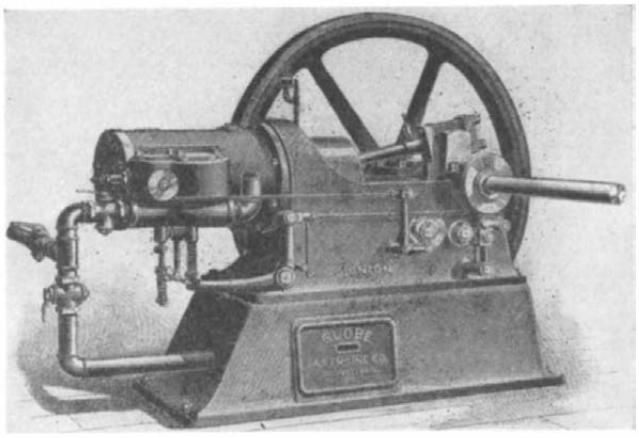
SEWAGE TREATMENT — "A practical application of electricity to sanitation has recently been made. . . Mr. William Webster . . . treats the sewage directly. He places parallel iron electrodes within a conduit or chute, through which the sewage is passed, the electrodes being alternately connected with the positive and negative poles of a dynamo. The nascent ammonia thus evolved at the negative electrode produces an alkaline reaction, which effects the precipitation of the solid suspended matter, while at the positive pole nascent oxygen and chlorine are evolved, producing an acid reaction, whereby the organic impurities held in suspension or solution are readily decomposed and purified."

DIAMONDS — "M. Moissan has not only succeeded in reducing the most refractory metals, but has fused and volatilized both lime and magnesia. Nearly all the metals, including iron, manganese, and copper, have also been vaporized, while by fusing iron with an excess of carbon, and then quickly cooling the vessel containing the solution of carbon in molten iron by suddenly plunging it into cold water, or better in a bath of molten lead, he has been successful in producing small, colorless crystals of carbon, identical in their properties with natural diamonds."

BEARINGS — "Ball bearings are successful only when the balls themselves are of the highest quality, and the shells and axles are of the best steel hardened and ground to the highest perfection. The limit of error in the best does not vary more than one-quarter of one-thousandth of an inch, or one-fourth the thickness of tissue paper."

ROOFS — "Flat roofs have several advantages, and can conveniently be constructed of concrete, with iron or steel girders at intervals. If the under side of the concrete has to be the ceiling of the room below, it may be desirable that it should be quite flat. In this case, the necessary falls and gutters can be formed with rough concrete laid on the top of the main body of concrete. The best material for finishing such roofs externally is asphalt."

GAS ENGINES — "The gas engine has been recognized by engineers as affording one of the most efficient prime movers known. The steam engine is far more wasteful of the energy received from its fuel when steadily running. Irrespective of this fact, a further source of waste, which may be of still greater degree, is that for intermittent power much of the fuel in a steam boiler furnace may be burned uselessly. . . . With the gas engine it is different. The gas is turned off when the engine is to stop, and none of it is used until it



is wanted. . . . The Globe Gas Engine Company's engines are built to work with both gas and gasoline. Perfect adaptation to the latter kind of fuel was shown in an experiment in which an engine was run for a long time with kerosene oil in place of gasoline. The fuel is vaporized before burning, simple atomization not being relied on, and no heat is required for the purpose."

MATH — "Mathematics should be regarded as a kind of mental shorthand; a ready means for stating a proposition exactly; an instrument for recording thoughts so that they cannot be misconstrued. . . . Mathematics is not essential to the art of theorizing, but it is essential to the art of theorizing rightly; it is the only economical method of thought."

LIGHTHOUSE — "The present Fire-Island light . . . on Long Island . . . is to be replaced by an electric light, said to be the largest ever made. It is claimed that it will have a brilliancy equal to twenty-five millions of candles. . . It is expected that the light can be seen a distance of 25 miles."

COAL TAR DERIVATIVES — "As a consequence of the progress made in the manufacture of coloring materials from coal tar, physiologists and physicians have been able to experiment with a host of new products, some of which have found a place as therapeutic or antiseptic agents. . . The number of organic bodies proposed as antiseptics or medicinal products is very large, and one or more medicaments are observed to make their appearance every day."

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BELL TELEPHONE SYSTEM

"Quotes . . ."

"IF AMERICA is to have enough jobs after the war we must encourage invention in small business. Invention and small business depend on patents. Patents protect the little fellow from having his ideas pirated. They are the sling shots that make it possible for the little Davids to compete with big Goliaths." *R. J. Dearborn, President, Texaco Development Corp.*

" " "

"THERE IS every possibility that before natural rubber again becomes available in quantity, we will have perfected a general-purpose synthetic able to compete with it on virtually even terms." George W. Vaught, Vice President, B. F. Goodrich Company.

" " "

"BEFORE THE WAR the nation was dependent upon only high-grade domestic and imported bauxite for alumina. Today, using a process developed by Alcoa after 25 years of research, the industry is making alumina from low-grade bauxite and even the red mud residue from the familiar Bayer process." *Roy A. Hunt, President, Aluminum Company of America.*

" " "

"IF THE NATION'S empty-bin boom is to be followed by growth and sustained prosperity, the flow of new capital into enterprise must be stimulated beyond any volume in our experience." John Clifford Folger, President, Investment Bankers Association.

" " "

"THE HELICOPTER in the future, when many problems now existing have been solved, and solve them we shall, will bring our new Age of Flight within the reach of practically everyone. It is an individual machine more than a common carrier." *Colonel H. F. Gregory.*

" " "

"THE WAR is disclosing new vistas. American industry must gear itself to peacetime production on a scale without precedent. That is largely an engineering job. . . A war-torn but industrially awakened world will require the service of engineers, not only for repair and reconstruction of its productive facilities, but also for a new productiveness." Robert M. Gates, President, American Society of Mechanical Engineers.

" " "

"TELEVISION OFFERS the soundest basis for world peace that has yet been presented. Perhaps that will surprise you, but isn't this logical: Peace must be created on the bulwark of understanding. International television will knit together the peoples of the world in bonds of mutual respect; its possibilities are vast, indeed." *Norman D. Waters, President, American Television Society.*

CHEMISTRY IN INDUSTRY

Conducted by D. H. KILLEFFER

Official U. S. Marine Corps photograph

Working on mosquito-infested jungle beaches, our fighting men cannot be hampered by protective nets. But chemistry is furnishing adequate protection with a new insect repellant developed by Carbide and Carbon Chemicals Corporation

Synthetics Offer Solutions

Some 160 Compounds Have Been Produced from Petroleum and Natural Gas. Many of these Will Become Essential Parts of New and Important Post-War Developments. Today the Processes Involved are Supplying War-Needed Products; Tomorrow They May be Applied to Liquid Fuel Production

ETHYL alcohol, required for synthetic rubber and a host of other war-connected applications, overshadows other alcohols in the news. That is as it should be. Only where troubles and shortages arise are headlines born. The chemical industry generally fulfills its duties so well in the war effort that few of its products or operations draw more than passing attention. The important alcohols derived from petroleum and natural gas, which are more numerous and useful than one might suppose, illustrate this fact.

Following World War I, American chemists developed a new industry based on the manufacture of scores of useful products through chemical elaboration of the hydrocarbons abundantly available from American oil and gas wells. This native phase of the chemical industry now yields solvents, resins, aviation gasoline, and synthetic rubber among others, and has grown to rank with that of the older coal-tar chemistry, supplier of dyes, pharmaceuticals, and perfumes. Its orderly growth made it equal to the burden of the demands of the present war and hence it has attracted little public attention.

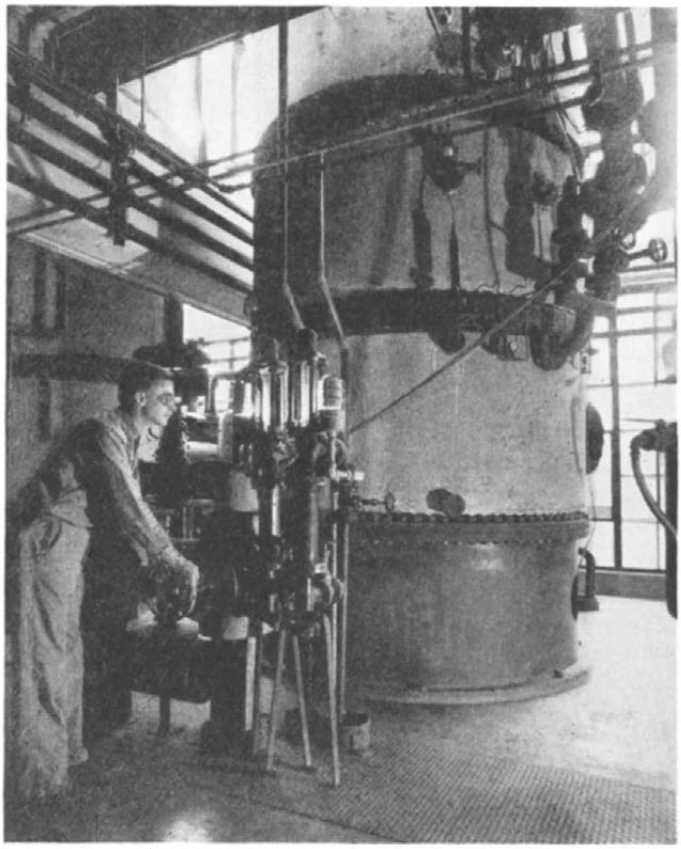
Current production of synthetic rubbers and 100-octane gasoline, requiring huge volumes of oil, emphasizes the approach of a famine in oil as our petroleum reserves are progressively depleted. To an important and growing extent our future supplies of motor fuel are destined to come from other sources, notably natural gas and coal. The shift will be gradual over a period of years and, during the transition, our reserves of natural gas will play an increasingly larger role as the first offset to depletion. Synthesis of motor fuel from gas will presumably precede the large-scale hydrogenation of coal to liquid fuel. The reason for this is the comparative simplicity of the gas-using processes and the fact that equipment and techniques for the purpose have already been designed and operated.

Thus the present production of synthetics from gas and oil, useful and important as it is, assumes special significance in view of the prospective diminution in oil reserves. Here exist processes and plant designs—albeit on a scale far smaller than will be needed—capable of adaptation to the future's immense problem. Today they produce many products, especially alcohols; in the future they will be adapted to make gasoline.

Alcohol, the word, normally means ethyl alcohol, fermentation product of sugar, even though alcohol may come from other sources. However, the term also designates a large and important family of chemically similar materials. Most of these are less widely known since the quantities of them employed in industry are tiny by comparison. Nevertheless, their functions are vital in many diverse ways. The alcohols

are also conveniently subdivided into a number of smaller groups, possessing the general characteristics of the large family but more closely related to other members of the smaller groups. Thus, the glycols possess the chemical structure of dual alcohols, and glycerol similarly may be considered a triple alcohol since its molecules embody three characteristic alcohol groups.

Most familiar of the glycol group of the alcohol family is ethylene glycol, widely used as an anti-freeze in the radiators of automobiles and now largely gone to war for similar service. Ethylene glycol is a somewhat syrupy liquid whose various properties are intermediate between those of ethyl alcohol on the one hand and glycerol on the other. Consequently, its commercial uses somewhat straddle between those of its more familiar relatives. However, its double alcohol nature allows it to enter a number of chemical reactions and to form derivatives of unique value. Thus, one or both of its alcohol groups can be converted into an ether group and the resulting compounds then possess important value as solvents. Or still other modifications can be made in its properties by combining one or both of its alcohol groups with an acid to form esters. The progressive modification of the chemical structure through these changes, effected singly or in various combinations, provides a series of derivatives in which particular characteristics are either emphasized or suppressed practically at will or wish.



In a styrene plant, where products derived from coal and petroleum gas are combined to produce an essential ingredient used in the manufacture of one type of synthetic rubber

WATER-SOLUBLE WAXES—From this glycol, synthesis also produces an especially interesting series of waxes which are unique in being waxy in the normal way but at the same time soluble in water, as no normal wax is. These interesting products are formed through chemical reaction of molecules of ethylene glycol with themselves. The two alcohol groups in each glycol molecule react with those in other molecules, with the result that the product consists of long chain-like molecules made up of many of the smaller original ones as links. The number of links can vary over a rather wide range and thus the properties of the product can be controlled to meet particular needs such as, for example, for a softer or harder wax. Under the trade-mark Carbowax, these water-soluble waxes are already performing important services in industry where their similarities to and differences from ordinary waxes make them particularly useful. They possess lubricating properties and hence can serve where solubility of the lubricant in water is important. Ordinary lubricants on textile machinery, for instance, occasionally stain goods in process, a trouble easily corrected if the lubricant can be washed out of the cloth with water. Wire drawing, molding of rubber and plastic articles, and other similar operations are benefitted by the use of this new family of lubricants.

Recent approval of the use of the Carbowaxes in cosmetics and pharmaceuticals opens other fields for their unique properties. Cosmetic creams and lotions forming powder bases that can be washed off, and medicated ointments for external application, which need no special solvents for their removal after their purpose is served, are obviously valuable. That these compounds can be produced with varying properties gives them other advantages over the useful waxes of more or less fixed characteristics.

Ethylene glycol can be made to react with cellulose to yield a water soluble glycol-cellulose. This product, marketed in limited quantities under the trade-mark Cellosize, possesses the film-forming properties of other cellulose derivatives but is easily dissolved in water. Furthermore, it strongly resists oils and oily solvents so that it can be applied from solution to protect surfaces—concrete, for example—from oil spilled on them. When the protection is no longer needed, simple washing removes the coating. Resistance to oil makes coatings of this material useful for lining paper containers for oily products. When moisture resistance is necessary, as it often is, Cellosize can be modified by the addition of appropriate amounts of glyoxal, the aldehyde derived from ethylene glycol, to make the finished film proof against any but prolonged soaking in water.

Glyoxal itself gives chemists a new tool for use in synthesis. It is a dual aldehyde in the same way that glycol is a dual alcohol, and since it is a solid with low volatility and very little odor, it can serve in many of the applications of the familiar formaldehyde. An example is its hardening action on casein in glues and paper coatings to which it imparts relative water resistance.

Recently attracting special attention is another glycol bearing the same relation to ethyl hexane that ethylene glycol bears to ethane. This compound —2 - ethylhexanediol - 1, 3, to give its proper chemical name—possesses the remarkable property of repelling insects of many varieties even though it is practically odorless itself. The pervading odor of citronella and other insect repellants in summer is barely sufferable to many people who endure it only in preference to the greater annoyance of ubiquitous mosquitoes, gnats, and biting flies. The idea has been to create an odor so disagreeable to insects that they will keep their distance. The new compound does just that. Apparently its odor disturbs the insects but is too weak and tenuous to annoy their intended victims.

The compound can be readily incorporated into creams, lotions, and similar preparations and in these forms retains its repelling ability for many hours. Just now this repellant is at the fighting fronts, protecting our armed men from insects infesting the tropical environments in which they fight. Mosquito-borne malaria is the most serious of the hazards against which it is providing protection. Its fighting garb includes a dual-purpose camouflage cream applied to the face and hands to hide the soldier from his human enemies and to protect him against the flying pestilence of mosquitoes.

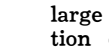
These few compounds illustrate the versatility of our developing chemical industry of compounds derived from petroleum and natural gas and called aliphatics to distinguish them from the aromatic family originating in coal tar. The chemical industry now produces a list of some 160 various compounds from these sources. Many of them were known before only as museum specimens or entries in the reports of scholarly researchers. Their industrial development extends back over a period of about 20 years and it is still going on. War demands have naturally stimulated their widened use and their larger scale production. When peace comes,

these once unfamiliar compounds will become essential parts of new and important developments.

GRAVITY OF PROBLEMS INCREASES—The relation of this phase of chemical industry to the present huge problems of synthetic rubber and aviation gasoline and to the future problem of diminishing petroleum supplies requires comment. These three problems are grave principally because of their magnitude. Synthetic rubber by the thousands of tons is the kind of operation which the chemical industry takes in its stride. By the hundreds of thousands of tons the problem is different. Similarly, aviation gasoline and motor fuel from either natural gas or coal become serious undertakings only when quantities needed suddenly soar to great heights.

The technique of converting the gaseous constituents of natural gas, for example, to the liquid hydrocarbons needed for motor fuel involve no unfamiliar chemistry. Processes for the purpose are known and already have been practiced on small scales well in advance of urgent need. Yet when output must be suddenly magnified some thousand fold, the very size of the operation introduces new problems. The same is, of course, true of synthetic rubber processes, some of which were operated in this country more than a decade ago, and of coal hydrogenation, long subject of experiments here. Although the chemical elaboration of natural gas to products described above is by no means the same as that demanded to solve the problem of future motor fuel, yet familiarity with the fundamental chemistry of it gives assurance of the successful solution of the difficulty as it develops.

With so large a demand in prospect for our natural gas output to supply motor fuel, the question naturally arises as to where raw material for expansion of these lesser synthetic operations will be found. The answer lies in the relative magnitudes of the two. Where motor fuel requirements reach above a hundred million tons annually, the need for chemical products of natural gas and petroleum are unlikely from present indications to be substantially greater than a similar number of pounds. Thus the problem of raw material supply for this latter purpose is scarcely subject for concern, at least for the present.



SOIL STABILIZATION

Achieved Through Use of New Resin Compound

A CHEMICAL method of preventing mud by making soil waterproof has been proved in use on roads, airplane landing fields, and other construction projects here and abroad, according to the Hercules Powder Company.

Its proper use means an end to muddy streets and roads, and a time-saving aid in road construction work where mud may cause delays. Stabinol, as the chemical compound is called, can be used to stabilize unsurfaced dirt roads in rural areas where the traffic is light, or it can be mixed with soil that serves as the base on main highways with hard wearing surfaces.

By mixing Stabinol, a resin compound, with the top few inches of soil, a waterproof surface is obtained. The water will drain off or evaporate, rather than seep through the treated soil and turn it into mud. Stabinol-treated soil resists penetration of surface water, the chemical company says, and also the capillary rise of moisture from below.

A truck can move over Stabinol-treated roads during or after a rainstorm without churning up mud or digging ruts in the road. A car splashing through a puddle on this type of road will kick up dry dust, not mud, behind it.

Only fractional amounts of Stabinol are required, usually about 1 percent of the total soil to be treated, and the "stabilized" soil has the same appearance as the original dirt. Hercules says that Stabinol does not increase the load-bearing capacity of soil, but it will prevent the soil from getting wet and thereby losing its strength. This effect of soil stabilization will last for years; roads laid down more than five years ago, for example, are still waterproofed.

PILLBOXES

Made of Plastic, Unaffected by Dampness

PILLBOXES—literal boxes for pills, not strong points of defense—assume special importance in this global war. Each soldier carries sulfa pills with him at all times and these must be carefully protected until they are needed. With armies operating in the jungles of the Pacific islands and the Far East, metal boxes are less than perfect. Latest development in this phase of the war is a pill box of transparent plastic which is unaffected by dampness and which permits its contents to be inspected at any time without opening or breaking the seal.

UBIQUITOUS CHEMICAL

Used in Perfumes, Insect Repellants, and Protective Coatings

PHTHALIC anhydride, produced now in large quantities by the catalytic oxidation of naphthalene, was once used principally as an intermediate product in the preparation of certain useful dyes. But, like many chemical products, its applications proliferated. A valuable perfume fixative capable of increasing the life of fine perfumes was derived from this intermediate. The compound, diethyl phthalate, was also valuable as a denaturant for alcohol to be employed in perfumes, and as a softening or plasticizing agent in nitrocellulose plastics. An important family of resins, particularly useful in modern paints and protective coatings, next came from phthalic anhydride and achieved such wide acceptance that this material has had to go under strict allocation in the present war production program.

The latest phase of phthalic anhydride's usefulness, however, threatens to overshadow, at least for the present, all the others. Diethyl phthalate, compound of phthalic anhydride and ethyl alcohol, has proved to be valuable in repelling the voracious malaria-bearing mosquitoes of the South Pacific. Practically odorless to the human nose, this compound turns out to be highly objectionable to insects. The combined demand for phthalic anhydride has forced further tightening of restrictions on its use. None is now available for civilian use.

WHITER PAPER

Promised by New Bleaching Process

SODIUM peroxide is the bleaching agent used in a new method of whitening mechanical paper pulp recently announced by engineers of E. I. du Pont de Nemours and Company. By using 1.5 to 2 percent of sodium peroxide in a new process of bleaching, groundwood pulp can be economically brightened as much as 7 to 11 points on the brightness scale used in the industry to compare papers. The characteristics of the pulp treated by the new method are reported to be far superior to those made by present practices. Principal application of mechanical pulp is in newsprint where its short life and lack of whiteness are less important than its cheapness. The new bleaching process is expected to widen its usefulness into other fields in addition to improving newsprint. War restrictions on production of sodium peroxide indicate that the new process will have to await peace for complete development.

CLEAN GUN BARRELS

Assured by New Cartridge Primer

GUN-BARREL cleaning, one of the bugaboos of soldiering, has been reduced to a minimum for United States troops through the use of a new type noncorrosive carbine cartridge that leaves no damaging deposit in the barrel when it is fired.

The deposit left in the barrel of a rifle by the primer after older cartridges had been fired, produced rust and made frequent cleaning necessary. Instead of leaving a rust-accelerating deposit, the new primer developed by Winchester for the 30-caliber carbine, leaves a protective deposit in the bore, and thus relieves the soldier from constant cleaning.

In order to take care of deposits due to elements other than the primer, the carbine is equipped with a cleaning apparatus, the use of which is required only once a day. The new cartridge is a 30-caliber pistol type, the bullet of which has a muzzle velocity of 2000 feet per second. Its effective range is 300 yards, which is four times that of a .45-caliber automatic pistol cartridge.

Lead Carries Its Weight

No One Surveying the Potentialities in New Alloys and Steels should Forget Those Old Standbys, Like Lead, That Have Entered New Fields and Permanently Improved Their Application-Positions Generally. Here Are Some of Lead's Recent Advances and a Hint of its Post-War Prospects

LEAD, distinctive for being the heaviest common metal and for having the lowest price per pound of all nonferrous metals, is also one of our most versatile industrial materials. Its list of applications, long as it was before the war, has in the last few years been extended—with the help of research, of new coatings and alloys, and of shortages of more critical materials—to include many new uses that are self-sustaining and hence of major interest to those who ponder the products of peace.

Among the more significant of these are certain applications that depend on the *weight* of lead for their existence. At the present time about 10 percent of the current consumption of lead is primarily utilized because of its weight. Thirty percent of the metal's consumption is the result of its softness, workability, and corrosion resistance, and 24 percent because of such properties of its alloys as low-melting points or good bearing qualities or favorable shrinkage properties. The applications of lead's chemical compounds are responsible for 33 percent of the metal's consumption.

IN BULLETS—Lead is 11.34 times as heavy as water, or half again as heavy as iron and 6.5 times the weight of magnesium. The best known application of this quality is its use for bullet cores. Lead's melting point is about 620 degrees, Fahrenheit, and some of its alloys are completely molten at 350 degrees, Fahrenheit, thus establishing their utility for solders, type metal, fusible alloys, short-run molds and dies, and so on.

Lead and certain of its strong alloys with antimony or calcium that have just the right electrochemical properties are also virtually completely resistant to attack by sulfuric acid and corrosive sulfates, hence are employed for storage batteries; its resistance to sulfuric acid alone brings the metal into use for chemical plant equipment—pickling tanks and the like. In addition, lead's general corrosion resistance is partly or entirely responsible for a host of such uses as roofing and flashing, plumbing items, cable sheaths, pole-line hardware, containers, and so on.

Removing a steel pattern from the molten lead bath used in the manufacture of molds for casting plastics. The lead is later reclaimed

Its ductility permits it to be extruded into long, heavy tubes for cable sheathing and pipe, or into tubing for toothpaste tubes, and to be rolled into heavy sheet for tank linings and sulfuric acid chambers, or into thin sections for wrapping-foil. Its special property of resisting the passage through it of X-rays and radium emanation make it useful for lining the walls of X-ray rooms or cabinets.

Among the chemical compounds of lead having greatest importance are white lead carbonate and sulfate, used in high-grade white paints; litharge and red lead, its oxides that are employed in storage batteries, paints, insecticides, enamelware, oil-refining, synthetic rubber, for examples; tetraethyl lead, used in high-test gasoline; and so on.

In one pre-war year (the following figures are for 1939) the order of annual lead consumption by various products, exclusive of the uses of lead chemicals, was something like this: storage batteries took 198,000 tons; cable sheaths 74,400; buildings (roofing, pipe, and so on) 50,000; ammunition 42,300; foil 21,800; solder 20,000; calking 16,000; type metals 14,000; bearings 12,800; automobiles 8900; non-ferrous castings 7500; lead-alloy coated steel sheet 6000; and other uses 63,100.

The picture since then has changed significantly. Storage batteries still head the list as the chief outlet but ammunition has moved up to second position, with lead-coated steel, bearings, and solders responsible for much higher tonnages of lead consumption than formerly. Some items—collapsible tubes, for example—appear on the list of major applications for the first time. In addition, two or three other wartime developments in the use of lead, not yet out of the "minor" classification, bid fair eventually to rank among the important uses of that metal.

MOST AVAILABLE METAL—Lead's present position must be studied against a background of the war's effect, for it has been the "most available" metal during most of the war period to date, and thus has been widely used to replace other metals wherever possible. Many of these applications were simply a more extensive use of lead in ways in which it had always competed on its own merits—plumbing pipe, flashings, and shower pans; flashing on buildings; lead-base bearing alloys; die castings; industrial pipe and tank linings; gaskets; and so on.

Other replacements are new uses for lead. Lead alloy nameplates, hard lead drum trap covers and rings, water-closet floor flanges, have been developed to take the place of brass. Lead alloy couplings are employed to save copper and bronze on certain kinds of cement-asbestos pipe. Lead foil is being used as wrapping in a number of new fields such as the fast-growing dehydrated food industry. Evidently here to stay are some of the above and a few others such as lead molds for casting plastics, lead battery-connectors and lead foil insulation.

Lead's versatility has been a boon to the industry that produces it, for it brings the metal into markets that are prosperous at the same time that some other uses may be suffering depression

pangs. This same diversification, a direct result of lead's varied properties, has been an even greater asset to the nation's war effort.

Bullet cores, for example, make use of lead's weight and ease of fabrication. The lead is first extruded as rod, cut into short lengths, swaged to the approximate shape of the bullet core, and then pressed into the jacket. Pure lead and antimonial lead (containing up to 2.5 percent antimony) are employed.

Again, antimonial lead die castings form the bodies of practice bombs. Lead counterweights are used in torpedo mechanisms and in anti-aircraft and other guns. It is increasingly applied to provide perfect weight balance in airplanes and gliders—an almost paradoxical application because its primary purpose is actually the reduction of excess weight in the mechanism for operating the ailerons and rudders!

Here's how this comes about: In modern aircraft design, flutter characteristics of movable surfaces are so important that balance weights are added to all ailerons, rudders, and elevators on pursuit planes. The weight of the surface tending to cause rotation about the hinge line in one direction is thereby resisted by a heavier balance weight at a relatively shorter distance from the hinge. Lead can be molded to the shape of the nose section so that its center of mass is at a maximum distance from the hinge line, and thus a smaller amount of balance metal has to be used than if a less malleable or ductile material were employed. One company alone has already consumed more than 200 tons of lead for just this one application.

IN PACKAGING—Another application where weight is at least no barrier to success is the use of lead foil for packaging in place of rigid containers of steel, tinplate, aluminum, cardboard, and so on. Although conservation of the materials formerly used was the prime mover in this development, the savings in weight, shipping space, and cost have been great enough to indicate that many types of lead-foil packages will continue to be used even when rigid containers are again available.

Heavy lead foils have long been used for packaging perishable materials, but such closures are expensive and easily damaged. The modern lead-foil package —essentially a bag made of foil-coated kraft paper—is substantial and economical while retaining the advantages of waterproofness and airtightness. These packages are being used as shipping and storage containers for rifles, machine parts, optical instruments, radio parts, powder, and detonators, in addition to the expected foods (the Army's famous K-rations, for example), drugs, bandages, cigarettes, and even matches.

The high density and atomic weight of lead also make it particularly useful in one field that is growing by leaps and bounds—the use of X-ray and radium for the internal inspection of castings, forgings, weldments, and finished industrial products. X-rays as well as the the gamma-rays of radium are injurious to persons inordinately exposed to them, so operators and "innocent bystanders" in industrial plants (where radiographic equipment may be in operation continuously, day and night) must be protected against the radiation.

Lead is the most efficient material that may be used economically to prevent the escape of X-rays from rooms or cabinets in which they are generated. A thickness of one millimeter of lead will completely absorb X-rays of the intensity developed by 75-kilovolt equipment and a 34-millimeter (1 1/3 inch) sheet is required to shield against 600-kilovolt X-rays.

X-ray rooms are, therefore, completely lined with sheet lead. Doors are constructed so that their lead coverings overlap the lead covering on the jambs all around. Wall holes for electrical wiring must be lead-shielded and nails are often lead-headed to provide a continuous barrier. Even windows in such rooms are made of glass with a high lead content so that the operators may safely look into the closed room. A new development that should simplify the application of lead shielding is a lead-clad plywood, now available from stock in the standard plywood sizes.

Technologically, the outstanding wartime development for lead has been the evolution of new lead alloy coatings and the great expansion in use of lead-coated iron and steel sheet. Recent improvements in lead-coating processes have yielded hot-dipped lead coatings that compare satisfactorily with galvanized steel in durability (in some cases the lead coatings are *more* durable), and have the added advantage of being an excellent base for paint.

The lead coatings are ductile and can be bent and formed without flaking or cracking. Lead-coated sheets may also be die-formed, the lead coating actually serving to lubricate the dies. The Western Electric Company is now applying lead coatings to more than 60 percent of its pole-line hardware. Items varying from small washers to thin curved sections 8 feet long are being successfully coated along with large amounts of sheet for duct work, containers, and so on.

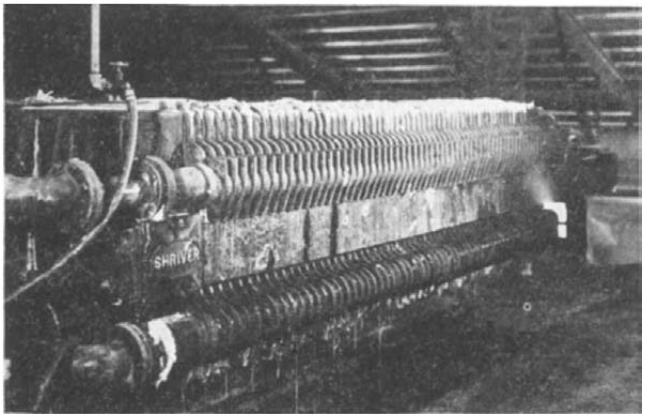
Another processing development of notable significance is the growth in use of lead "burning"— the welding of lead components directly to each other without the employment of another metal as in soldering or "wiping." Forced by the shortage of easy-working high-tin solders to learn lead-burning, many plumbers have found it a surprisingly convenient method of making lead joints (some plumbers have been strong proponents of lead burning for years) and one that "pays off" in any case. Many plumbing installations now use no solder and thus save $5 to $10 or 3 percent of the total cost in a typical bathroom.

Lead has recently been found to be an excellent mold material for casting certain thermosetting plastics. It is sensitive enough to receive the smallest and most delicate impressions from the pattern. It is soft enough to be easily removed from the casting, yet sufficiently strong enough to retain its shape during the pouring of the liquid plastic.

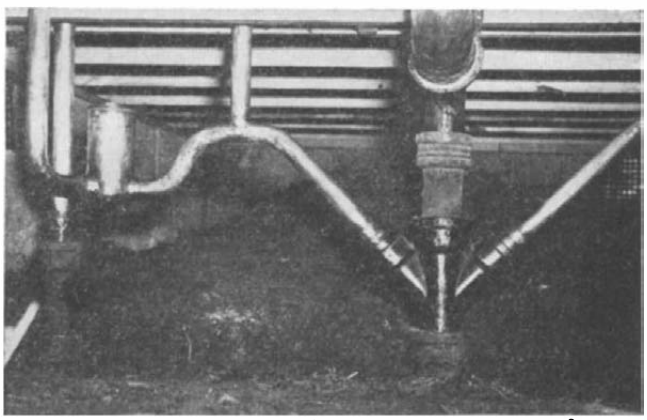
For straight-draw molds, for example, a steel pattern of the exact size and shape of the plastic article to be made is dipped into and quickly withdrawn from a bath of molten lead. The lead, chilled by the cold pattern, adheres to it as a thin sheath. The sheathed pattern is then cooled in water and the pattern is withdrawn, leaving a perfect lead mold, into which the liquid plastic is poured.

MOLDS RE-USED—The mold is later removed with an air-hammer and returned to the melting pot for re-use. This technique suggests that there may be many possible uses for lead in forms and molds that must be destroyed in removing them but which can be salvaged at negligible cost simply by remelting.

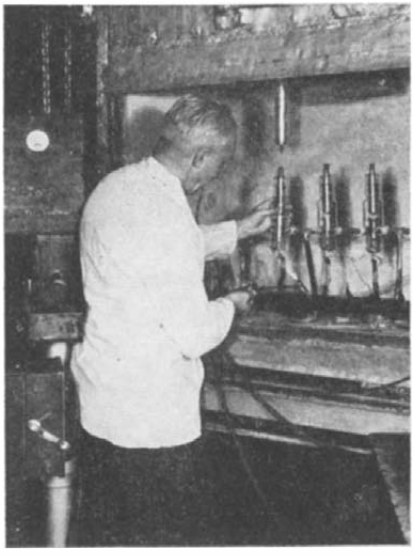
Typical of some of the new uses of



Filter presses for processing highly corrosive chemicals embody large amounts of lead in plates, frames, and so on



All joints in this double-Y connection of waste, drum trap, and lavatory waste were made by use of lead welding



During manufacture, X-ray tubes are tested in this cabinet, which is lead lined to protect the operator

lead that not only conserve a more critical material but provide better service performance is Electric Auto-Lite Company's steel re-inforced lead-alloy terminal for automobile batteries. The commonly-used metals strong enough to withstand the vibration of service are soon corroded by the battery fumes, with consequent impairment of the car's electrical performance. The new terminal is acid-proof, yet strong enough to be clamped immovably to the battery post. The manufacturer believes the new terminals have an exceptionally bright future.

In general, the lead industry is cheerful about the place of its chief product in post-war America. At the present time only 40 percent of lead consumption is supplied by primary domestic production—the rest is imported and made from secondary metal. This makes lead one of the few major metals (perhaps the only one) whose war-production capacity has not been expanded beyond the probable post-war requirements. Nor will lead scrap come back to plague the primary producers to the same extent as will the scrap of other metals.

In addition, it is expected that out of its expanded use as an alternate and substitute, lead must gain certainly some, probably many, permanent conquests. These will probably not include the high-lead solders, which are unpopular with the average worker and will be retained on anything like their present scale of use only in the canning industry. The high-lead bearings, on the other hand, have made an engineering hit and will continue in use, although they account for only a small amount of lead because of the thin films employed.

Expectations on foil are mixed. The new foil-coated paper package is believed to have a bright outlook, but the ordinary lead foil of commerce will meet some tough competition from other foils and wrappings. In the field of collapsible tubes, though, lead tubes may permanently replace a large proportion of the tin tubes formerly used.

And since automobiles, houses, and public utility lines—the respective outlets for lead in storage batteries, plumbing, and cable sheaths—will be produced in boom amounts to fill the war-starved demand, the future of lead in these products is obvious.

Yes—as a leading aluminum manufacturer once respectfully said of lead—"lead carries weight," and it will carry more than its share in the post-war industrial world.

PREFABRICATED HOUSES

Will Use Both Metals and Non-Metals in Mass Production

THE PREFABRICATED (or better, processed-materials) house of the future will depend on non-metals as much as on metals for its mass-produced units, surface beauty, and requisite strength. This was predicted at a recent meeting of the design-materials group of the Architectural League of New York, held under the direction of Morris Sanders. Desigers familiar with steels, non-ferrous metals, plywoods, plastics, and so on, discussed the possible applications of their specialties in post-war housing of this type.

Because of their cost, the non-ferrous metals are expected to find little application for the entire thicknesses of walls, but they are likely to serve in laminated forms as exterior surfaces over steel. For example, thin copper or brass layers rolled onto steel sheets can be made on a mass production scale and would offer the strength of steel plus the surface beauty and strength of the copper or alloy at a nominal cost.

Similar composites involving plastics as veneers over steel will possibly be even more popular because of the variety of colors or surface effects that will be possible. Plastics "all-the-way-through," however, will scarcely be used, owing to the relatively high cost and inferior stiffness properties. The opportunities for plywoods, rolled out and bonded on a scale to match sheet metal manufacture, seem especially good.

Structural steel itself has been shown by long-time tests to be not seriously corroded in normal construction in non-industrial atmospheres. Thus steel, especially when used in conjunction with non-metallic or non-ferrous veneers, seems to have a bright future in this field.

FLUOROSCOPIC INSPECTION

Useful for "Pre-Selection" of Metal Castings

THE USE of fluoroscopy (visual examination of the internal nature of an object on a fluorescent screen) for industrial X-ray inspection has generally been confined in this country to the examination of auto tires, packaged goods, citrus fruits, and shoe fittings. At the present time, however, considerable research is underway to establish the best operating conditions for the fluoroscopic inspection of aluminum and magnesium aircraft castings.

The fluoroscopic method is most useful as a method of "pre-selecting" castings with relatively gross defects for subsequent radiographing. It is especially valuable for the inspection of cored passages in castings and as a tool for the general control of foundry practice. Properly applied, it can cut down in large measure the great amount of X-ray photographic work (radiography) now applied to light alloy products.

The suitability of a casting for this type of inspection is governed by its size and shape. Light alloy castings are suitable that have a maximum cross section of two inches in any portion and that are of such shape that manipulation will allow the X-rays to penetrate each part of the specimen and give a readable shadow on the fluorescent screen.

ELECTROLYTIC MANGANESE

Has Interesting Properties; Uses Slow in Developing

MANGANESE, vital to the manufacture of virtually all types of steel, is now produced in this country in amounts exceeding 400,000 tons per year. Smelting processes are employed, and yield a mixture of manganese and iron plus other impurities known as ferro-manganese.

In recent years the Bureau of Mines has sponsored the development of a process and plant for the electrolytic manufacture from low-grade domestic ores of highly pure manganese metal, for the original purpose, it is believed, of relieving this country's dependence on foreign sources for much of its manganese ore. According to R. S. Dean of the Bureau, in a paper presented at a recent meeting of the American Institute of Mining and Metallurgical Engineers, electrolytic manganese production capacity in this country is now about 1800 tons per year.

New uses for this pure material have been slow in developing. At present its chief application is in the manufacture by the mints of the new nickel-free "nickels." It has also been used in magnesium bomb casings and has been sent to England under lend-lease for addition to aluminum alloys.

An interesting use for electrolytic manganese that may increase in importance is in an age-hardening alloy containing 60 percent copper, 20 percent manganese, and 20 percent nickel. Its properties (its tensile strength is 80,000 p.s.i. for soft material and 180,000 p.s.i. for hardened) and its fatigue strength are said to be superior to those of beryllium-copper.

Although its high price *has* restricted the applications of electrolytic manganese, as the Bureau avers, it is also true that, even if it could be sold at some figure near the price of the contained manganese in the regular ferro-alloy, its use in the major market (steel-making) would not significantly increase, for metallurgists can see little advantage in purity alone for steel-making purposes.

Safety Increases, But . . .

Statistics Show that, While Much Has Been Done to Reduce Industrial Accidents, There is Still a Long Way to Go. Codes and Standards Are Starting Points. Small Plants Must Be Brought Abreast of the Practices of the Large Ones if the Average is to Brought Up

SOMETIME early this summer the National Safety Council will release its 1944 edition of "Accident Facts," a terse but lucid accounting of what has been done about keeping industrial workers from getting injured and killed on the home front. It will show that, as compared to World War I, and even to 1926, the industrial accident figures so far in World War II are highly encouraging—but by no means encouraging enough. Many of the figures will have gloomy implications, as, for example:

1) The accidental death toll of workers from getting injured and killed nearly three times the total for our armed forces. From Pearl Harbor until January 1, 1944, 32,078 soldiers, sailors, and marines died as war casualties; 94,000 workers were killed in accidents.

2) The number of workers injured will dwarf the total of war wounded. 45,595 of our armed men were wounded up to January 1, 1944, while 8,800,000 workers were injured. (The report, when issued, may use even later figures.)

3) Accidents will cause each 1000 industrial workers to spend an average of 150 to 200 days away from work per year. Time lost without the hurt men leaving their jobs will add another 600 to 700 days. In short, the entire war effort will lose, each year, more than a full week of production because of industrial accidents. And this time loss will be multiplied many times over by the "indirect costs of accidents"—the time lost by men who leave their machines to help the injured one, the slowings down by workers who suffer shock at seeing someone else get hurt or who fear that hard effort may cause them to get hurt, the absenteeism and the labor turnover caused by workers disliking to work in a place where they have seen a distressing accident.

4) Frequency of accidents, as measured by number of injuries per million man-hours worked, probably will go down a little in 1943 figures.

5) Severity of accidents, as measured by the number of days lost per 1000 man-hours, probably will go up somewhat in 1943 figures—this is one of the paradoxes which all safety engineers are studying, pondering, and attacking.

Distressing as these figures are, they are not nearly so bad as they might be. The fact is, half again as many workers were injured per million man hours worked in World War I, and the increase in the accident rate as new workers were trained in that war was much higher than in this one. Direct comparisons of figures are not too practical—statistics were not so complete then as they are now, and many kinds of dangerous chemical, metal working, and other industries exist now that had not yet been born then. Nevertheless, it is certain that factory hazards have been cut by one third, and in some big plants (steel mills are an example) they have been cut five sixths.

Courtesy Carnegie-Illinois Steel Corp.
Sandblasters are completely armored

Statistics are fairly clear from the mid '20s on, and the National Safety Council uses 1926 as the 100 percent or "yardstick" year. Some of the measurements are startling.

Frequency of accidents, per million man-hours worked, went down more than 60 percent between 1926 and 1932. The trouble is, it has remained on a fairly constant level since then, going up and down a trifle from year to year and being about 68 percent below 1926 right now, but not going on down.

Safety men are happy about this, but not overjoyed. They point out that every school child begins getting the kind of training which will cut down accident frequency rate while he is in kindergarten, and that "don't get hurt" psychology is dinned into him in his church, when he learns to drive his car, during his military training—in fact, everywhere he turns. It is probable that more agencies have concentrated on getting Mr. U. S. Citizen to avoid the practices which cause little accidents than have influenced any other phase of his life. Much as the industrial safety engineers have done—and they have done plenty—to reduce the accident frequency rate, that rate is as low as it is because the whole nation has been working on it.

The severity rate is a different matter. It did not go down nearly so fast as the frequency rate and it never has gone down so far. But the decline has been steady. Almost every year finds it lower than the year before, and it is now down over 50 percent from 1926. Here the trouble is that most of the decline has been in the minor degrees of injury. Deaths have gone down only some 40 percent, permanent partial disabilities only 25 percent, or less than half the total severity rate decline. And this, of course, is one of the major safety problems.

METHOD OF ATTACK—Safety engineers know that no drastic reductions in industrial accident rates, such as were possible when guards first were applied to machines and equipment, are in sight right now. Much of the safety progress of the immediate future will be made by correcting a host of minor deficiencies, the results of which can add up to very large gains over a long period of time. The safety battle has become a war of attrition, the results of which can be aided by accurately recorded statistics.

First step is the simplified report. Accident reports, unfortunately, must be long and complex, for the employer and his insurance company depend upon them to defend themselves in law suits. But every pages-long report can be reduced to a simple sentence. Examples: "The man put his bare forefinger into a hole in an attempt to extract a broken drill, and received a deep cut." "Lumber was piled improperly; a board slid off the top of the pile and struck the man in the abdomen." "The woman neglected to wear her safety goggles and was struck in

Courtesy Willys-Overland Motors, Inc.

The girl on the left has a good all-purpose suit for light work but would be better off with safety shoes. The girl on the right is inviting trouble in many respects

the eye by a steel chip." And so on.

Such sentences are easy to tabulate by common causes and severities of accidents. The tabulations are used in the factories compiling them, of course. But even more important, such figures can be forwarded to the National Safety Council and to the American Standards Association for industry-wide action.

Entire industries get together with the American Standards Association, apply the collected data, add the personal viewpoints and experiences of safety engineers, and work out safety codes. Right now the American Society of Bakery Engineers is working with ASA on a safety code for that industry. (Food industries in general are slightly higher in frequency rate of accidents than the average of all industry, but are lower in severity rate.) Standard safety codes have been worked out recently for hoists and cranes and jacks—heavy materials handling is one of the worst sinners, accounting for about one fourth of all compensated injuries and one fifth of all permanent injuries. Gas hazards are bad in industry; a proposed ASA code will hold the maximum concentration of oxides of nitrogen (found at welding and other operations) to 25 parts per million as compared to the 39 parts per million which has been in common use since 1913.

CODES ARE STARTING POINTS—State labor departments use these codes, add figures from the reports of their inspectors, consult the researches made by the United States Bureau of Mines, the National Bureau of Standards, and other agencies, and from them work out laws which their legislators enact. It is a rare factory, however, which does not go beyond the demands of the law in working out its own safety practices. All the codes possible to compile cannot be more than starting points for the development of real safety programs.

The effect of a code is to list the hazards common to any factory, department, or occupation, and the minimum protections permissible for overcoming them. From that point on, safety engineers of individual factories list the hazards applicable to their own conditions, and take steps to reduce them.

Slippery floors are given abrasive coatings or admixtures in the concrete, or provided with surfaces which will make footing safe. Hot or otherwise dangerous objects are painted distinctive colors—the American Standards Association has a code for this and the Du Pont company has developed a safety color system which was described on page 224 of the May, 1944, issue of Scientific American. Light is thrown into dark corners. Special safety clothing is provided—the advance in the design and use of safety clothing shares with machine guards the principal credit for the advance in industrial safety of this war as compared with the last one. Special hazards are studied; the presence of an electrical hazard, for example, outlaws some types of steel-capped safety shoes which are acceptable for other hazards.

Areas of the body most likely to get hurt are studied. Generally speaking, fingers receive 22 percent of injuries, the remainder of the hands only 8 percent. Trunks receive 20 percent (protective armor for the abdomen is hard to design), and the legs, which also are hard to protect, 13 percent. Toes are so well guarded by safety shoes that they receive only 4 percent in spite of the likelihood of heavy objects falling upon them and workers stepping into dangerous places. Eye injuries are down to 4 percent; they could be nearly eliminated if safety practices regarding goggles and face masks were followed.

The slightness of the increase in accident rate with the hiring of so many thousands of untrained workers is due to training programs as well as to machine guards and protective equipment. Untrained workers do have higher frequency rates of accidents, of course; this is demonstrated by the fact that the newly industrialized far west has a higher rate than the older industrial regions of the east. "Lack of knowledge or skill" is blamed for 30 percent to 50 percent of all accidents due to personal causes. But safety training is intensive. Bethlehem Steel Company even goes so far as to have a Gas Mask Training School in which students are treated like combat troops—they work under actual smoke-discomfort conditions against which their masks alone can protect them, while instructors watch through glass panels and tell them what to do.

Training courses seek to keep employees safety-minded "around the clock." One good reason for this is that a man is not likely to change his mental habits just by entering the factory door; if he is dangerous in his practices at home he will be dangerous at work. Another is that accidents occurring off the job cause from 20 to 40 percent more lost time than the "on the job" ones. Western Electric encourages employees to buy and own their own safety clothing and safety type tools, publishes stories in its house magazine of employees who have been saved from being hurt by wearing safety shoes while working in their garages or by using life lines while painting their houses. Pullman Standard, in its "no compromise with safety at any time" program, requires plant visitors to wear goggles and other protections while walking through its shops.

Studies are made of special types of employees. National figures show, for example, that the old and well trained employee is far less likely to have small accidents—his frequency rate is low. The trouble is that when he does have an accident it is a bad one. His comparative severity rate is high. Handicapped workers are in a similar group; only 2 percent of accidents due to personal causes are attributed to body defects and handicapped workers are among the safest in the plant in the frequency of accidents, but their severity rate is high.

The old bugaboo of the "accident prone" person, who was believed to have caused most of the trouble, has been laid by such studies. Figures prove that the man who has had one disabling accident is the one least likely to have another. A survey reported in *American Machinist* showed that of 4404 previously injured men only eight had bad second accidents in 13 years.

WOMEN'S RECORD GOOD—Women have been the subject of special studies of industrial accidents. So far their record is unusually good. Much of this can be credited to special precautions—many companies have redesigned their machine guards for greater safety for women. Use of more hoists where weights must be lifted for women has helped too—heavy weight lifting probably is the Number One cause of injuries, especially among inexperienced personnel. Still, safety men argue, "what is sauce for the goose"—the practices developed for women may be used to cut down accidents among men workers too.

Safety practices are easy to apply in a plant having 2000 employees or more, since the volume of business is large enough to carry the overhead charges of a full-fledged safety department. But the case of a plant employing less than 100 is different. And it is

A light chipping operation requires protection for face, hands, and trunk

in these smaller plants, which make up more than 90 percent of all factories, that the hardest drive of the next year may be made.

National Safety Council surveys indicate that the accident rates in smaller plants are nearly 50 percent higher than in large ones of the same industries.

Many small plants, of course, have safety records which are the envy of some of the big ones. Special observation shows that luck plays very little part in this superiority. These small plants have appointed safety executives ranging from foremen to superintendents, although, strange to say, treasurers and paymasters make good ones too; the principal requirements of a small-plant safety manager are that he have authority and that he be safety minded and willing to learn. They are using the same methods as the large ones.

Right now the smaller plant gets most of its safety education from industrial journal advertisers of safety equipment and from the salesmen of safety products. State inspectors, local safety committees, insurance company inspectors, and others who have a professional stake in safety, carry the rest of the informative burden.

The forthcoming drive will feature safety posters, simple report forms, and the profits in uninterrupted production which safety can pay. Safety for the small plant will be made simple. And if there is any abrupt and drastic reduction in industrial accident rates, it may easily come from the combined drive of the safety equipment sellers and of all other agencies on these smaller plants. Safety in the larger plants and in the average of all industry will continue to grow, the pressure behind it will continue to increase, but the smaller plants must be brought abreast of the practices of the big ones.

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FLAME CLEANING

Has Advantages of Speed and Thoroughness

Extremely rapid heating of surfaces of metals, followed by rapid cooling, for the purpose of removing scale, rust, and other surface coating, is coming into ever widening use. In some cases, as with removal of material from carburized surfaces, it is undesirable to heat the metal itself any more than necessary. Therefore an acetylene flame is used, being applied to very small areas at one time and quickly withdrawn; the soil has a tendency to lose its bond to the metal and to chip and flake away.

Some encrustations have different chemical combinations on their outer and inner surfaces. These will act like bi-metals when heat is applied—either their outer surfaces will expand more than their inner ones, or vice versa, resulting in a buckling and blistering action which breaks them loose. For these a wide flame generally is applied; the wider the area of heat application, the greater the effect of surface differences in thermal coefficients and the more effective the process.

On some alloy steels the pickling process used to take hours and was not always successful. Flame alone will not descale these steels. But when the action of the flame has loosened the scale, turned it into chips and raised the chip edges so the pickling liquor can get beneath them, the pickling process is rapid and clean.

Flame cleaning was known before this war began. It received its impetus when a war-born shortage of pickling materials made resort to other cleaning methods necessary. And improved flame cleaning is one of the techniques which definitely will survive the war.

MORE STAINLESS

Will Be Used as a Result of Increased Workability

Production men in the plants of automobile, aircraft, household refrigerator, and other mass-production item makers are excited over the prospect that stainless steel may soon be far more workable in press dies than ever before.

Refusal to flow under the dies has been one of the principal handicaps of stainless. Even so, the use of this metal has grown from some 34,000 tons per year in the 1920's to about 400,000 tons per year now. Nearly three quarters of this growth was during the peace years—stainless is not a war baby.

Product engineers like stainless for its high strength and its resistance to abrasion as well as its non-corroding qualities. Stainless probably has more strength-for-weight than any other metal in common use. If the cost of fabricating it had not been so high, nobody knows how great its production might have become in pre-war years.

The exact degree to which flow-ability has been added is a military secret. Engineers talk more about the degree to which this quality is expected than about actual accomplishments; the necessary steel-making knowledge still is in the laboratory stage. Final results probably will need more power in the presses than the pre-war ones had; greater strength in the dies. But the war has taught production men how to get these things.

WORN GAGE BLOCKS

Can be Salvaged To Advantage

In time, gage blocks become worn so that two or more surfaces are no longer accurate to the millionth-inch limits to which these blocks are made. Worn surfaces may be roughened, concave, convex, or out of parallel with each other.

Such blocks may be lapped so that they are true again, but then will be off size. With blocks as inexpensive as they are today, it generally is preferable to buy new ones to replace worn ones.

The worn blocks have many uses, however. In one shop, holes are drilled through them and they are used for testing depth gages. In another, the worn block surfaces are ground to contours which are used for checking accuracy of pieces which are to be form ground; such blocks then are excellent for checking the settings and the wear of dial gages which are to follow such contours either when mounted on the grinding and lapping machines or in the inspection department. But most often the worn blocks are refinished to the exact setting of a gage which must be correct within .00001 or even only .0001 inch, and are assigned permanently to that gage.

INDUSTRIOUS JEEPS

Are Already Doing Jobs in Industry

The jeep, which performs more than 50 separate tasks on the battlefield, is finding its place in industry. Emergency transportation in the mile-long war plants is one of them. The jeep takes engineers, emergency maintenance crews, badly wanted supplies, and winds its way in and out of production lines, getting almost anywhere at higher speeds than are practical for most vehicles.

Ability to get through mud too can be useful to industrial operations, and the jeep can go where even a horse will bog down. When a pipe line must be followed across the fields to where a leak is to be repaired, or a high-tension power transmission line is down and must be restored to service, the jeep can make hours of difference in getting the men and tools there and getting the job done.

Very few jeeps are available to industry right now—the armed forces want all they can get. Only the most important war plants are allowed to have any. But engineers looking ahead see many post-war uses for this car in big factories, in lumber camps, and for mining operations.

FELT FOR INSULATION

Is Dampening Vibration in Industrial Tools

Wool felt, perhaps the oldest form of textile known to man, is rapidly becoming one of the newest of industrial materials.

Reason for the rapid development of new uses was the plentitude of this material. While other materials were held back because of shortage of supply, wool felt was tried as an emergency substitute for one purpose after another. Felt was mixed with synthetic fibers, processed by new methods, given all sorts of impregnations.

To the old industrial uses as a lubricant-sealing material for bearings and as a temperature insulator, employment as a vibration absorber was added. This proved important. Felt is now used as the basis of super-fine polishing wheels and even grinding wheels; it will absorb the shock of applying the wheel to the work and will dampen the billions of tiny shocks which occur when grits cut into steel.

Electronic Aviation

Military Developments Hold Definite Promise for Peace-Time Applications in Both Commercial and Private Flight. Radar Principles can Give Birth to Systems that Will Warn of Possible Collisions, Provide Block-Signal Control, and in Other Ways Promote Safety in the Air

By VIN ZELUFF
Assistant Editor, *Electronics*

MILITARY communiques, stories, and rumors covering accomplishments of electronic equipment on military bombers, fighters, and transport aircraft have naturally initiated serious thinking about peace-time possibilities of these electronic developments. Most post-war thinking recently has been directed toward commercial utilization of radio directing and ranging equipment, but easing of secrecy restrictions on electronic autopilots and engine controls now permits discussion of these topics too.

Autopilots in general have been used for more than ten years on commercial airliners, particularly on runs between New York and Chicago. The modern electronic autopilot, however, is a military development with extensive peace-time possibilities. Designed primarily for precision bombing, it holds bombers on an exact course determined by the bombardier. During the 15 or 20 seconds of the bombing run, the mechanism provides the stable platform which is essential if bombs are to be dropped accurately from high altitudes. During these few seconds, the plane must not deviate from its set course by a single degree. At 25,000 feet an error of one mil means that the bomb will miss the target by 360 feet.

The electronic autopilot system, as developed by Minneapolis-Honeywell Regulator Company, is built around a gyroscope with its case fixed to the plane and the spinning rotor free to move in all directions. When the plane dives, climbs, or banks, it moves the gyroscope case with it, but the rotor remains fixed with relation to the ground. This movement about the rotor is translated by electrical means into control of the operation of the plane's rudder, elevators, and ailerons, to return the plane to straight and level flight.

AUTOMATIC EYES—In this respect, the autopilot works automatically in much the same manner as a human pilot in maintaining straight and level flight. The gyroscope of the autopilot system

Spinning gyroscope unit of an electronic automatic pilot being tested on a tilt table at a plant of Minneapolis-Honeywell Regulator Company

operates as do the eyes of the human pilot to detect flight deviations and to signal the vacuum-tube amplifier in the electronic "brain" of the autopilot.

This amplifier, in turn, controls the operation of the servo units that manipulate the controls of the plane, just as the brain of the human pilot commands his muscles to correct flight deviations. In the case of the human pilot, his susceptibility to fatigue, his "reaction time," and his inability to detect slight variations the instant they occur, as well as errors in judgement and muscle coordination, limit the degree of precision of which he is capable.

The autopilot suffers none of these human failings. It detects flight deviations the instant they occur and instantaneously operates the proper plane controls to correct the deviations. Such automatic correction neither over-controls nor under-controls the plane, but keeps it flying straight and level with all three control surfaces operating in full coordination.

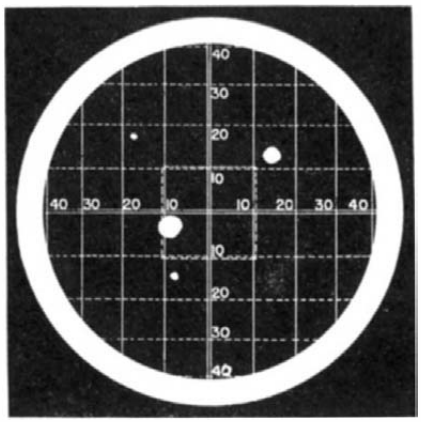
Another of the promising electronic devices now installed on multi-engine bombers and transport planes is the turbo-supercharger, a turbine-driven air compressor. This is used to boost the air pressure at the carburetor inlet to secure greater power output and better performance of aircraft engines at high altitudes.

In operation, air at atmospheric pressure is brought into the supercharger air intake and its pressure is increased by an impeller or turbo-compressor that is driven at high speed by engine exhaust gases directed on a turbine wheel. The air passes from the turbo to the intake of the carburetor, after losing some of its heat of compression to an intercooler. The higher up the plane is, the thinner is the air and the faster must the turbo-supercharger operate to maintain constant air pressure at the carburetor inlet as required for constant power.

PILOTS CAN CONCENTRATE—Since there are many variables that enter into the operation of the supercharger, an electronic control is used to adjust turbo-supercharger speed automatically whenever the plane changes altitude. This allows the pilot to concentrate on essential flying controls, whereas formerly he had to readjust engine controls continuously during changes in altitude. This electronic control is actuated principally by a pressure-sensitive element on the intake manifold and a governor on the turbo-supercharger. The control also limits manifold pressures and turbo speed to safe values, and anticipates pressure increases from turbo acceleration to prevent over-shooting of manifold pressures.

In response to signals from the control units on the engine assembly, the electronic amplifier furnishes power to a reversible motor geared to the waste gate in the exhaust manifold. This gate changes turbo-supercharger speed by allowing more or less exhaust gas to escape without going through the turbo.

Although there is a widespread opinion that radar devices will greatly



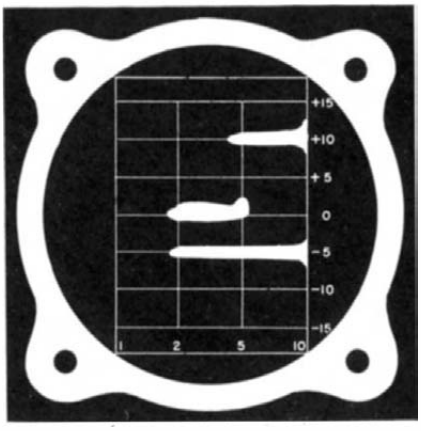
Indicator proposed by CAA for showing horizontal separation between planes in flight. Dots show relative positions of near-by planes; dot size roughly indicates their distance

change the aviation picture in the immediate post-war period, the peace-time applications of this highly secret system will be based on an entirely different situation. For military use, radar equipment detects the presence of objects which will not "co-operate," and this requires complicated and expensive apparatus. Peace-time aircraft, on the other hand, will "reveal" their presence to radar apparatus, so a different technique involving less expensive and less complex apparatus will be used.

Scheduled commercial air service must operate regularly and this means flying in practically all conditions of weather. To permit this, several electronic devices for installation in aircraft and airports have been suggested by Glen A. Gilbert, Chief of the Air Traffic Control Division of the Civil Aeronautics Authority, who recently stated that plans of the CAA for post-war air control are now ready and can result in a four-time increase in capacity of the present traffic control system.

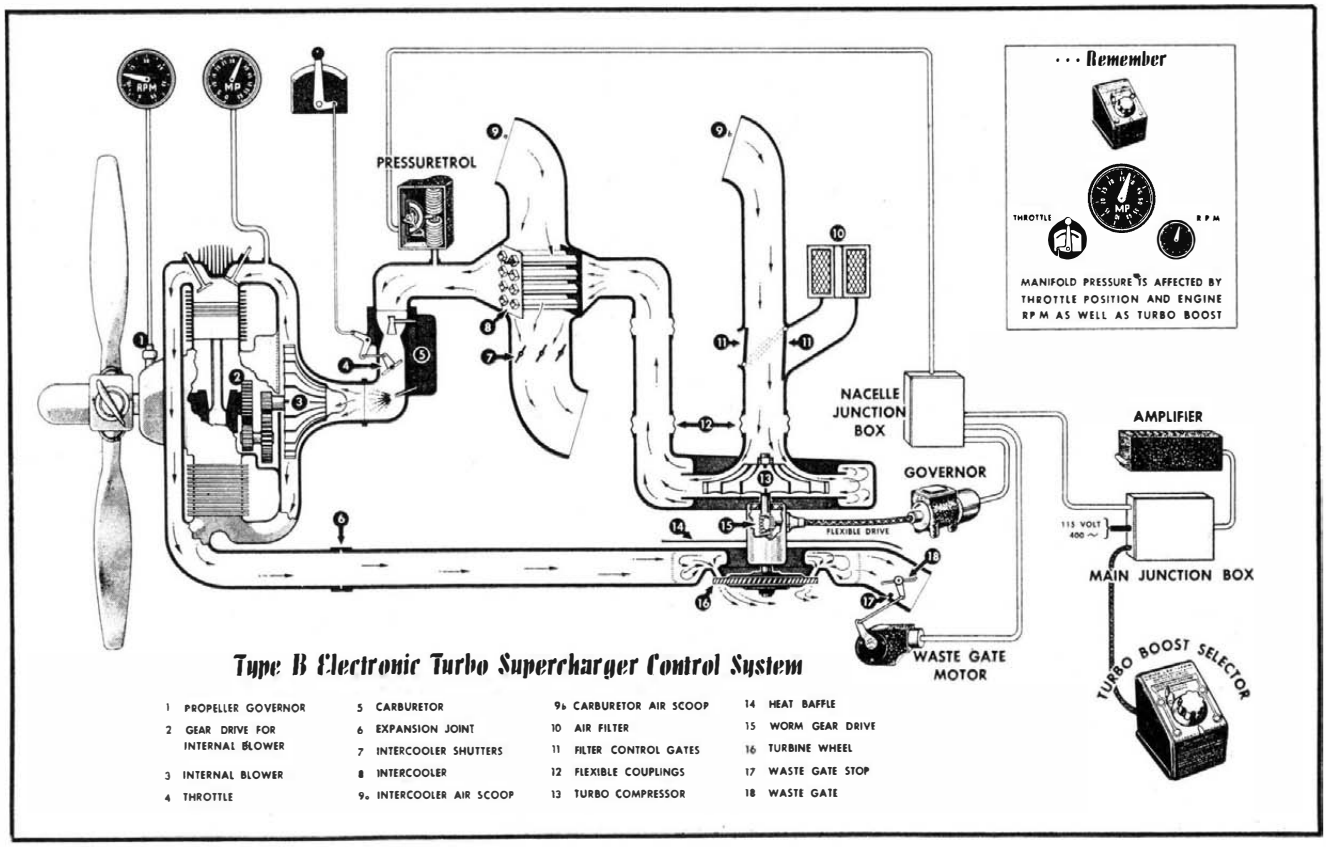
One of the devices that will result from peace-time application of electronic war equipment is a collision warning device which will indicate the relative positions of other planes in the vicinity. Thus, each pilot flying in instrument-weather conditions will be able to avoid collision with other aircraft by observing the screen of a cathode-ray tube on which the location of other planes in respect to his own will be shown. Development by the CAA of this electronic indicator, called a vertical separation indicator, was halted by the outbreak of war.

At the present time, aircraft report to control towers on landing fields enroute so that their path may be checked at fields along the route. This communication is carried on at present by means of voice signals over the radiotelephone equipment and forms a major limitation of the present air-traffic control system. The development of an automatic aircraft position reporter would materially reduce this limitation. Such a device would permit an aircraft to actuate a reporting mechanism as it passes each "fix" along the airways, in the manner that a train trips signals as it passes predetermined points along its route. The system would make use of a vertical pattern transmitter at each fix and a receiver in each plane to indicate the entry of the plane into the pattern. At the same time, a radio transmitter in the plane would be controlled by the fix-pattern receiver and a receiver at the fix point on the ground would receive the automatic report signals and relay them to an airway traffic control center.

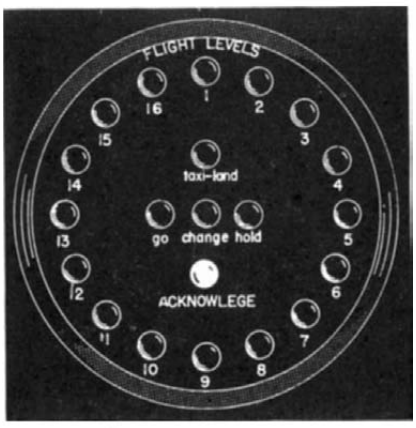


With a vertical separation indicator a pilot would be able to determine the vertical distance between his own plane (on the zero line) and planes above and below, even when flying in clouds or at night. Length of forms corresponding to other planes would be proportional to horizontal distances

VOICE SIGNALS ELIMINATED—Automatic posting equipment at the control center would be fed the position reports and would post them on a large panel, in much the same manner that stock quotations are posted on electrical posting boards. Such automatic posting of positions of planes and automatic transmission of traffic-control instructions from the ground would eliminate voice signals in the control of air traffic.



Complete electronic control system for a turbo-supercharged aircraft engine. See text.



The traffic clearance indicator envisioned by CAA technicians might take this form, with lights to indicate flight levels and central indicators to authorize movement of the plane aloft or on the ground

Reception of automatic control instructions in each plane can be accomplished by a traffic clearance indicator. This would consist of a dial containing a series of small lamps, one for each flight level. After clearance for a specified flight level has been received, the lamp for that level remains lit. Reception of clearance to another altitude would cause another lamp, designating another altitude, to flash and attract the pilot's attention to the fact that new orders had been received. He would then press a button, automatically transmitting a signal to acknowledge receipt of the clearance order and his plane identification. These signals would register on the control board on the ground, which would automatically register any disagreement if an error should occur.

Other indicator lamps on the pilot's panel would indicate special instructions when the plane is on the ground and would direct taxiing and take-offs. Eventually, the traffic clearance indicator and the automatic aircraft position reporter may be combined into an automatic system similar to the block signal system used by railroads in this country. Such a system would contain marker stations that would transmit a signal that would act as a screen across each airway. These transmitters would be located at block-signal fixes perhaps 10 to 15 miles apart. Each plane proceeding along the airway would set up a "hold" signal for following planes on the same level. This hold signal would not be cancelled until the first plane had moved into the next block on the route or climbed or descended into another level. This would prevent two planes from being in the same block at one time on the same altitude level.

A constant picture of the actual position of planes within several miles of an airport can be made available to the ground control operators by means of electronic scanning screens. Each plane would be represented by a moving spot of light on a fluorescent screen. As the plane changed position, the spot would move to correspond and indicate the aircraft's horizontal position. A second screen would show the vertical relationship of the aircraft to one another.

In the predicted 500,000 aircraft flying in 1950 will be many other new and old electronic applications ranging from radio communication systems, radio direction finders, and crew intercommunicators to electronic de-icing equipment, electronic gas gages for remote fuel tanks, electronic altimeters, and a variety of electronic controls, both for passenger comfort and flying requirements. The amount of electronic equipment per ship will naturally vary with the size and purpose of the ship, with commercial and military craft carrying far more vacuum-tube equipment than family flivvers. CAA predictions of 10,000,000 passenger miles of scheduled passenger traffic and 600,000,000 tons of freight, express, and mail moved by air in 1950 point clearly to a promising future for individuals and manufacturers alike in electronic aviation.

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GYRO BALANCER

Uses Piezo-Electric Potentials and Cathode-Ray Tube

AN ELECTRONIC instrument, developed by Sonntag Scientific Corporation, for balancing gyro rotors, differs from conventional balancing machines in that it directly measures the alternating bearing forces exerted by the unbalance of the rotor, rather than tangible displacement of balancing parts.

The rotor to be balanced is mounted on rigid bearing supports and the entire assembly is seismically suspended on springs to eliminate the disturbing influence of floor vibrations. Alternating unbalance forces are transmitted by a practically rigid platform to quartz crystals, producing piezo-electric potentials which are magnified by vacuum-tube amplifiers and made visible on the screen of a cathode-ray oscilloscope.

The magnitude of the unbalance is indicated as a sine wave pattern, representing magnitude and location of unbalance. The cathode-ray screen is graduated horizontally into 360 degrees for reading the location of unbalance, and vertically into units representing the amount of unbalance.

ELECTRONIC HEATING

Demonstrates Multiple Industrial Uses

INFESTATION in grain is frequently troublesome. By application of electronic heating, wheat can be raised to a temperature of 135 degrees, Fahrenheit, to effectively destroy bacteria without harming the wheat. Insects can also be killed by this method, even though the infected products may already be in packages. The use of electronic heating for killing bacteria in fruit and vegetables canned in glass jars shows considerable promise.

Curing rubber and cooking and dehydration of dry goods are other applications which appear to be promising for electronic heating. Coffee has been roasted by this process but there are indications that the inside of the bean is heated more than the surface, with a resulting change in flavor. Feed corn has been heated, and table salt (if not too moist) has been heated and dried. Paper cartons, rayon fiber, and shredded vegetables have also been dried satisfactorily by electronic means. In foundries, sand cores for molding have also been dried by dielectric heating.

RADIO RANGE ALARM

Provides Automatic Safety For Airplanes

A NEW automatic radio-range monitor for use at airports provides instant warning if any radio course shifts as little as 3 degrees from its normal setting or fades below its normal strength, and also provides a check on the operation of airway fan markers located near the airport.

Four receivers are required for the radio-range monitor, one on each of the four radio courses of the standard CAA four-course radio range. So long as the radio course does not shift, the monitor receiver continuously picks up the interlocking "A" and "N" signals transmitted by the range station. If the course shifts, either the "A" or the "N" signals begins to predominate. When this happens, the monitor receiver automatically transmits an electrical impulse to the monitor board at the airport, which flashes a red light and sounds a siren to warn the ground crew; at the same time, the monitor automatically dials the range transmitter, which begins to send out to all pilots a warning signal at the end of each cycle.

The fan-marker monitor receiver is located near the marker, and is connected through a telephone line with a monitor board in the airport control room. If the marker radiation strength, or its percentage of modulation, drops below a certain level, or if the marker identification signal keying becomes faulty, the red light flashes and the siren sounds.

SPLIT-SECOND TIMER

Utilizes Accurate Capacitor Charging

IN AN electronic timer developed recently by Paul B. Weisz of the Franklin Institute, a capacitor is charged for the exact duration of the time interval to be measured. The capacitor voltage resulting from this charge is then measured with a vacuum-tube voltmeter calibrated to read from 0 to 140 microseconds with an accuracy of better than two millionths of a second. Uses of the timer include determining projectile velocities by measuring the interval between passage of the shell through two spaced pick-up coils mounted beyond the barrel of the gun, measuring propagation velocities and reaction rates, and measuring time lags of relays.

Explosives - - Inside and Out

Some of the Chemical "Whys" of Black Powder, Nitroglycerine, Guncotton, Smokeless Powder, Toluene, Picric Acid, TNT, Ammonium Nitrate, Amatol, and the New Penthrite which is no Longer Hush-Hush. The Basic Chemistry of All these Explosives is Relatively Simple

By SIDNEY J. FRENCH
Professor of Chemistry, Colgate University

IN THE motion picture, "Destination Tokyo," occurs a breath-holding sequence. Slim crawls through a small opening in the broken superstructure of the submarine *Copperfin*, to remove, with realistic fear, the fuse from an unexploded, well planted Jap bomb. Once the fuse has been removed no one pays further attention to the bomb. For all the audience knows, that bomb remains embedded in the submarine's superstructure for the duration. Even though the *Copperfin* is depth-charged all over Tokyo Bay—and there is plenty of concern aboard—no one aboard seems concerned about the bomb, or

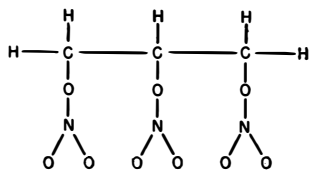


Figure 1

for that matter, about the glistening assortment of potent TNT-bearing torpedoes making up the *Copperfin's* own deadly cargo.

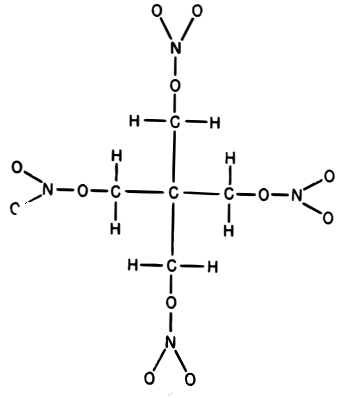
Neither the bomb nor the torpedoes will explode. Jar them, shake them, drill them, drop them, saw them—nothing happens. Even hammer them (lightly) or shoot through them with a rifle bullet and nothing may happen.

How can an explosive be so violent and at the same time so lethargic? Yet there are explosives which will actually blow up at the drop of a hat, or the tickle of a feather.

Explosives are, in fact, like people. Some lose their cork at the first sign of irritations; others will take a lot of punishment before they let go—but when they do, look out! Lazy explosives blow hard. And just as it takes many sorts of people to make a world, so, too, it takes many sorts of chemical elements to make an explosive.

Most important, and basic to nearly all explosives, is the very anti-social element nitrogen. Though it makes up four fifths of the air we breathe, it is merely an inactive partner in the loose firm of oxygen and nitrogen; oxygen does the work, nitrogen looks on. Two tiny invisible nitrogen atoms grasp hands thus ⓃⓃ to form a self-satisfied, lazy, and anti-social molecule of nitrogen gas. The chemist writes it N_2. It took science a round century to learn how to break the deathlike handclasp between two nitrogen atoms and to force the unhappy divided nitrogen twins into "shotgun" marriages with atoms of other elements. And, like most shotgun marriages, these result in an unhappy—if not unholy—state of affairs. Nitrogen atoms will go to violent extremes to break the unnatural wedlock and return to the close comforting embrace of its twin.

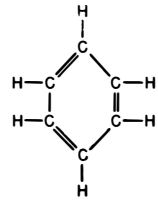
Take the case of nitrogen tricked into marriage with the element iodine by the chicanery of the chemist. The union is so repulsive to both elements that it remains intact only so long as the fellow with the shotgun remains close by. This fellow is water. Let the water evaporate and the dry, unstable compound of nitrogen and iodine (the chemist calls it nitrogen triiodide and gives it the label, NI_3) is all ready to demolish itself and everything else in the neighborhood. Now drop your hat, or tickle it with a feather, or just sit patiently by while a curious fly investigates. A loud noise and purplish



PENTHRITE
Figure 2

vapors of free iodine result. Or perhaps the slight jar of a distant footfall, an opening door, or a loud voice will be sufficient to dissolve the marriage. Obviously, such a supersensitive explosion could have little military value.

On the other hand, nitrogen can be



BENZENE
Figure 3

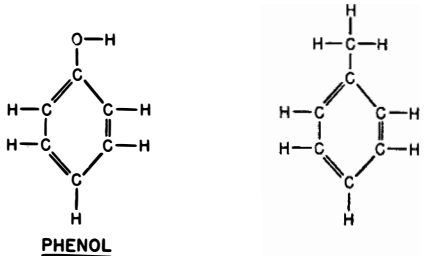
forced into marriage with oxygen by chemical trickery and the marriage is reasonably successful. If there is no happiness, there is at least no great repugnance. It will take a lot more than a dropped hat, a tickling feather, or a curious fly to break up this union. Here comes the next chemical trick. The marriage which chemistry made, it must now break—by trickery. Oxygen is the most gregarious element known. If nothing better offers, an atom of oxygen will twin up, as does nitrogen, with a fellow oxygen atom. But the embrace is light and airy, not the clasp of death. When some other fair charmer strolls around, the light embrace is quickly broken; the oxygen atoms vigorously grab new partners. Preferred as partners are atoms of hydrogen (H), sulfur (S), and carbon (C), or perchance the atoms of an active metal such as magnesium (Mg) or aluminum (Al). With each of these, oxygen has a *burning* desire to unite and with each it is willing to remain till death. The trick is simple; the marriage between oxygen and nitrogen is broken by presenting to oxygen one or more of these fair charmers—sirens capable of breaking so light a marital tie with dispatch and commotion. Nitrogen becomes free again while oxygen gains its burning desire.

Black gunpowder is a pulverized

mixture of sulfur, charcoal (carbon), and saltpeter. The chemist knows saltpeter as potassium nitrate and writes the formula for it, KNO_3, the K standing for potassium (Latin, *kalium*). Here we have all of the necessary ingredients for a marital mix-up. Nitrogen is wedded to oxygen; oxygen is quite ready to desert this tie for a happier one. The sirens, carbon and sulfur, are present to disturb the peace. A lighted match or a spark sets these unhappy atoms into action. Nitrogen breaks loose; oxygen atoms, delighted, quickly wed themselves to sulfur or carbon atoms, producing the pungent fumes of sulfur dioxide gas (SO_2) and the odorless carbon dioxide gas (CO_2). Enough oxygen is left to satisfy the needs of potassium. And all the complicated exchanges are accomplished in the twinkling of an eye to the great pleasure of those concerned.

If this were all that happened there might not even be an explosion. A handful of solid black powder produces some ten gallons of the mixture of nitrogen, sulfur dioxide, and carbon dioxide *gas*. Here is the other great secret of an explosion—the conversion of a small amount of solid or liquid into a large amount of gas—sudden expansion sufficient to shatter buildings or push massive projectiles from a 16-inch gun a distance of 30 miles.

And herein, too, lies an important difference in explosives. Some let go with shattering suddenness; these are the bursting charges or high explosives such as TNT, tetryl, picric acid, dynamite, nitroglycerin. Others let go more



PHENOL or CARBOLIC ACID

TOLUENE

Figure 4

gradually and thus push instead of shatter; these are the propellants such as black powder and smokeless powder.

Black powder was used by the early Chinese. It was mentioned by Roger Bacon in 1270 A.D. It was first used in wooden cannons in the battle of Crécy in 1346, and up to less than a century ago it was the only military explosive used. Then came a new idea. Why *mix* the several ingredients together? Why not have atoms of all of the necessary elements tied loosely together in one unhappy, unstable molecule. In 1847, chemist Sobrero found that when he treated glycerin with nitric acid he got just such a molecule. It was the very potent and explosive nitroglycerin.

Figure 1 is the chemist's picture (structural formula) of a nitroglycerin molecule. It takes but one glance to see the unhappy state of affairs in this family molecule. Oxygen is linked to nitrogen; it would much prefer carbon or hydrogen. Hydrogen is linked to carbon; it would much prefer oxygen; so would carbon.

Highy sensitive, but not supersensitive, liquid nitroglycerin can be caused to explode even by the sudden clanging of cymbals, yet it can be wheeled safely in rubber-tired carts, ladled, and poured. And when it does explode there is no hesitation; the re-shuffling of atoms takes place far faster than a flash of lightning—to produce the gases, carbon dioxide, steam (H_2O), and nitrogen. Truly, here is a *high* explosive.

To tame this very sensitive substance, Alfred Nobel had the happy thought of soaking it up in sawdust and earth and thereby invented useful dynamite which still packed the wallop of nitroglycerin but was safe to handle.

While Sobrero was experimenting with nitric acid and glycerin, chemist Schöenbein was doing similar tricks with nitric acid and cellulose. Cellulose, the principal stuff of cotton and wood, has a molecule something like that of glycerin but twice as long and with six instead of three carbon atoms linked arm to arm. From these experiments (after a number of unpremeditated explosions costing lives and factories) came nitrocellulose or guncotton. Less sensitive than nitroglycerin, it is still too sensitive for comfort—and highly inflammable. Luckily it was later discovered that moist guncotton is not only safe but can be exploded if primed with a little dry guncotton.

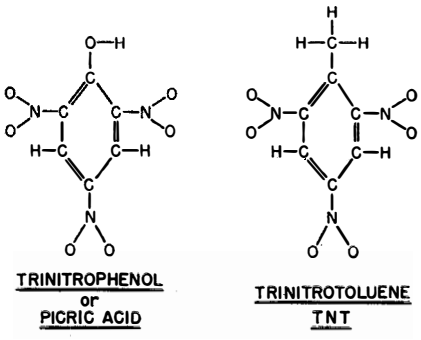
Here were two new high explosives of great value—but what was really needed was a new powerful propellant to take the place of black gunpowder. Both nitroglycerin and nitrocellulose exploded too suddenly (the scientist would say they were too brissant). The job was to slow down the explosion. In 1886, Vieille treated nitrocellulose with a mixture of alcohol (no wonder there is little beverage alcohol today) and ether. The result was a tough, horny substance much like the collodion or Nu-Skin of the drug store. It was more than that, however; it was a slow burning explosive which left no smoke. In short, it was smokeless powder. Soon, Nobel had done similar tricks with mixtures of nitroglycerin and nitrocellulose. King for five centuries, black gunpowder was forced to abdicate in favor of this new king of propellants—made from high explosives. In effect, the unhappy high explosive molecules had been dropped in cold molasses where their boundless energies became both bounded and slowed down.

There are many other important high explosives with molecules similar to those of nitroglycerin and nitrocellulose. Even the manna of the Bible can be nitrated to yield an important high explosive, nitromannite—so sensitive that it is used as a substitute for fulminate of mercury in detonator caps.

Then, there is penthrite. The chemist calls it pentaerythritol tetranitrate and pictures it as in Figure 2. Its name stems from its five linked carbon atoms. Like its relatives it is highly sensitive—a quick change artist and a top-notch explosive for demolition jobs.

For many months before and immediately following Pearl Harbor, penthrite was on the hush-hush list. It was to be mentioned only in the right places at the right time. It carried—and still carries—a mysterious symbol. Penthrite is no longer a secret; our enemies know all about it—know what damage it can inflict, how and where it is used.

There is one thing they do not know—we hope. They do not know how to make it quickly, economically, and safely. We do, thanks to the interchange



TRINITROPHENOL or PICRIC ACID

TRINITROTOLUENE TNT

Figure 5

of information between the allies—and thanks to the Canadian, Dr. James H. Ross, who was largely instrumental in developing the methods.

It seems evident that these explosives, involving, as they do, carbon atoms strung together in chains and festooned with hydrogen, oxygen, and nitrogen atoms, are all sensitive, fast, high steppers. Only by a molasses-like process can they be slowed down. Then, they become useless as high explosives. Where do we turn to find that ideal high explosive, the one that can be roughly but safely handled and yet explode with the best of them when properly induced?

We turn to another family of carbon festooned molecules. The chemist calls members of this family the aromatics because of the many pleasant odors among them. Instead of a festooned *string* of atoms, we have a circle of atoms, usually six carbon atoms to a circle or hexagon (Figure 3). This is the famous benzene hexagon—the molecule of benzene as the chemist pictures it.

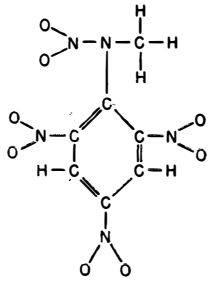
First cousins of the benzene molecule are phenol or carbolic acid and toluene (Figure 4). Now, by means of a simple chemical trick involving treatment with nitric and sulfuric acids, these basic non-explosive molecules are converted to high explosives which the chemist pictures as in Figure 5. Here are two famous explosives. Picric acid was a favorite in World War I when toluene was scarce. TNT has been the favorite high explosive for more than 40 years.

Both of these explosives are as nearly foolproof as an explosive can be and still explode. Picric acid does have the bad habit, however, of attacking metals and forming with them dangerously explosive compounds. Hence, shell or bomb cases must be lined with paint or varnish. A huge ammunition dump of picric acid has been known to burn to the ground without an explosion. TNT can be sawed, drilled, or dropped

from considerable heights without exploding. It is quite insensitive to blows but can be exploded against a metal surface by the severe impact of metal. A rifle bullet is likely to have little effect unless the explosive is in a metal container; in small amounts it burns without exploding.

Why are these explosives so slow to anger while nitroglycerin and guncotton are so irritable? It is all in the molecule. Note, for example, that the nitrogen atoms are attached directly to carbon atoms with no intervening oxygen atom. Note, too, that the circle holds the carbon atoms in place, as it were; while in a chain the atoms are free to twist about. Then, too, each carbon atom extends double arms to one partner, making the task of breaking the ring more difficult. Taken all in all, these ring explosives are a far happier family than the chain explosives. It is no wonder that they are the more popular with those who must handle explosives.

If these molecules are so slow to anger, how is it possible to make them explode at all? Here comes in another simple trick. One small match can serve to start a great conflagration if the materials are properly arranged: Paper, shavings, light sticks, large sticks, logs, in that order. One small match applied directly to the log is wholly ineffective. To ensure the explosion of TNT it is necessary to use a bit of booster which is nothing more nor less than a sensitive high explosive. Tetryl (Figure 6) is the favorite booster for TNT. In this unhappy molecule one nitrogen atom is linked by one hand to another nitrogen atom—a tantalizing state of affairs. It can hardly wait to entwine its twin with the other two arms. When this starts, the rest of the unhappy molecule is also torn asunder and re-assembled into happier units. Thus, sensitive tetryl serves to stimulate insensitive TNT to let go.



TETRYL

Figure 6

But even tetryl must have more than a tickle to set it off. A mixture of highly sensitive fulminate of mercury and potassium chlorate is included in the bomb cap along with the tetryl. A firing pin sets off the fulminate which explodes the tetryl which in turn explodes the TNT. Thus, a few grains of fulminate of mercury initiate an explosion capable of demolishing massive buildings.

Even detonators or primers such as fulminate of mercury and lead azide depend on the anti-social nature of nitrogen for their sudden and violent reactions. The chemist pictures these detonators in Figure 7. (Hg stands for mercury and Pb for lead.) In the fulminate, mercury has little love for plebian, gregarious oxygen (for mercury is a noble metal) and is quite willing to sever the degrading tie. Nitrogen, of course, is always willing. Carbon and oxygen are ever ready to get nitrogen out of the way and embrace each other. In lead azide note the tantalizing situation of the nitrogen atoms, almost—but not quite—free to go into triple-armed embraces. No wonder lead azide is a fast-stepping detonator.

Most surprising, perhaps, of all explosives is a staid old friend. Every college freshman who takes chemistry has been introduced to ammonium nitrate—the chemist labels it NH_4NO_3. The freshman puts some of this white, innocent-looking material in a flask, heats it gently; bubbles appear, out comes a gas. This gas is the well known dentist's aide, nitrous oxide or laughing gas (N_2O). Note what has happened—the hydrogen of the ammonium nitrate teams up with the oxygen to form two molecules of water (H_2O) leaving the two nitrogen atoms teamed up with one oxygen atom, thus:

$$NH_4NO_3 \rightarrow 2\ H_2O + N_2O$$

The freshman whiffs the gas and imagines that he feels like laughing. He might feel less of laughter and more of awe, however, had he realized that he had just been handling one of the best high explosives known to man. He need not fear, however, for ammonium nitrate is quite insensitive. Alone, it behaves as any gentlemanly chemical should—breaking up quietly into nitrous oxide and water when heated, refusing to explode even when dropped, sawed, bored, hammered, or shot full of holes.

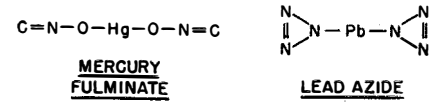
Mixed with TNT, or other high explosives, however, and strongly detonated, it loses its gentlemanly behavior and in the contagion of the moment explodes with startling violence. This time it breaks up not into nitrous oxide and water but into nitrogen gas, steam, and oxygen.

In World War I there was a great shortage of toluene, basis of TNT. It could be obtained only as a by-product in the production of coal gas. Strong measures were needed to maintain the supply of TNT. City gas mains were stripped of their small quantities of toluene. Still there was not enough. In desperation, almost, the scheme of diluting TNT with ammonium nitrate was tried. It worked. It not only worked; it even gave a superior explosive.

Used first in small amounts, the percentage of ammonium nitrate was gradually increased till instead of being merely a diluting agent it became the main ingredient of this mixed explosive.

Today there is no shortage of toluene. Chemists have learned how to make it from petroleum products. The tails of long carbon chain hydrogen festooned molecules of gasoline are twisted to make toluene rings out of the chains.

Even though there is no shortage of toluene or TNT in this war, even though we could now get on without using ammonium nitrate to dilute the TNT, there is little likelihood that we will try it—for the simple reason that for many purposes the mixture is superior to TNT alone. Each ingredient complements the other. TNT is short of oxygen; ammonium nitrate has an excess of oxygen. There is just enough extra oxygen in ammonium nitrate to tie up with the unhappy left-over carbon atoms in the TNT. The result is an explosive which is almost smokeless—and fully as powerful as TNT alone. If smoke is wanted, it is only necessary to include a smoke box. This mixture of ammonium nitrate and TNT is known as amatol (abbreviated from the names). Many other mixed explosives also contain ammonium nitrate. The only necessary condition to be observed is that there be present a sufficient quantity of a more sensitive high explosive to set off the relatively insensitive ammonium nitrate. Ammonal, containing a little charcoal and aluminum powder as well as amatol, explodes with a brilliant flash, making night observation of hits an easy matter. Dynamites often make use of the power locked up in ammonium nitrate.



MERCURY FULMINATE

LEAD AZIDE

Figure 7

Truly this innocent, useful chemical, so harmless in a peaceful environment, can become a giant among explosives when properly teamed with other more active giants. It is indeed one more example of the versatility of these important nitrogen compounds.

What happens when the firing pin of an artillery piece strikes the priming cap of a high explosive shell? Fulminate, on being thus crushed, emits a spark; combustible chemicals pick up the torch and carry it forward, enlarged, to an ignition charge of black powder. Here real conflagration begins which is passed on to the main propellant charge of even-burning, high-pressure-producing smokeless powder. The projectile can move only forward—and it does, gaining speed and power on the way.

When this projectile strikes its target a similar process is repeated. This time the firing pin, driven backward (sometimes forward), initiates a stream of fire through the detonator, through a train of black powder the length of which can be adjusted to time the instant of explosion, to the booster tetryl. All these are in the cap. Then comes the culmination of this complex series; TNT lets go with all of its destructive fury.

Explosives today have special jobs to perform. Roughly they are classed into primers, igniters, propellants, boosters, and bursting charges, but it is a rare explosive that does not have at the bottom of its structure and behavior the all-important anti-social key element, nitrogen.

High-Octane Gas

What Effect will the Wartime Advances in Technology and Plant Facilities that are Giving Remarkable Fuels to Aviation have on Post-War Uses, Air and Automotive? Will You Fly with 100-Octane Gas and, More Immediately Interesting to the Average Reader, Will You Drive With it?

THE WAR has seen tremendous advances in high-octane fuel technology and in the growth of the nation's facilities for manufacturing such "super" gasolines. It is to be expected that the greater number of the new plants will be diverted to other purposes once the war is over, but many will remain dedicated to their present uses.

The heat contained in a fuel and air mixture has an equivalent in work-possibilities, but it cannot all be converted into work after completing its task unless temperature of the burned fuel at the exhaust is reduced to the deadly cold of absolute zero. In the internal combustion engine, of course, the burned fuel has to exhaust at temperatures well above that of our ordinary atmosphere. Another factor which determines the efficiency of heat conversion into work is the highest temperature which the internal combustion engine attains during its working cycle.

There is little to be done about the temperature of the exhaust, but the highest temperature attained within the cylinder can be raised by increasing the compression ratio—the rise in pressure during the compression stroke. With a compression to 70 pounds a square inch, the efficiency of the gasoline engine is only about 20 percent; at 150 pounds it may be as high as 30 percent. There is, however, a definite limit to the compression ratio and the resulting temperatures which it is possible to use in the engine, because when these are raised to a high point there may occur pre-ignition or detonation—closely allied though not identical phenomena.

Supercooling the engine is not the method of approach, since excessive cooling means loss of power. The modern alternative is to use fuels or doped fuels which will not knock at very high compression ratios and the accompanying high temperatures.

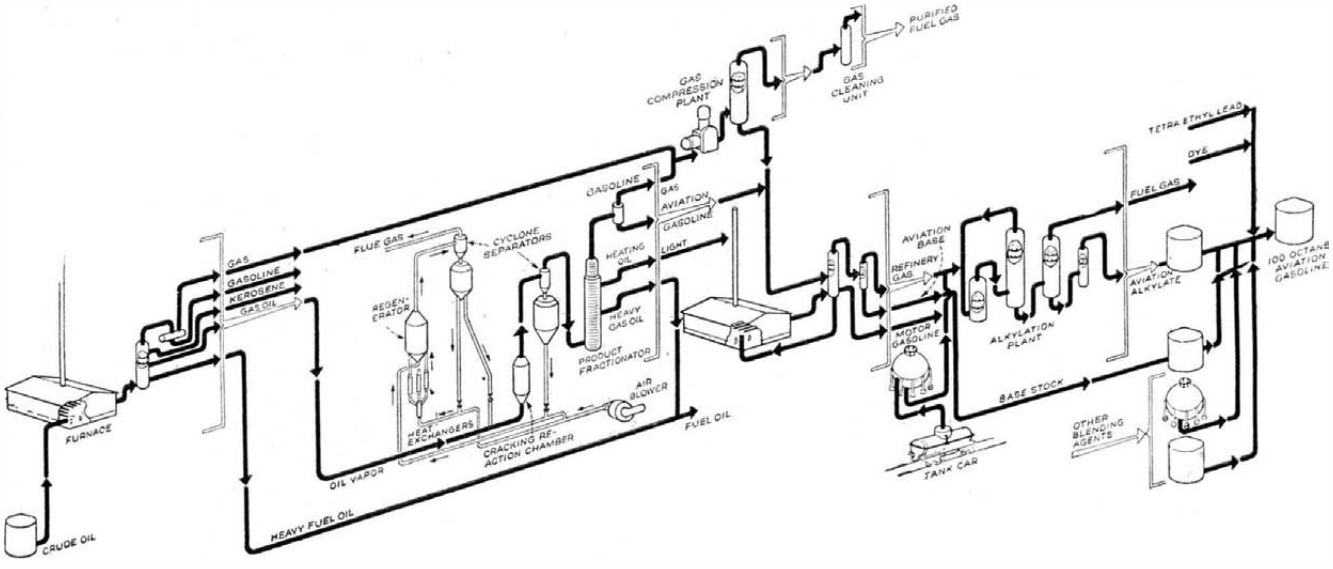
Besides inventing anti-knock fuels, chemists had to establish a measure of their qualities. Years ago they devised a method of grading by "octane numbers." It was found that a certain hydrocarbon, iso-octane, is a good anti-knock fuel, while another hydrocarbon, normal heptane, is very poor. To the former is given the knock rating of 100; to the heptane the value 0. Single cylinder knock-testing engines are employed to measure these properties. If a fuel is found to have the same anti-knock characteristics as a mixture of 70 percent iso-octane and 30 percent normal heptane, it is said to have an octane number of 70.

Just because iso-octane has a rating of 100, there has arisen the misconception that 100 is the highest rating attainable. Nothing could be farther from the truth. A fuel which has better anti-knock properties than iso-octane has a considerably higher rating.

An ordinary automobile gasoline has a rating of 70 to 75. High-test aviation gasoline can easily have a 90- to 100-octane number.

FOUR SOURCES—Aviation fuels derive principally from different series of hydrocarbons—paraffins, olefins, naphthenes, and aromatics—each with its own peculiarities and characteristics. There are innumerable ways in which the carbon and hydrogen combine, and the carbon atom can hold on to two or more atoms of hydrogen. Just the names of some of the combinations sound intriguing: methane, ethane, butane, hexane, and so on. It is on the arrangement of these atoms, straight-chain and branched-chain; on the length of the molecule; and on similar properties; that anti-knock characteristics depend.

Not so long ago the petroleum refiner had to be content with using combinations in the manner in which nature provided them, but now they are trans-



Courtesy Standard Oil Company (New Jersey)

Simplified flow diagram showing production of 100-octane gasoline from crude oil

formed and combined in the most extraordinary manner.

A process called "catalytic alkylation" is used to combine butylene and isobutane to form iso-octane and to produce combinations far superior to iso-octane. The raw materials are introduced as gases into the cracking coils of a refinery and, by cracking, by application of heat and pressure, by distillation, iso-octane and other anti-knock compounds are formed.

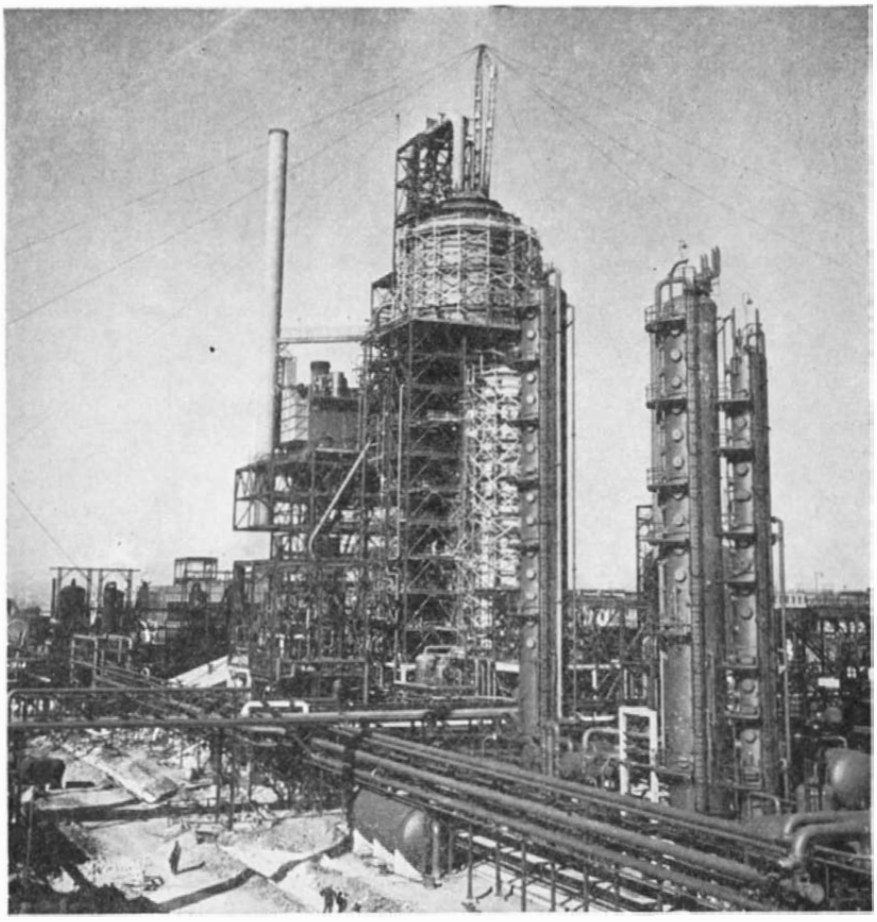
With improvement in technology there has also come decrease in costs of production, and this decrease has come very quickly. The first commercial plant to produce iso-octane by alkylation was built late in 1938, only a year before the war, but the price already has dropped from $20 to less than 15 cents a gallon. Moreover, the rate of production of high-octane gasolines has grown to stupendous proportions—how else could we keep our Flying Fortresses and Thunderbolts in the air?

TEAR DOWN, REASSEMBLE—Modern aviation gasoline is the climax of a series of separate and, in some cases, extremely complicated, chemical processes. It is no longer a question of merely distilling crude oil to "recover" its gasoline content. The modern fuels are synthetic products which result from chemically tearing apart the petroleum molecule and then reassembling it into anticipated chemical patterns. We are indebted to the Standard Oil Company (New Jersey) for the simplified flow diagram shown in one of our illustrations. The crude oil is first heated in a specially designed furnace, in which is started the first separation into the principal petroleum fractions—of which gasoline and "gas oil" are of principal importance as far as high-octane aviation gasoline is concerned.

The "gas oil" is "cracked," which is the chemist's name for a literal cracking up of the petroleum molecule under heat. The cracking occurs in the presence of a finely dispersed catalytic powder which is carried along with the vaporized gas oil during the cracking reaction. This powder controls the way in which the moecules are first cracked and then re-combined to form the desired types of chemical compounds. Following the catalytic cracking, high-grade aviation gasoline is separated for use as a base stock for super fuel. The gases produced in the catalytic cracker are compressed so as to separate highly important compounds which go to the alkylation plant.

The alkylation plant in itself constitutes a complicated chemical step. In the alkylation plant and under the influence of an entirely different type of catalyst, the specially segregated gases both from the crude and from the cracking process are combined to form the high-octane synthetic aviation alkylate. The final blend of 100-octane gasoline includes base stock, alkylate, and sometimes other special blending agents. To all this is added the requisite amount of tetraethyl lead.

The flow diagram appears simple but when the process is realized in steel and other materials it is embodied in huge criss-crossed pipes, gaunt steelwork skeletons, and massive silhouettes of tanks and towers.



The "Baltimore Giant," Standard's fluid catalytic cracker

It takes a year or more to build a new plant to make 100-octane gasoline, even in peace time. Yet in 1943 more than 72 new major plants were built, and the product output has been quadrupled, then doubled, then doubled again. The war-time expansion has been stupendous. The opinion has been voiced that after the war all this enormous plant capacity will remain to provide 100-octane gasoline for every motorist. It is more correct to say that the manufacture of high-octane gas on this stupendous scale will not continue after peak military demand has ceased and the Government ceases to be a willing customer of 100-octane regardless of cost. The facilities remaining in active operation will, however, suffice to support military and naval aviation on a higher scale of operation than pre-war, to support commercial air transport and private flying of great proportions, but will be used in the automobile on only a small scale.

What does high-octane gas do for aviation? It allows us to crowd more power into the aviation engine, to use the gasoline more efficiently, and to improve military performance beyond measure. Thus, for the same gross weight at take-off a plane using 100-octane gasoline can fly 20 percent farther than a plane which uses only 87-octane. A heavy bomber flying to an objective 1000 miles distant can carry five more 1000-pound bombs than one using 87-octane. Greater power for the same weight of engine means much to our airmen: the ability to carry better armament, more bombs, to fly from smaller fields. The American superiority in making higher powered gasoline, and in making vastly more of it, is a vital element of our superiority in the air to the Germans and Japanese.

THE REASONS—We can also define the beneficial effects in slightly more technical language: Engine power is directly proportional to the intake manifold pressure and the amount of supercharging. The higher the octane rating the higher is the permissible intake manifold pressure without danger of detonation.

Again, the greater the knock rating of the fuel used, the higher can be not only the intake manifold pressure, but also the compression ratio and the mean effective pressure in the cylinder.

It is interesting to note that aircraft engines today are no higher in compression ratio than automobile engines (with ratios varying from 6:1 to 6.7:1). If their compression pressures are very much higher, this is because they are supercharged for power. This is the reason why the aviation engine is so much more susceptible to the wiles of high-octane gasolines.

The improvement in airplane performance with 100-octane gas is startling but the skill of American technologists has gone even further, and they may, by now, have attained 130-octane and even 160. Military secrecy guards further disclosures today but

newspaper stories carry hints of wonderful things to come. Thus, Dr. Gustav Egloff, president of the American Institute of Chemists, told a conference of the National Association of Manufacturers that we now have an airplane fuel which is 50 percent superior to iso-octane and is likely to give the Allies even greater superiority in the air. The new "supergas" is called triptane (paraffinic - trimethyl - butane). While the world has known of the gas for seven years, it is only now that methods have been developed by the Universal Oil Products Company for manufacturing triptane on a commercial scale and the original price of $3000 a gallon has been reduced to less than $11 a gallon. The anti-knock properties of triptane are of such magnitude that no commercial engine has been built which is capable of utilizing its full power value.

Sun Oil also has a gas of great power —Dynafuel, 50 percent more powerful than standard 100-octane fuel. Dynafuel is never used undiluted but is blended with 100-octane gas. Other companies, no doubt, have similar developments.

In the motor car, gasoline is a vital element of cost. The average private owner does not put a figure on his own services while driving, and makes no analysis of insurance or depreciation costs. But mileage per gallon is likely to loom quite largely in his mind. In scheduled aviation the situation is quite different. Pilot's pay, depreciation, maintenance costs, and so on, are far more important than the cost of the fuel. Further decrease in the actual weight of fuel to be carried is a far more important matter than its cost. The payload of the airplane, particularly on long ranges, is likely to reach a low percentage of its gross weight, and when the payload decreases the cost per ton mile increases inordinately. Hence, in civil aviation almost as much as in military aviation, the emphasis will be on specific fuel consumption rather than on fuel cost. Anything that increases the power and fuel economy of the engine therefore is eagerly welcomed. Thus 100-octane gas at 16 cents a gallon will be chosen without hesitation in preference to 91-octane at 13 cents. We venture the prediction that air transport will take the highest number it can get.

IN YOUR CAR?—Predictions have been made regarding the use of 100-octane gasoline for the post-war motor car. We believe that these predictions are extravagant. Everything seems to indicate that the post-war motor car will not be so very different from the 1942 models. Manufacturers are much more likely to resume production on the proved models than to seek radical changes in design and delay resumption of manufacture. And the pre-war cars did not really need much better gasoline than the 75-octane variety.

There are avenues of approach to economy in the motor car other than in high compression and high-octane gas. Engine speed can be reduced, automatic transmissions can help, lighter materials can reduce ground friction and therefore the horsepower. To take full advantage of advanced gasolines we would need completely redesigned, expensive engines. Normal fuels will still be cheaper than the 100-octane gas, and post-war trends are likely to be in the direction of economy. Furthermore, our oil resources are decreasing and we shall be forced to use those methods which give us more fuel for a barrel of crude. Certainly, as a result of the war, we shall be able to buy at wayside stations fuel several octane ratings higher than pre-war. But, by and large, 85-octane is likely to be the highest knock rating which can be used effectively by automobiles in the immediate post-war period.

Mr. A. T. Colwell, Vice-President of Thompson Products, in a paper presented before the Society of Automotive Engineers, has expressed some very interesting views. "We can make the fuel, but what about the automobile engines? There is nothing to be gained in using high-octane fuel in an engine not designed for its use—that is an economic waste of octane numbers. Greatest efficiency is obtained from fuel when it is on the verge of knocking." And again: "Only a portion of our high-octane fuel capacity—about 10 percent of our total capacity—will be used by aviation after the war. The excess capacity will be available for automobiles, *if it can be utilized.*"

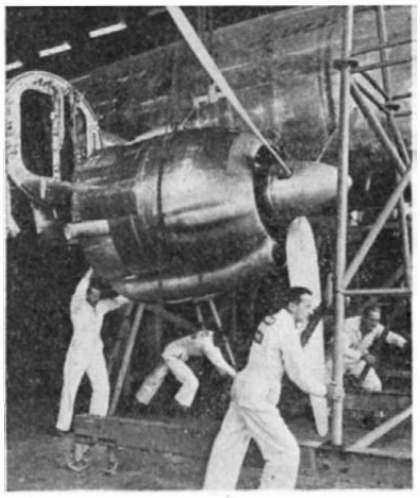
In conclusion: So far as aviation is concerned there is scarcely a limit to the octane rating of fuel which can be utilized and for which the industry will be glad to pay high prices. When, however, it comes to the post-war automobile, it is probable that the growth in use of high-octane fuels will be much slower—because the automobile engine of immediate post-war will scarcely need it, also because the trend will be to economy, and because our diminishing petroleum resources will force us to be wary of producing high gasolines with lesser yields per barrel of crude.

POWER EGGS

Changed in Quick Time on Lockheed Constellation

To reduce ground time in maintenance of a transport airplane is a vital factor in operating costs. An example of progress in this direction is the Lockheed four-engined C-69 Constellation, in which it is now possible to make a complete change of power plant in 27½ minutes. Our photograph shows one of the steps in this quick change, which has been carefully timed by Lockheed design engineers.

To achieve this remarkable interchangeability, particular attention was paid to the grouping of the lines, ducts, and connections at the fire wall, with quick disconnects of all units. Collector rings on the big Wright twin-row 2200 horsepower engines exhaust through two jet-type tail pipes that protrude through the cowling of the power-egg itself. The nacelle is fixed



Quick change of power eggs

to the airplane at the fire wall by only ten bolts, all readily accessible.

A regular sequence of disconnections is followed: Carburetor air-scoop removed; disconnections started at fire wall; hoist sling secured; engine ready to be lowered; engine swung aside and lowered; new power plant swung into place preparatory to securing structural connections; engine in place; structural, electrical, hydraulic, and cable connections being made; new power plant completely installed, ready for propeller—all in 27½ minutes.

THE LOCKHEED LIGHTNING

Is Now Faster, Carries Heavier Load

For some time many independent authorities clamored for long-range fighters to protect our bombers. The official answer was that the bombers were so well armed that they needed no fighter protection. But they did need protection, and our Flying Fortresses and Liberators could not possibly carry out the present damaging attacks on German cities and war plants without the aid of Thunderbolts and of the P-38, as the twin-engined Lockheed Lightning is called. It is quite true that we have introduced few new models to the war fronts since Pearl Harbor but, on the other hand, the models that existed before the war have been improved beyond all recognition.

Thus the P-38 is now capable of flying over Berlin from British bases and is the twelfth model of the Lightning. It is now capable of carrying two 1000-pound bombs—double that of any single-engine fighter—and packs the heaviest bomb load of any fighter-bomber. The power has been increased from 2300 to 3000 horsepower. The rate of climb has been increased 100 percent at altitudes over 30,000 feet and materially increased at all altitudes, while service ceiling is well over 40,000 feet. Single-engine speed is now over 300 miles an hour. Combat maneuverability has been improved by mechanical aids to the pilot in the form of hydraulic aileron boosters combined with the old combat flap, while new power and temperature controls facilitate the task of the pilot. Armament remains heavy.

Water Conditioning

Master Chemical of All Chemicals, Water Produces as Many Industrial Headaches as it Solves. However, Intensive Research on the Whole Water Problem is Pointing the Way Toward Treatment Methods Adaptable to Almost Any Troublesome Situation in Factory or Home

By J. D. RATCLIFF

ONE OF the earth's most amazing chemicals is ordinarily taken completely for granted. That chemical is water. It may be either hard or soft, muddy or clear, good or bad tasting. Taste gets most emphasis, yet we drink only a quart or so of water a day, whereas we use 50 to 75 gallons daily for other purposes.

Instead of being so concerned about the taste of water, we might better ask: Does it clog hot-water pipes with minerals? When mixed with soap does it produce a hard curd that seals pores and causes skin disorders? Does it leave a gritty deposit which makes hair dull and lusterless; shaving a painful daily ritual?

Answering such questions as these keeps scores of research men busy. They work steadily to solve problems posed by that amazing fluid that gushes forth every time we open the tap at the kitchen sink. Yet few of these men have ever seen absolutely pure water—rare among laboratory chemicals. *Pure as the driven snow* is a pretty phrase—but as wrong as it is pretty. Even the snow that falls on the North Pole, even the rain that drenches tropical forests, is contaminated. It contains considerable amounts of dissolved gases, dust, spores.

Because water is the universal solvent, really *pure* water is never found in nature. To some extent it dissolves everything—even solid rock, glass, or gold. As it flows through rock strata it picks up a little of everything it touches. It dissolves carbon dioxide, producing naturally carbonated water. When it dissolves natural gas in the ground, we see that amazing phenomenon of water that gives off inflammable bubbles.

This solvent action poses staggering problems for industry. As little as one part of iron in two million parts of water can wreck a textile mill by staining cloth. Traces of minerals upset the delicate chemistry of rayon making. Boiler scale, formed of the minerals left behind by hard water, is a costly hazard in power plants.

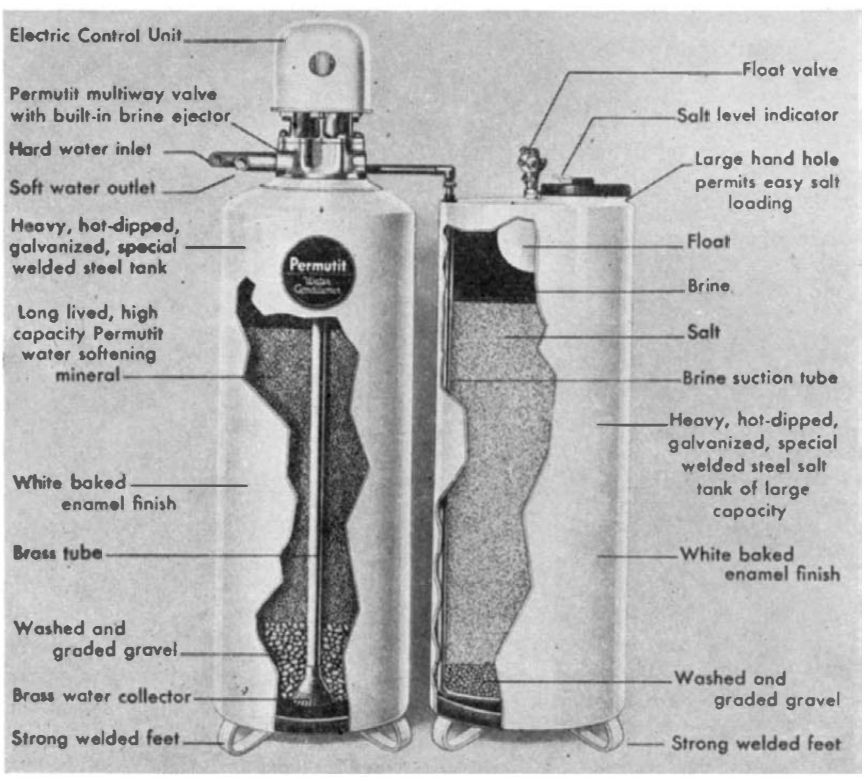
Getting rid of unwanted water components is the job of the research men. They have devised dozens of delicate chemical processes to do the work and are constantly seeking better methods. Many of them are at work in one of the most fascinating laboratories in the country—that of the Permutit Company. It is the world's largest laboratory devoted to the study of water-conditioning problems.

Water hardness poses the biggest problems encountered by industry and householders alike. Hardness is governed by the quantity of calcium and magnesium compounds dissolved in water. Less than one grain (about one seven-thousandth of a pound) of these compounds per gallon makes water objectionably hard for certain industrial uses. For general household use, though, water that does not contain more than a few grains of hardness is usually considered to be soft water.

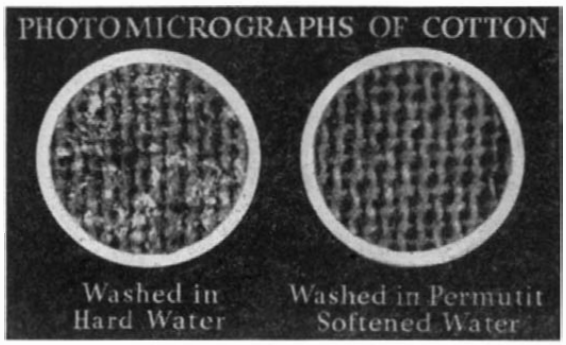
TWO THIRDS OF THE NATION—New England, the South (except Florida), and the Pacific Northwest have fairly soft waters. The rest of the United States has hard water of varying degree, the central tier of states having the worst problem. Thus, hard water is a headache to approximately two thirds of the people of the nation.

Hard water smudges glasses, dishes, and silver, leaves a rancid, sour smell in linen. Minerals from such water are deposited in hot-water pipes—often reducing the bore of a six-inch pipe to one inch in relatively short order. This scale has insulating properties virtually equal to that of fire brick. Thus, it wastes large amounts of the fuel used in boilers and water heaters. It forms in auto radiators and in engine-cooling jackets, radically reducing efficiency.

The sticky curd that results when soap is lathered in hard water is costly to large linen users: Hotels, hospitals, sleeping cars. This curd lodges in textile fibers and may cut in half the life of sheets, towels, and pillow slips. Hard



An automatic water-softener unit of the household type



When fabrics are washed in hard water, a sticky curd remains on the individual fibers despite thorough rinsing. This curd may act to reduce the service life of the fabric by as much as 50 percent. No such deposit results when soft water is used

water is also a soap eater. To get the same amount of suds, hard-water Chicago uses twice as much soap as soft-water Atlanta.

Some foods—especially beans, peas, lentils—are excellent water softeners. They take up the calcium in water, but they come out of the pot themselves hard and leathery. Some Westerners have their own measure of water hardness: If cooked beans are edible, the water they were boiled in was soft enough for all practical purposes. Any householder can get a rough estimate of water hardness by examining the bathroom tumbler. If water permitted to dry in the glass leaves a hard, chalky film, the water is hard.

Industrial water-conditioning problems pour into the laboratory. Locomotives have to be laid up frequently while scale is removed from boilers. The laboratory designs water-conditioning equipment which costs $169,000; the first year it is used it saves the railroad $300,000.

TYPICAL PROBLEMS—A filling station writes in. Local water is so hard that washed cars have a streaked, dirty look; car radiators are jammed with scale. A $200 water softener solves this one.

A hotel has a problem. Its water tastes bad and contains so much iron that linen is being ruined. An activated carbon filter is supplied which removes taste, and special softening equipment is installed to remove iron and hardness.

A commercial swimming pool finds itself confronted with huge water bills. Equipment is designed which permits re-use of the water after treatment. Pool water is pumped through filters and chlorinated so that it comes out adequately pure and make-up water is reduced to a minimum.

A beauty parlor complains that it is impossible to give good shampoos with the hard water from city taps. A small softener is installed. Incidentally, Mrs. Coolidge had a softener installed in the White House after visiting such a beauty shop. Windsor Castle has a water softener—and so has W. C. Fields!

Specially treated water is essential in scores of industries: Oil, steel, moving pictures, radio, synthetic rubber, munitions, and so on. It is desirable elsewhere: In dairies and bottling plants to insure clean bottles; in laundries where it accounts for soap savings up to 75 percent; in citrus packing plants where soft water in washers gives oranges and grapefruit a clean, bright appearance, thus commanding a higher market price.

The oldest method of water softening is achieved by adding lime and soda ash to precipitate the calcium and magnesium. A newer method depends on minerals called zeolites, available in both natural and synthetic forms. These granular substances have the seemingly miraculous property of softening water. Pass water of any hardness through a bed of zeolite and it comes out of the bottom completely soft. The zeolite takes calcium and magnesium from the water and replaces it with sodium—which doesn't contribute to water hardness. In time the zeolite becomes exhausted and has to be regenerated. This is done with common salt, which gives the zeolite fresh sodium.

The base-exchange properties of zeolites, by means of which sodium is exchanged for the calcium and magnesium of hard water merely by passing the water through the zeolite, have been known for almost a century but no practical use of them was made until the early 1900's, when granular zeolites were first manufactured and equipment was designed for using them in water softening.

Chemically, a zeolite is a compound of a basic oxide, such as soda; an amphoteric metal oxide, such as alumina or iron oxide; silica; and water. There are a number of amphoteric metals—metals that can form either acids or bases—but the two most commonly used are iron and aluminum. By combining these materials in a rather lengthy process, synthetic zeolites can be produced which have distinctive properties for special purposes. Natural zeolite, which also requires processing before it can satisfactorily be used in water-softening equipment, is commonly called "greensand," and is a mineral that was originally formed under prehistoric seas. Today it is being mined by the open-pit method from deposits now on dry land.

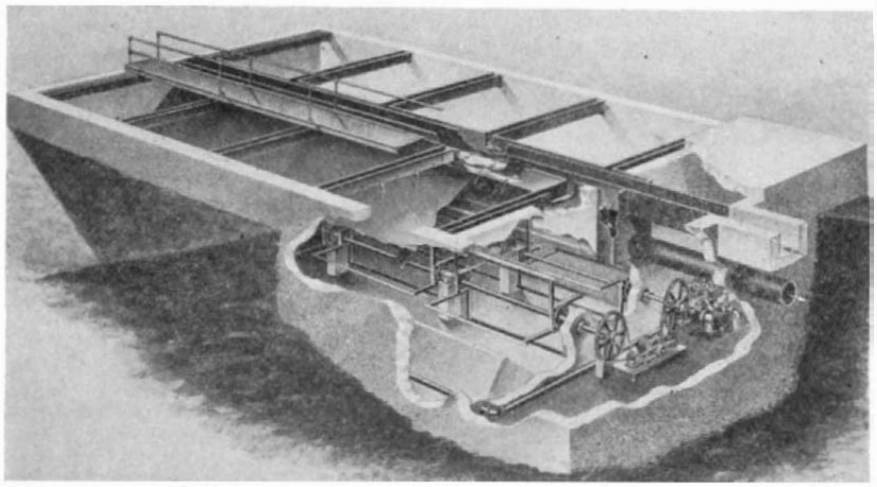
Automatic home water softeners using zeolite cost about $250 and will probably cost as little as $150 after the war, if present plans for mass-production materialize. Even less expensive equipment is available for the same purpose if the user does not mind the minor inconvenience of occasionally operating the regeneration controls by hand.

These home water softener units have much the appearance of two kitchen hot-water boilers sawed off to a height of about five feet. One tank contains the zeolite, the other the salt for regenerating the softening chemical. About once a week—depending upon the amount of water that has passed through the zeolite—it is only necessary to flip a switch on the automatic unit. This sets in motion the mechanism which backwashes the zeolite bed, regenerates it with a salt solution, and thoroughly rinses it. Accumulated hardness is washed down the drain. With manually controlled units, the same action is obtained through manipulating a couple of valves.

Because of the staggering waste caused by hard water it seems likely that water softeners will be included in all post-war homes built in the hard-water belt. One conservative estimate indicates that hard water costs the average family $117 a year—in wasted soap, unnecessary plumbing bills, shortened life of linens, ruined foods.

About 500 municipalities now soften city water supplies. Sarasota, Florida, for example, softens water from 65 grains down to 5. Sea water is used instead of salt to regenerate the zeolite softeners.

SOAP SAVINGS—After such municipal systems are installed, soap sales nose dive, sometimes as much as 70 percent! Madison, Wisconsin, estimates that it saves its citizens $250,000 a year in soap alone—in addition to such other



Cut-away section of a horizontal concrete precipitating unit for removing impurities from liquids by precipitation, adsorption, settling, and upward filtration. Such units are made in sizes handling from 1000 to 10,000,000 gallons a day

advantages that go with soft water as better tea and coffee, cleaner clothes, more refreshing baths. One water chemist boasts that he can make an accurate estimate of water hardness in any city by drinking a cup of coffee or by looking at the complexions of the people!

Large industries pay far more attention to boiler feed waters than a mother does in preparing water for a delicate infant. Twenty-five years ago good water was desirable; today it is a vital necessity to them. In this period boiler pressures have gone up from 200 to as high as 1200 pounds per square inch in some cases. Even a small amount of scale in a high-pressure boiler is an expensive hazard. It causes overheating of the tubes, with consequent failures, and increases fuel and maintenance costs. Scale is also objectionable and wasteful in cooling systems. One public utility saves $80,000 a year in fuel by softening the cooling water for its condensers.

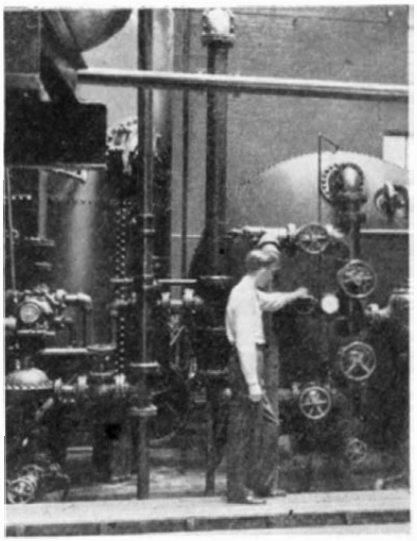
To Howard L. Tiger, director of the Permutit laboratory, water isn't just something to drink—it is something to fix. He has spent 25 years, nearly all his professional career, working at it. Among other things, he has designed chemical treating plants which can convert swamp water into the equivalent of distilled water, at a cost only one twentieth of that of distillation.

This rich background of water experience stood Tiger in good stead when war came. The armed forces have innumerable water problems besides the one of providing safe drinking water for the men. Distilled water, for example, is needed in large quantities for use in the batteries which provide power for radio and telegraphic communications. Carrying this water to the front was an awkward, time-consuming job. Did Tiger have any ideas?

He and his helpers went to work. In a few months' time they came up with a piece of apparatus, no larger than a suitcase. In seconds, this "demineralizer" converts the murkiest creek water into water suitable for battery use. Here, again, zeolite came into the picture. By means of the small unit, the unwanted minerals, which would damage batteries if raw water were used, are removed. The demineralized water is found to be every bit as good for the purpose as distilled water. In fact, the demineralizing process produces an effluent comparable with or lower than commercially distilled water in mineral content. It is applicable to most fresh-water supplies but not to highly saline waters such as sea water.

SALT WATER MADE DRINKABLE—However, even sea water has yielded to the knowledge of the water experts. Flyers and seamen adrift on rubber rafts can now be supplied with a compact apparatus which takes the salt out of sea water and delivers life-giving, potable water.

Man has sought to solve this problem for centuries and has come up with some pretty bizarre solutions. These have included tiny gasoline stills, solar stills, and even a stomach still. In the latter, the man adrift on a raft pressed a flask of sea water against his stomach. Body heat caused some of the water to vaporize, and it was condensed in a tube which trailed in the cold sea water. There were chemical approaches, too, but they were all too complicated or too cumbersome. Then came the winner.



Water used in processing textiles is softened in these zeolite units

The new apparatus consists of a plastic bag, about the size of an ice bag, and chemical cartridges the size of five-cent candy bars. The bag is filled with sea water and one of the cartridges is dropped into it. The chemical precipitates the salts in sea water and they are filtered out. Each cartridge, whose composition is a war secret, produces a pint of drinking water—enough to provide the needs of a man for a day. This device has been adopted by the armed forces and is in wide use.

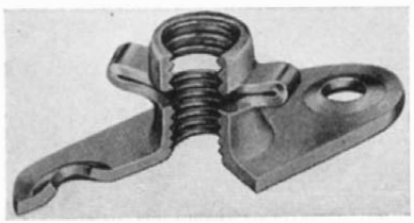
Post-war applications of principles learned in water softening and conditioning will have wide uses. The chemical swap-shop idea encompassed in the zeolites can be used to reclaim the factory wastes often dumped into rivers. Chrome, silver, gold, and other metals used in electro-plating are being experimentally recovered from liquid wastes. One process has been worked out for reclaiming nicotine lost in tobacco curing. This should cut the cost of this valuable insecticide. Another method is available to reclaim pectin from citrus wastes. Pectin is the material that makes jelly jell.

Such applications as these will be valuable to industry. But the home owner will be chiefly interested in better water. It will give the man of the house two to three times as many shaves with the same razor blade and save him money in other ways. For the housewife it means less labor spent scrubbing sinks, tubs, clothes. Hundreds of thousands of home water softeners are now in use. Water conditioning, now well past the experimental stage, has thoroughly proved itself. It is here to stay.

LOCK NUTS
Stay in Place, Save Weight

ONE of the mechanical problems that has plagued industry from the beginning has been that of securing machine and other parts which are subjected to vibration. Ordinary nuts, no matter how firmly they are turned into place, will loosen sooner or later as a result of vibration. Accordingly, many different methods have been devised to hold bolted fastenings securely. These methods have ranged from various spring lock washers through complicated pinning arrangements to unconventional nut forms which exert a locking pressure in one manner or another.

Aviation in particular is concerned with this vibration problem. Bolted connections must remain solid regardless of vibration. Thus when aircraft production went under forced draft a few years ago, recognition was taken of the fact that welding or riveting could not do all the fastening jobs that must be accomplished; many parts had to be put together with threaded fasteners. These must hold regardless of vibration, yet must be capable of being unfastened quickly and easily.



Principle of the Boots lock nut, as applied to a wing style anchor nut designed for use on aircraft

Into this gap came a type of lock nut that had been proved in service and which offered additional advantages. It was made from sheet-metal stock and was light in weight, yet gripped the threads of a bolt so tightly that no amount of vibration could displace it. So light in weight is this lock nut that, it is reported, use of it has added over 1,500,000 pounds of carrying capacity to American fighting planes.

Pictured in these columns is a cross-section of one form of this lock nut, developed by Boots Aircraft Nut Corporation. Here can be seen the one-piece construction in which the threaded part of the nut is divided into two sections. When this type of nut is applied, the bottom threaded section serves in the normal manner. However, since the threads in the top part are out of lead with the rest of the nut, tightening of the connection establishes a constant force between the threads of the nut and the bolt, thus locking the unit firmly without damage to any of the threads. Axial thread play is eliminated.

So successful has been the use of these nuts in aviation that they are

finding extended application in other fields. They are applicable, in a variety of types, to the solution of fastening problems on automotive equipment, farm machinery, industrial and office equipment, bicycles, household appliances, and many other products.

MILKWEED FLOSS

Replaces Kapok in Life-Saving Garments

THE present intensive campaign underway throughout a large part of the United States to collect milkweed floss for use in filling "Mae West" life vests, aviators' suits, and other critical life-saving apparel is another example of the interchange of materials made necessary by war. The fiber from the tropical Ceiba or kapok tree has for a long time depended upon where the combination of high buoyancy, moisture resistance, and light weight were demanded. And the only place in the world with large kapok-producing plantations is Java. This means, of course, that we have been living on our reserves since December 1941, and

Pod, floss, and seed of the milkweed

that it will probably be several years before kapok is again available to us in the quantities required.

Although kapok is a member of the Bombax family, botanically far removed from the milkweeds, the fibers of both plants are surprisingly alike. Although kapok trees may exceed 100 feet in height, compared with only a few feet for the milkweed, both are similar in having pods from 4 to 6 inches in length, filled with woolly haired seeds. And, strangely enough, the seed hairs or floss are also very much alike. The individual fibers are about 30 to 40mm long by .005 to .03mm in diameter, tapered, and with virtually hollow air cell some five or six times as wide as the thin outer wall. Both fibers have a silky, lustrous appearance; both are light and soft; because of their springiness both fill confined spaces without packing; both are wax coated. While both are similar in the high alpha-cellulose and furfural content, milkweed floss is slightly higher in lignin. The ash content of both is nearly identical. No other material known is closely similar to these two in chemical and mechanical properties, or in actual performance.

Both have very high insulating value, milkweed being reported as slightly better than kapok, and both better than wool or fur. Both are very high in buoyancy value, with milkweed apparently retaining buoyancy a little longer. Milkweed has been found to be exceptionally resistant to storage deterioration and destruction by molds.

Thus while many other materials can be employed as substitutes in the numerous places formerly filled by kapok, only milkweed will do in the all-important life-saving apparel. This is why every possible pod is needed this coming fall so that no American life will be lost for lack of sufficient life-saving equipment.

RAIN TEST

Accurately Evaluates Water Penetration of Fabrics

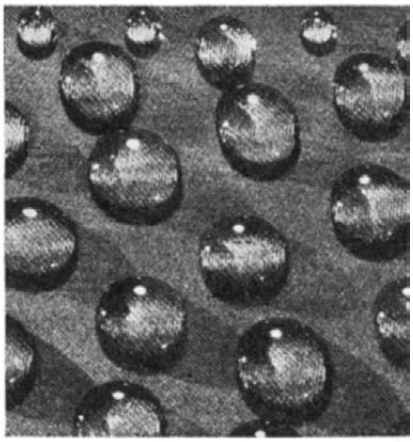
THE tempest in a teapot has a serious scientific counterpart, the "cloudburst in a beaker." Simulating a heavy tropical downpour, a new rain tester has been devised for evaluating water repellent fabrics, now so widely used in military and civilian garments.

George A. Slowinske, of the Du Pont Company's Fine Chemicals Division, who designed the experimental apparatus, is one of the leading authorities on the subject of water repellency and is in charge of research in this field at the Technical Laboratory of the Du Pont Dye Works.

The laboratory rain maker, which has been employed in work on numerous fabrics, may still undergo changes before being offered in its final form. It consists of a shower head at the bottom of an eight-foot glass tube. At the top of the tube is a large vessel or beaker of water, supplied through a hose running up from the water faucet. This inverted shower bath arrangement provides a spray of uniform intensity, directed horizontally upon the fabric to be tested. The sample of cloth is clamped to a support board held at a fixed distance from the shower head. But back of the cloth is a piece of blotting paper. By weighing the blotting paper before and after the synthetic rainstorm, one can calculate the amount of water that gets through the treated fabric. This figure and the time required for the artificial rainstorm to penetrate the fabric give an accurate measurement of the impact penetration resistance of the water-repellent fabric. By shortening the tube one may simulate lighter rains.

Testing water repellency of fabric

The rain test and other tests developed by Mr. Slowinske are expected



Water forms globules, hence does not penetrate a water-repellent fabric

to do much to remove the guesswork from the fabrication and sale of rainwear, ski suits, jackets, and other water-repellent garments. "Proper construction of the fabric and the garment are necessary," Mr. Slowinske says, "in order to obtain the full benefit of the chemical treatments. The chemicals used, including 'Zelan' durable water-repellent, make the individual fibers shed water without clogging up the pores which permit the garment to breathe. Therefore the cloth must be woven closely enough so that rain won't go through the pores.

"It has been appreciated for some time that two thicknesses of a suitable treated fabric will invariably give better protection against rain than a single thickness of even the best heavy fabric and that added protection can thus be achieved without increasing the garment weight.

"Through investigations with the rain tester it has been further found that the rain penetration through the outer layer of cloth is surprisingly dependent on the type of lining fabric used. Less rain gets through the outer layer if the inner one is of a resilient material, such as a light flannel, than if it is a thin, non-resilient fabric. The springy lining seems to cushion the blow of the rain drops, so there is less tendency for them to penetrate the outer fabric. The protective qualities of the garment can be even further increased by applying a water repellent to the lining."

POST-WAR GAS

Will be a Versatile Fuel, High in Octane Rating

POST-WAR airplanes may be designed to use the same gasoline as post-war automobiles, Thomas H. Risk, refinery technologist of Ethyl Corporation, predicts in a survey of factors affecting the anti-knock performance of peace-time

gasolines. Ethyl gasoline with an octane number of 85 to 88 will make this dual function possible, Mr. Risk says.

Such gasoline will be comparable in anti-knock quality to the 87-octane aviation gasoline sold prior to the war. Hence it is conceivable that many of the post-war planes, estimated at 500,000 by 1950, will be designed to use premium grade motor fuel rather than a special aviation gasoline, the survey points out.

Values of 85-octane number for premium fuel and 79-octane number for regular fuel are indicated for as early as next year, should the war end that soon. Refinery equipment now under construction will have been completed by 1945 and therefore available for peace-time production of gasoline.

Owing to tremendous advances in refining technology during the war and to other important factors, laboratory-determined octane numbers alone (such as the American Society for Testing Materials figures quoted here) will not tell the full story of anti-knock quality of post-war fuels, it is declared. New characteristics derived from improved refining processes and new blending stocks will result in better performance than even the higher post-war octane numbers indicate, Mr. Risk explains.

"Besides octane number, the chemical composition of the fuel, the engine that will use the fuel, and the type of transmission used in the vehicle, all will affect the anti-knock quality of the gasoline on the road. Yet, laboratory octane number is the only yard-stick we have at present with which to estimate the post-war anti-knock quality of gasoline, because there are, of course, no post-war cars in which to test the new fuels.

"Post-war prosperity, or the lack of it, will affect public demands for gasoline quality," Mr. Risk continues. "Other factors that must be considered include the probable condition of engines in older cars and the anti-knock requirements of new cars. Therefore, because of post-war uncertainties, the amount of premium grade gasoline sold may be anywhere between 10 and 20 percent of the total production."

Aviation fuel after the war is expected to account for 6 to 8 percent of all gasoline produced as compared to only 1 to 2 percent in pre-war days. This is approximately a four-fold increase, and reflects the effects of war-time expansion on future aviation gasoline demands.

Capacity to produce aviation fuel will greatly exceed the forecasted peace-time demands by the time the war is over, says Mr. Risk in discussing what is likely to happen to new refinery equipment when the war ends.

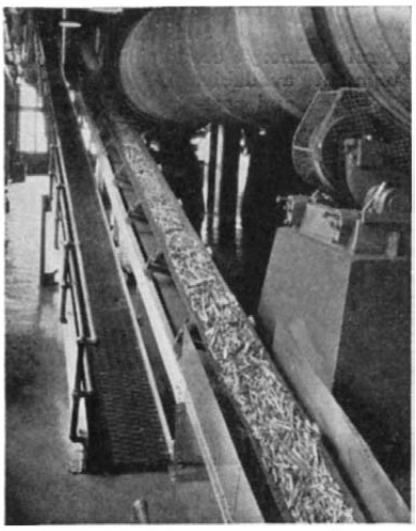
"Conceivably the petroleum industry could continue to produce 100-octane gasoline up to the full limit of capacity and dump the excess into motor gasolines. To determine the effect of this procedure, an estimate of post-war aviation gasoline consumption is required. Estimates of this demand vary considerably from about 50,000 barrels a day to 150,000 barrels a day.

"Due to wartime restrictions, the excess cannot be stated in actual figures, but it has been estimated that, if the excess post-war aviation gasolines were used in this manner, the over-all effect would be a two to three octane-number increase in motor-gasoline octane number. This relatively slight increase in octane number would be expensive since aviation gasoline costs the refiner considerably more to make than motor gasoline.

"It is, therefore, much more likely that new refinery equipment not needed to make aviation gasoline after the war will be used more directly to produce gasoline suitable for automobiles, trucks, and buses. The exact manner of utilization will vary within the industry and will be based on such factors as relative demand for various grades of fuel, that is, aviation, premium, housebrand, and third grades; general refinery economics, that is, equipment available, crude supplies, and so on; and post-war car requirements and comparative demands."

FLUORESCENT LAMPS
Will be Made in New Forms Post-War

DESIGNED to meet the lighting needs of the post-war era, two entirely different shapes of fluorescent lamps, one circular to fit inside the shades of floor and table lamps, the other a long, slender tube only three quarters of an inch thick, will be manufactured as soon as



Wood chips are carried to the distillation retort on a conveyor belt

war conditions permit, the Westinghouse Lamp Division announced recently.

The circular lamps will be used in the home for portable lamps and in many types of ceiling and wall fixtures throughout the house. They could be used either alone or in combination with ordinary types of incandescent lamps.

While the new long, slender fluorescent lamp may also be used in the home, its chief advantage will be in advertising display and show-case lighting and for locations where long lines of continuous light are needed to harmonize with an architectural design. Because of its additional length—three feet longer than the largest fluorescent lamp now made by Westinghouse—it will be better adapted to many specialized types of lighting than the more usual size of fluorescent lamp.

WOOD DISTILLATION

Carried on at High Temperature To Obtain Greater Yield

A WOOD distillation process introduced on a commercial scale by Henry Ford 20 years ago is today providing the United Nations with quantities of badly needed chemicals. Known as the Ford-Stafford process, it is employed at the wood distillation plant located at Iron Mountain, Michigan.

Operating on a 24-hour basis, the plant is producing such vital war-time chemicals as ethyl acetate, a solvent used in quick-drying lacquers for trucks, tanks, jeeps, and other war vehicles; denaturing grade methanol used for making denatured alcohol; chemically pure menthanol, quantities of which are used in making plastics; and methyl acetone and acetate, solvents used in war plants.

Originally most of these chemicals were regarded as by-products, with the production of charcoal being the real objective. The demands of wartime industries, however, have altered the picture until the chemicals are as important as the charcoal.

In the usual type of distillation plants an intermittent process is used whereby cord wood up to six inches in diameter is placed on small cars and trundled into horizontal ovens. The walls are then heated, and as the wood slowly carbonizes the resultant vapors are drawn off. It is from these vapors that the various by-products are obtained.

Under this older process, temperatures must be limited to around 600 degrees to prevent damage to the equipment. Time also is lost in loading and unloading the retorts.

The Ford-Stafford continuous process utilizes a vertical, thick-walled retort about 40 feet high. The wood is chipped by running it through a grinder, then is fed into the top of the retort. The retort is heated to 1000 degrees. The released vapors create an exothermic reaction which maintains the 1000 degree temperature.

Charcoal, drawn off at the bottom of the retort, is compressed into briquettes, while chemical-producing vapors are drawn off from the top through condensers. Wood chips are added, as required, to maintain a level seven feet from the top of the retort.

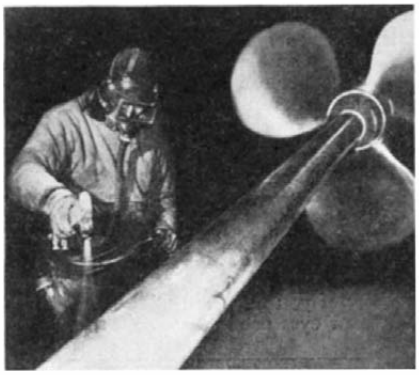
The maintenance of higher temperatures not only produces better charcoal by extracting more volatiles, but yields a greater volume of chemicals per ton of wood.

RUBBER COATING

Protects Propeller Shafts From Electrolytic Action

A SUCCESSFUL solution to the menace of destructive electrolytic action, which eats away the propeller shafts of Navy subchasers, minesweepers, and other wooden vessels, has been found to be synthetic rubber flame-sprayed onto steel propeller shafts by a new process, according to the Schori Process Corporation. Heretofore, bronze propellers fitted to steel shafts on wooden vessels produced an electrolytic action through the union of two dissimilar metals in salt water, with the result that the shaft is so eaten away within a few months that it cannot stand up under the high-speed operation.

After nearly a year of experimenting with flame-sprayed plastics, which all proved too brittle and could not be easily ground for spray-gun operation, Schori engineers found that Thiokol synthetic rubber could be sprayed on the shaft while in position on the ship. The molten rubber hardens rapidly to form a firmly bonded coating with an extremely high abrasion resistance. Since the shaft is completely protected from contact with the sea water, there is no opportunity for corrosion or pitting to set in.



Flame-spraying Thiokol onto a propeller shaft to prevent electrolysis

This same coating can also be used advantageously to coat the interior of bronze valves on salt-water pipelines, low temperature condenser plates, and other inaccessible but vulnerable underwater portions of steel vessels, it is stated.

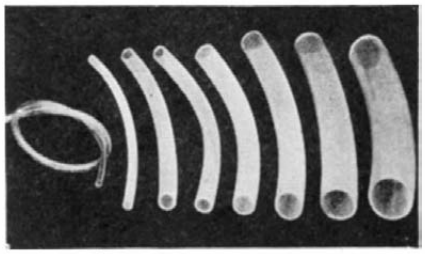
TRANSPARENT TUBING

Resists Solvents, Has Many Industrial Applications

SOLVENT-PROOF, rubber-like, transparent tubing, made of compar, a type of vinyl resin developed by Resistoflex Corporation, is finding a number of uses in aircraft and other industries.

In the laboratory, its transparency permits constant inspection of the contents. Because the tubing is tough, strong, and inert to almost all organic solvents it is highly useful for low-pressure, room-temperature handling of these hard-to-handle materials. It is not affected by even such active solvents as carbon disulfide, carbon tetrachloride, trichlorethylene, perchlorethylene, acetylene tetrachloride, benzol, and toluol, or by oils and fuels such as high-octane gasoline with the highest aromatic content.

Having the lowest permeability to gases of all natural and synthetic rubber-like materials and being unaffected by such gases as freon, methyl chloride, methyl bromide, phosgene, mustard,



Transparent, solvent-proof, rubber-like

propane, butane, and water gas, further applications for compar tubing are immediately apparent. When used on Bunsen burners or other laboratory appliances the tubing does not absorb the protective odors with which illuminating gases are usually loaded and, therefore, prevents the laboratory atmosphere from being contaminated by them.

One of the many interesting applications which has been developed recently and for which transparent compar tubing has been used with greatest success in the aircraft industry, is as temporary instrument lines for test flights. Filled with mercury, its transparency permits taking moving picture records of the fluid movements during test flights, thereby making possible an accurate check of the flight instruments. Another application for which the translucent tubing has proved well adapted is as a cover for conveyor hooks passing through degreasing operations.

While transparent compar laboratory

tubing is extremely tough and strong it is not generally recommended for industrial applications which now employ fabric reinforced hose constructions containing tubes or cores of other compar formulations. Resistoflex hose and hose assemblies, using compar, are widely employed for aircraft instrument and hydraulic lines, fuel and oil lines on industrial machinery.

HOT PROPS

Ice Formation Prevented By Heated "Skin"

ONE of the most persistent enemies of safe flying—formation of ice on propellers of planes in flight—is now being overcome by a new electrically heated propeller "skin," made in part of a special conductive synthetic rubber, that enables the propeller surface to warm up like a sick-bed heating pad.

The new heated propellers, to which dangerous "ice in the sky" cannot cling, were developed in conjunction with the National Advisory Committee for Aeronautics and are now, following tests, being installed on planes destined for icy-region operation, it is announced by The B. F. Goodrich Company.

The "skin" is made of a combination of two kinds of synthetic rubber, the outer surface being a thin coating that is tailor-made to conduct electricity instead of blocking its flow.

Since the current comes from a generator attached to the shaft, the propeller can be kept warm and ice-free as long as the engine is running. When there is no danger of icing, no current is passed through the skin. It simply rides the propeller, cemented permanently in place and conforming exactly to its shape so as not to interfere with aerodynamic design or performance.

ELECTRICAL CHALLENGE

Many Things Yet Unlearned About Utilization of Electricity

A FULLER utilization of the more than 80 "octaves" of the ether spectrum offers perhaps the greatest promise of bringing a fuller, healthier, and longer life to mankind in the postwar era, according to Samuel G. Hibben, noted lighting authority and director of applied lighting for the Westinghouse Lamp Division.

"When we speak of an 'octave' in the ether spectrum," Mr. Hibben explains, "we are using a term that denotes an electrical frequency twice as great as some other frequency, just as in music, when a note has twice the frequency of another, we speak of it as being an octave above it in pitch.

"In one limited region of the light spectrum, comprising about three 'octaves' of electrical radiation," Mr. Hibben declares, "we have achieved particularly interesting developments. Expressed in terms of angstrom units, the unit of measurement by which we denote the length of light waves, the radiations within this span of three 'octaves' range all the way from 2000 to approximately 16,000 angstrom units.

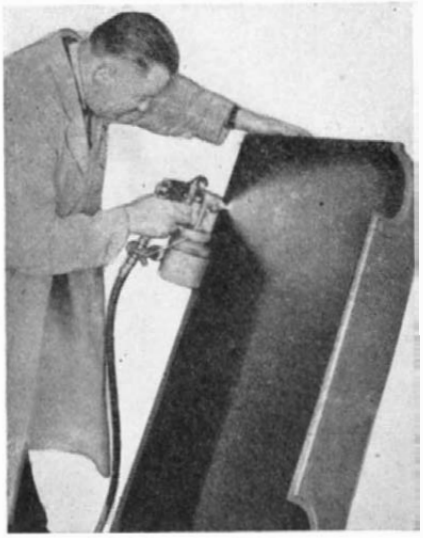
"That is the limited span in which all the outstanding lighting progress we have made has been achieved. But there still remain some 77 'octaves' of light radiations—more than 25 times the 'territory' we have so far covered—about which we know very little and which offer a fertile field for research.

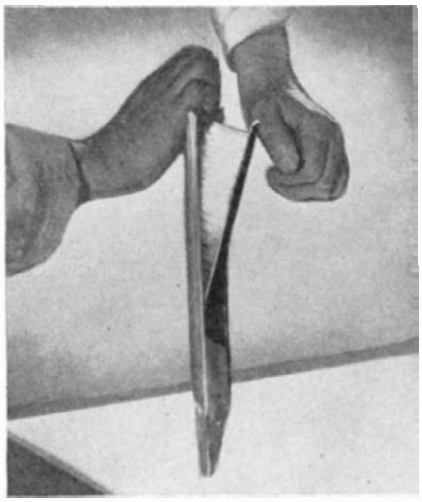
"Within the present explored range there are many outstanding developments. One of these is the infra-red heat lamp, now filling many industrial heating and drying needs in the nation's war plants. This lamp seems destined to become a popular device in the home and on the farm, not only for supplementary spot heating, but also for animal husbandry, regulation of plant growth, and humidity control.

"In this same range, also," he continues, "is the high efficiency mercury vapor lamp which has proved such a valuable aid in the lighting of large industrial areas and for supplying powerful searchlight projection.

"In the near-ultra-violet region, we have discovered that sources of electrical energy can be used to produce 'black light' for the excitation of fluorescent dyed materials such as carpets and upholstery fabrics, to aid crime detection, and for food and drug analyses.

"Delving further into the ultra-violet region," Mr. Hibben reports, "we find an increasing interest in radiations used to reproduce anti-rachitic sunshine, or for general health maintenance, while still further down the scale we find perhaps the most important tool of all, the ultra-violet lamp which is used to kill





Spraying an adhesive sound deadener on the interior surface of a metal housing. Right: A number of pliable adhesives have been developed for bonding a wide range of materials, both porous and non-porous

pathogenic bacteria and spores of the mold-forming fungi. This device gives promise of controlling many types of infectious diseases and should prove a valuable tool in the field of air conditioning.

"Since we all hope to do tomorrow's jobs better than we have in the past," Mr. Hibben emphasizes, "it is gratifying to realize the scientific progress we have made to date. However, many 'unknowns' await the future scientist and we must not be complacent about what we have accomplished when so much still remains to be done.

"For example, we would like to know how to obtain 100 lumens per watt, or one sixth the possible efficiency from a light source; how to obtain two colors from the same electrical discharge in a gas or vapor; how to develop indoor sunshine for a vegetable garden in the basement and for comfortable seeing in the factory. These and many other scientific problems await our solutions. Herein lies the challenge to our scientists of the future."

ADHESIVES

Do More than Bond Materials Together

One of the significant trends in industry, under the impetus of war production, has been the increase in the use of adhesives. This development refers to pliable adhesives for bonding materials together—impervious materials such as metal to glass, formica, Masonite, and metal to metal; materials of impervious and porous natures such as metal to leather; and two porous surfaces such as leather to wood.

Varying uses require different types of adhesives. Thus, for example, more than seven hundred types of industrial adhesives have been developed in the laboratories of the Minnesota Mining and Manufacturing Company. Before the outbreak of the war and the sudden widening of adhesive horizons which followed, the automotive industry was the largest and most consistent user of industrial adhesives.

Adhesives have numerous other uses than that of bonding materials together. Sealers, for example, have been developed to meet special war production requirements, such as sealing riveted joints in airplane gas tanks, sealing plane pressure cabins, sealing naval gasoline storage tanks, and a variety of related uses.

So many problems have been solved easily and inexpensively with sealing compounds that if there is anything certain about post-war industry it is that it will depend heavily on the time- and money-saving properties of this type of adhesive.

Another type of adhesive with an assured future in post-war industry is used for coating purposes. During the last three years, with the war industries practically cornering the supply of metals, the only hope many industries had of carrying on at all was to find suitable substitutes. In this field adhesive coatings have proved to be veritable life savers. They have proved efficient as protective linings in pickling and plating vats, in heater tubes, and as protection against the corrosive action of exhaust gases. Another large use of this type of adhesive is for coating the underbodies of automobiles, trucks, and passenger coaches on railroads as a protection against abrasion, rust, and corrosion.

Adhesive coatings can be applied by brushing, dipping, or spraying. The most efficient method of application is determined by the shape and size of the object and the type of compound used. Insulation against heat, cold, and noise for post-war automobiles, buses, railroad coaches, and airliners, will be much simpler and more economically applied in those post-war days which seem to hold so much promise for American industry.

NEW RESINS

Now Available, Offer Wide Range of Characteristics

The name "Geon" has been chosen for a group of unique polyvinyl resins which are now available to industrial users. Geon, from the root word geo (the earth) was selected because the basic raw materials from which these polymers are derived have mineral origin, according to The B. F. Goodrich Company.

Coating of fabrics, paper, foil, and other materials, insulation of wire, manufacture of film for packaging, and the manufacture of extruded and molded products are among the principal fields for Geon resins. Purchases of any of the resins are subject to allocation by the War Production Board under General Preference Order M-10, under which the polyvinyls are allocated, although reasonable quantities are available for experimental purposes.

Two chemical types are offered currently. The Geon 100 series are special vinyl chloride polymers characterized by their thermal and light stability, toughness, and chemical inertness. The Geon 200 series was created to meet the need for polyvinyls which combine increased solubility and thermoplasticity with exceptional stability, chemical resistance, and wide useful temperature range. Their resistance to hydrolysis by boiling water or even hot alkali is outstanding in the field of vinyl chloride copolymers, and like the Geon 100 series they have unusual stability to light and heat.

When compounded with other materials, Geon resins can be processed in many ways, including injection and compression molding, extruding, calendering, and solution coating.

Compositions varying from the rigid thermoplastic to a very soft jelly can be obtained by modifying the Geon resins with other materials. Each composition exhibits to a high degree the many desirable characteristics of the base resin used.

Tailor-made formulations can be supplied for special purposes. It is pointed out that, because these materials can be varied so widely in useful properties, it is greatly to the advantage of the prospective user to consult the manufacturer in choosing a compound formulated to fit a specific need.

TOMORROW'S AIRPORTS

Must be Planned Now For Many Purposes

Airport planning is the lazy giant of post-war aviation that must be put to work immediately if the vast potentials of commercial and private flying are to be attained, according to C. Bedell Monro, President of Pennsylvania-Central Airlines.

"The two undeveloped wings of aviation planning now are airport development and private flying," says Mr. Monro, "and among the major tasks of the entire aircraft industry are the development of programs to meet the needs in these two fields.

"PCA has been studying methods of helping the private flier, and we feel that the airlines, with their huge maintenance base facilities, their know-how, their experience in aircraft upkeep, and their other facilities such as weather forecasting and dispatch procedures should provide concrete and reasonable

access to these facilities for the private flier, especially during the period after the war when these facilities will not be readily available in many places.

"But this will not be enough," continued Mr. Monro, "unless airports are blueprinted today to handle a minimum amount of air traffic. Even the most conservative estimates mean that immediately after the war the airports of this nation will have to handle at least three or four times the volume of plane traffic handled before the war. Many American cities will be left grounded and many Americans will be denied the full benefits of air transportation for several years unless the blueprints are drawn today.

"Airports cannot be built overnight, in weeks, or even in months. And even though we have acquired hundreds of new fields during the war, many of them are not so situated as to be available for use by cities. Many have been engineered for war and not for peace. Many are off the beaten track, and civic airports can only be brought into being after periods of planning and even longer periods of construction.

"There are some enterprising and far-sighted American cities that are not only studying and planning their airport needs, but which will be ready to meet the advance of the air age. But for every such prepared city there are hundreds of unprepared communities where inertia will lose for them the full benefits of the air tomorrow.

"Not only are airports essential for the business life of a city, but they can play a major role in providing jobs for the several million men in the Air Forces, many of whom will be looking to aviation for employment when they return home. For many, it is their only vocation, and our responsibility to them is staggering. It can only be met if we here at home prepare now, with what we have, to provide jobs for them when they return.

"Cities must study the whole encompassing picture of tomorrow's aviation—it is not enough to build large airports solely for commercial operations. Hundreds and thousands of persons will want facilities for private flying. These facilities will mean business and progress. They will mean a strong and safe America, for it is only through the development of millions of flying youth that the nation can remain in the forefront of the flying race—and to lag in that race will mean doom in the world of tomorrow."

GERM KILLING

Can be Accomplished in Air-Conditioning Plants

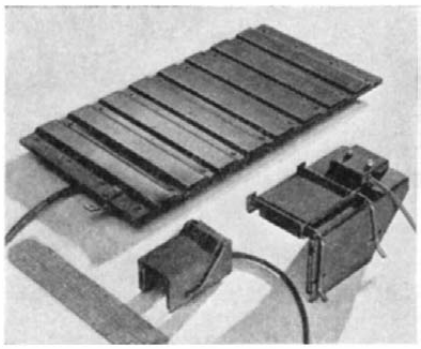
UTILIZATION of air-conditioning plants in motion picture theaters, schools, and other public gathering places, to "reduce the menace of airborne infection" through "sterilization and purification of air supplies by ultra-violet light" is urged by G. Morley-Davies, District Health Officer, Bristol (England) Public Health Department, in a scientific paper published in the British magazine *Municipal Engineering.*

"Now that excellent air-conditioning plants are available and have been installed in so many large and commodious public halls and meeting places, it is time someone gave a modicum of thought to the important matter of sterilizing and purifying the air after it has passed through the usual mechanical processes, whereby it is washed, warmed, or cooled and is on its way into the auditorium," Mr. Morley-Davies states.

"Recent research in the world of electricity has brought into use the ultra-violet rays of light, and shown their amazing powers where sterilization is concerned. These ultra-violet lamps, when in action, can kill almost all bacteria that come within a range which can be quite large in its extent. The ultra-violet lamps so far developed have demonstrated their high efficiency and it has been shown that their effect on germ life is devastating. Experts have shown, through the microscope, many colonies of disease germs floating about in enclosed air, suddenly rendered completely inactive when the ultra-violet lamps have been brought into action against them.

"Germicidal lamps are definitely going to find a place in air conditioning some time in the future. It is not sufficient to wash the air going into a building; it will have to be thoroughly filtered and treated germicidally as well. It is known in medical circles that blacked-out atmospheres incubate and spread disease germs quicker than any other. The cinema must come under suspicion in this connection. Few cinemas can be flooded with sunlight during the morning, and it is well known that sunlight is one agent that keeps national illness and disease down to its present satisfactory level. Where sunlight cannot enter, then disease germs will thrive and flourish.

"It is my opinion that in the not so far distant future every cinema auditorium will be fitted with several of these ultra-violet lamps, suitably arranged to flood the whole of the atmosphere inside the theater with health-giving ultra-violet light. This is not visible light, of course, and it will not affect the requisite darkness of the auditorium. I have not yet heard of this being done anywhere, not even in



Types of electric contact heaters

America, but I think it will come sooner or later.

"Infectious epidemics such as influenza and the common cold, which are the bane of public health authorities, are helped considerably to advance their evil hold on a community by the crowding together of people in stuffy atmospheres. Modern air conditioning has done noble service in removing the 'stuffiness" from our theaters and entertainment halls, but more will have to be done. Indeed, it would appear that public health authorities must yet learn to realize that there can be a tremendous advantage in getting a crowd of pople into an enclosed building such as a theater. They can there be given treatment through the aegis of air that would not be possible by individual methods! If the air can be charged with a safe germicide—ultra-violet light is a safe germicide—then the benefit to the health of the people subject to this treatment would be far-reaching. The risk of epidemics could be blotted out by such large-scale dosage and control."

ELECTRICAL HEATING

Made More Efficient By New Design

UNTIL now a military secret, an advance in electric contact heating involves a process which is serving a wide range of uses, principal among them being the heating of the bolt or firing mechanism on machine guns, of the hydraulic actuating mechanisms on airplanes in the stratosphere, and of storage batteries in army tanks in below-zero theaters of war.

Since the new heaters attain a high degree of efficiency, it is expected that they will be adapted to a multitude of peace-time uses, for they can be made in nearly any size, contour, and capacity. They have the advantages of light weight, of operating at low wattage, of being safe in the presence of explosive vapors, of operating without deterioration of the heating element, of withstanding severe vibration, and of maintaining exact temperatures within close limits. The efficiency of one unit, as an example, may be judged by the fact that, even with outside temperatures as low as 65 degrees below zero, Fahrenheit, it will raise the temperature of a machine gun mechanism to well above the desired operating temperature.

A combination of several factors accounts for the efficiency of the principle developed by the H. and A. Manufacturing Company. Despite the low current consumption, which ranges from 35 watts to 400 watts in the various sizes and shapes of units so far developed, thermal losses are so well controlled and heat transfer so efficiently accomplished that a unit weighing only a few ounces will raise the temperature of 30-odd pounds of steel 90 degrees above sub-zero external temperatures. This is partly due to the methods of insulating and housing the heating element and partly to the method of attaching the heater to the object to be heated. By this method, the fact of the heating plate is held in compressive, resilient contact against the surface through which the heat is to be transferred. No nuts or bolts or permanent attachments ordinarily are required; the units in most cases can be "sprung" onto the object. While they can readily be removed, their "grip" withstands the severest vibration.

FOOD DEHYDRATION

Requires Application of Engineering Skill

THE rapidly expanding field of food dehydration can no longer be handled by haphazard, makeshift methods, but is a scientific problem evolved in the past 15 years and requires the application of engineering knowledge and techniques, said W. R. Marshall, Jr, of the Experimental Station of the E. I. du Pont de Nemours and Company, in a recent address before the Metropolitan Section of the American Society of Mechanical Engineers, New York.

"Because the scale of production of dried foods is so large," said Mr. Marshall, "engineering is imperative in designing, building, and operating the large pieces of drying equipment required.

"Although the problem of removing moisture from solid materials has been encountered by man through the ages, nevertheless the underlying principles involved in effecting this removal have been studied scientifically only during the past 15 years. The reason for the delay in the development of drying as a science is the fact that quantitative information on drying processes was not required before the advent of our present large-scale industrial chemical plants which involve drying as an important unit operation.

"Thus, when the need of removing tons of water an hour arises, the problem is no longer a simple matter of drying in any space which happens to be available, but one of engineering proportions in which the well-established thermal and thermodynamic properties of air-water vapor mixtures are required, together with exact information on rates of heat and mass transfer for various conditions of drying. It is apparent, therefore, that the operation of drying logically falls in the realm of the engineer trained in the fundamentals of heat and mass transfer and the broad field of heating and air conditioning.

"A development of a drying theory may be pursued along two lines. One

approach may be termed the 'internal method,' which is a fundamental viewpoint and concerns the exact manner in which a liquid moves through a given solid during drying. The other approach is the 'external method' and is more empirical in that the drying characteristics of a solid are interpreted in terms of the effect of the external drying conditions of air temperature, air velocity, and air humidity.

"All the developments and methods used to study the drying of non-food materials have application in the present rapidly expanding field of food dehydration. Since the drying of foods involves the use of thermal means for its consummation, problems of heat transfer are encountered. Likewise, the removal of moisture involves transfer of liquids and vapors and thus permits the application of concepts developed in the field of mass transfer. The special problems which food dehydration brings to the field of drying are those of maintaining high food value in the dried product, retention of characteristic taste and odor, and imparting keeping or preservation properties to the dried food for purposes of storage and shipping."

MORE CHICKENS QUICKER
Made Possible Through Use of Ultra-Violet

A YEAR-LONG study in 400 chicken, duck, and turkey hatcheries and feeding stations has demonstrated that electrically produced ultra-violet rays reduce poultry mortality as much as 68 percent, according to Dr. Harvey C. Rentschler, director of the Westinghouse Lamp Division Research Laboratories.

Stressing the fact that reducing the mortality of both baby chicks and mature birds is of special importance at this time because of the meat shortage, Dr. Rentschler says:

"Sixty percent of chick mortality occurs within the first 16 days. Germ-killing rays of short-wave ultra-violet are helping to reduce these losses. In addition, the small amount of vitamin-D wavelengths generated by bactericidal lamps steps up the growing time of young birds—an important factor today when feed is scarce.

"To a poultryman, time is money in the most literal sense of the word—a bird grown in five weeks instead of eight puts the price of two and one quarter pounds of feed in the poultryman's pocket and a more reasonable chicken dinner on the nation's tables," Dr. Rentschler points out.

In a carefully controlled test of two battery brooding houses, identical except that one contained the bactericidal ultra-violet lamps called Sterilamps, Rucker's Imperial Breeding Farm and Hatchery, Ottumwa, Iowa, reported 68 percent lower mortality and 50 percent fewer culls and runts—or discards—in the house employing the lamps. Birds in the irradiated unit grew to range size in five weeks, compared with eight weeks for the unirradiated birds. The test involved 11,000 chickens.

Many diseases of fowls are of a respiratory nature and the infectious organisms are carried by the air. Continual disinfection of the air through bactericidal irradiation reduces the contamination below the level at which it might become epidemic. At the same time, short-wave ultra-violet destroys mold and fungus that can be responsible for such diseases as mycosis and brooder pneumonia.

SUGAR SCIENCE
To be Studied in Co-operative Plan

A LONG-RANGE program of research on sugar, the most familiar and yet one of the least understood scientifically of all the products of nature, is underway at the Massachusetts Institute of Technology in co-operation with the newly established Sugar Research Foundation of New York. Announcement of this work was made recently by Dr. Karl T. Compton, president of the Institute, and Joseph F. Abbott, president of the Sugar Research Foundation. The foundation was created for the development of fundamental knowledge in the field of carbohydrate chemistry, biochemistry, and nutrition. Membership is open to all producers and processors of sugar in this country, Puerto Rico, Hawaii, and Cuba.

It is anticipated that the chemical studies conducted under the arrangement will not only extend knowledge of the role of sugar and other carbohydrates in the human body, but also will

Acid-proof mortar being poured in a joint in a pipe line for disposal of acid waste from an industrial plant

unfold wholly new industrial uses for sugar and its derivatives. An important stated objective of this broad research program will be the training of scientists in the field of carbohydrate chemistry to prepare them for service in the industry for further technical studies. Provision has also been made for fellowships for young graduate students who are candidates for advanced degrees to permit them to continue their work in this promising field.

Sugar, whether from cane or beet, is one of the purest chemical substances known to man and is produced in enormous quantities at relatively low cost. As an inexpensive source material, its chemical conversion to substances which can be utilized for other purposes than as a food is an interesting scientific challenge which demands the most advanced investigation.

ACID-PROOF MORTAR

Saves Steel and Natural Rubber

MADE of sulfur plasticized with synthetic rubber, acid-proof mortar is saving thousands of pounds of precious steel and natural rubber in the construction of pickling tanks, acid-proof floors, chemical vats, and industrial sewers for the disposal of used acids and other wastes.

Manufactured under the trade name "Tegul-Vitrobond," by The Atlas Mineral Products Company, this Thiokol-sulfur cement is reported to be stronger than the best concrete available and has many other interesting characteristics which ably fit it for its war-time job. For example, it is inert at temperatures up to 200 degrees, Fahrenheit, and is unaffected by hot or cold acid, by corrosive salt or mild alkaline solutions, has a bond to brick of from 400 to 500 pounds per square inch, and is impervious to penetration by liquids. It is also able to withstand severe trucking abrasion and mechanical punishment. Equipment built with it is said to be virtually impervious to wear.

Through processing a type of synthetic rubber developed for this cement with sulfur, and adding other ingredients, a comprehensive series of Tegul-Vitrobond cements has been developed to meet numerous industrial applications requiring compounds of different properties. These mortars are particularly suited for chemical process equipment for the production of chemicals, explosives, pigments, and rayon.

Perhaps the greatest saving of steel effected by this sulfur-Thiokol cement is in the substitution of concrete vats lined with acid-proof brick joined with the cement for steel tanks.

Of major importance in acid-proof brick construction is the method of taking care of contraction and expansion when the tank is in service. This is accomplished by placing an acid-proof and acid-tight expansion joint in the brickwork at varying intervals, depending on the size, shape, and operating temperature of the tank. This joint is built up by cementing a series of horizontal and vertical, soft, unvulcanized rubber plates to their adjoining brick surfaces in such a manner as to displace a given volume which would otherwise be filled with Tegul-Vitrobond. The completed expansion joint cuts the joined brickwork into separate sections which are bonded by an acid-proof and acid-tight rubber connection.

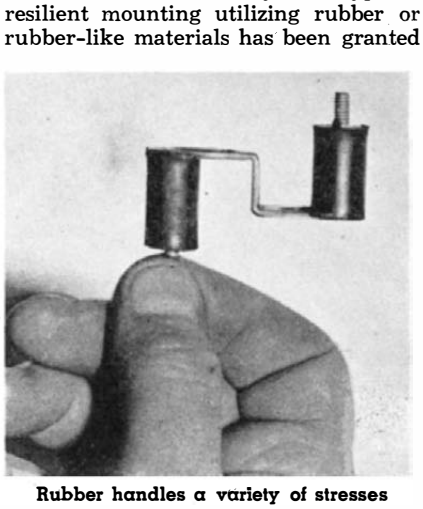
Tegul-Vitrobond is heated in iron kettles over a wood or gas flame. When the material reaches the correct temperature, it is ladled into the joints between the brick. Horizontal joints in the brickwork are made by placing ¼-inch chips of Vitrobond beneath the brick. When the molten mortar is poured into the joints, it flows against the form work and upon solidification seals every joint, as well as impregnating the brick.

The versatile Thiokol-sulfur cement also has high utility in the construction of acid-proof floors. When molten cement is poured between tiles, the resulting floor is durable, attractive, and acid-proof. Such construction is being widely used in industrial chemical plants, dairies, and food plants.

RESILIENT MOUNTING

Permits Flexible Designs in Many Fields

A PATENT on an entirely new type of resilient mounting utilizing rubber or rubber-like materials has been granted



Rubber handles a variety of stresses

to Herbert H. Fink, engineer of The B. F. Goodrich Company. Mountings covered by the new invention have cushioning cylinders interconnected by arms in S-fashion. This arrangement permits an extremely soft suspension under light load and allows the resilient material freedom of movement in all directions.

Handling of a variety of stresses including shear, bending, torsional, or twisting is accomplished by the mounting, which also permits the material to be stressed simultaneously under both shear and tension.

Various arrangements of the rubber cylinders and the arms to which they are attached will change the rate of deflection of the new mountings in any direction.

The invention is valuable in a variety of applications, including the mounting of housings for aircraft compasses and other instruments, motors for musical instruments, including those of the coin-operated type, flexible power transmission couplings, and in other fields where structures are mounted resiliently.

The degree of movement permitted by the cylindrical resilient bodies of the new mountings by the stresses in torsion, shear, bending, and compression allows action in any direction to be controlled by the way in which the mounting or groups of them are installed.

THIRTY HORSEPOWER

Delivered by Motor

Weighing Only 57 Ponnds

THE streamlined projectile-like contraption which George Pfau, General Electric tool maker, is shown assembling in the accompanying illustration may look like a new secret bomb, but actually it's a new "tailor-made" motor destined to help make our bombers more effective. One of several models now being built, this small motor will serve as the "engine" driving the propellor of a small model plane operated in a large wind tunnel under conditions equivalent to those of actual flight.

This motor is only 5 inches in diameter and 13 inches long, yet it has a rating of 30 horsepower. It weighs only 57 pounds and while its rated speed is 6000 revolutions per minute it can operate in excess of 7000 revolutions per minute. It is water cooled.

The small parts to the right of the motor comprise the tachometer assembly for determining its speed. This assembly fits into the front end of the motor.

Despite its small size, this new electric motor has high power rating

WHITEST OF WHITES

Titanium Dioxide Does a Number of Industrial Jobs

FROM one of the blackest of black substances, ilmenite, comes the whitest of whites, which is also the ninth commonest element in the earth's crust. Between breakfast and bedtime everyone is sure to handle at least one object containing this substance—which is titanium.

Although titanium is an important ingredient in such everyday things as fabrics, linoleum, refrigerator enamels, paper, and white paint, as recently as World War I it had scarcely any commercial value and even today is chemically among the lesser known elements. Yet among the thousands of chemical compounds manufactured by Du Pont, it is one of the most versatile.

Titanium dioxide is a white powder, so fine that 16 million individual particles of it side by side would measure only one inch long.

It is used by the armed forces in the protective creams that safeguard skin against painful flashburns inside gun turrets, and in other creams that offer protection against sunburn and insects in the tropics.

This same titanium dioxide, as an ingredient of the coating for welding rods, assists in maintaining a steadier arc and in improving the weld.

It is titanium dioxide which gives present-day white paints their extraordinary whiteness and hiding power, and the lighter colors their clarity and resistance to fading. Many peacetime products such as white rubber and the best white leather depend for their whiteness on titanium dioxide. White buckskin, for example, is pigmented in the tanning operation with titanium which is so fine that the particles go all the way through.

Linoleum and felt-base floor coverings owe much of their resiliency and long wear to this compound. It reaches the consumer in coated fabrics, even in soap.

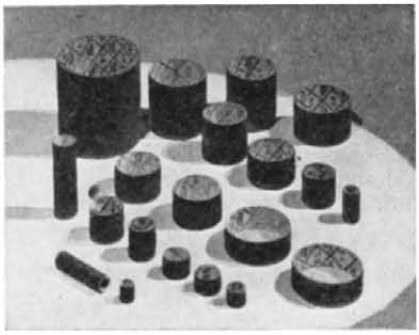
Titanium dioxide is handling a job in the field of paper manufacture that affects all of us at the present time. Wartime needs for paper are so great that the Government asks for waste paper as salvage. Books and magazines are printed on thinner paper. Even the writing paper you buy today is thinner.

A few years ago it would have been difficult or impossible to use such thin paper, because the print or writing would have "shown through" from the back. But titanium dioxide, added to paper, keeps this from happening and so conserves paper—makes it go further.

New Products

ABRASIVE BANDS

GRINDING and finishing of intricate pieces often causes delays and expenses far out of proportion to their size. This is no longer necessary if advantage is taken of the time- and money-saving grinding specialties developed and produced by the Minnesota Mining and Manufacturing Company, such as, for example, Three-M-ite Cloth Evenrun Bands. Reported to be fast cutting and long wearing, these handy abrasive bands turn out difficult jobs on what might be called a mass-production basis. Fitted over rubber mandrels of suitable size, Three-M-ite Cloth Evenrun Bands, with an electric drill, flexible shaft, or tool-room grinder to supply the power, make the individual finishing job a matter of seconds and are solving production problems in many plants.



Available in 33 sizes

Three-M-ite Cloth Evenrun Bands are available in 33 diameter sizes, ranging from 3/32 inch to eight inches, and with a face width of from ½ inch to three inches.

OSCILLOSCOPE

DEVELOPED and produced by the Reiner Electronics Company, a new five-inch cathode-ray oscilloscope of special design permits the study of complex wave forms such as square waves and pulses encountered in television work. Square wave signals from 40 cycles to 50 kilocycles can be accurately reproduced. The response up to one megacycle is great enough to make the unit useful at this frequency. This extended high frequency range makes this oscilloscope practical for the study and measurement of intermediate frequency phenomena.

MOBILE INSPECTION UNIT

A COMPLETE inspection department that can be moved to any point of work is now possible through the use of the new DoAll Mobile Inspection Unit manufactured by Continental Machines, Inc. With this unit, all work-measuring instruments can be correctly set in tools and machines, a job that formerly required shut-downs and delays while the measuring instruments and parts were sent to the inspection department for checking. Now, however, the mobile inspection unit, occupying little more than an area 24 by 42 inches, and containing a complete precision inspection department, is wheeled right up to the point of work on any job.

The unit contains all the necessary instruments and gages ordinarily employed in an inspection department. Monochromatic light waves, viewed through an optical flat, are used as the basic standard of measurement. A set of gage blocks, gaging instruments, and a comparator are provided to interpret this unwavering standard when checking dimensions of parts and tools. The set of 83 precision gage blocks has an accuracy in height, flatness, and parallelism which is plus or minus .000004 inch. The set of 20 different precision measuring instruments includes calipers, trammel points, center points, scribers, base blocks, gage holders, vernier gage block, master square, sinebar, straightedges, master flat, and a precision surface plate. The comparator gage has four ranges of magnification, and an illuminated magnifying glass on a stand is also provided.

The accuracy of these instruments which might be affected by wear, dirt, and rough handling, may in turn be quickly checked by using the optical flats and monochromatic light.

The mobile inspection unit is strongly built to safeguard the instruments and provide a smooth surface upon which to make inspection. It is of all steel construction which assures sturdiness and prevention of warp or twist. This forms a rigid foundation for the working surface which is covered with heavy-duty linoleum. This material provides a scratch-proof, smooth, shock-cushioning work surface that is easy on tools and gaging instruments.

Accuracy assured at point of work

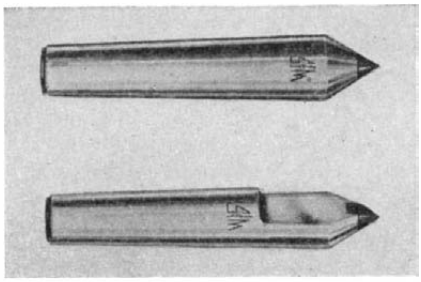
The unit is easily moved throughout the plant on four rubber tired, heavy duty caster wheels, which can be locked so that the unit becomes securely anchored when in use.

Every convenience is provided for the inspector so that he can quickly use his measuring instruments and record his findings and recommendations. A plug-in box is provided at the back of the unit to supply electricity for the monochromatic light, electric comparator, and magnifying glass. This box contains a 50-foot extension cord that is secured to an automatic take-up reel.

LATHE CENTERS

LONGER service life for lathe centers and half centers is achieved by the extension of the carbide insert into the shank of the tool. This extension, as made by Wendt-Sonis, is approximately equal to the exposed portion of the tip, allowing extra regrinds before need of replacement, should the bearing surface of the tip become damaged.

Because of special precision manufacture, these lathe centers are guaranteed



Carbide tipped center and half center

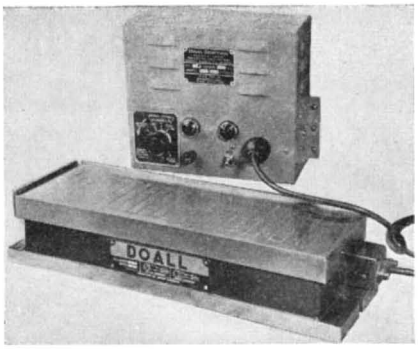
to a concentricity within 0.0002 inch or less, permitting finish grinding and turning to closer tolerances, and will hold this accuracy for a long time, due to the wear resistance of the carbide tip.

VERSATILE MAGNETIC CHUCK

Two new and related products—the DoAll electro-magnetic chuck and the DoAll Selectron, a revolutionary new current rectifying and demagnetizing unit—are made by Continental Machines, Inc. This combination, chuck and Selectron, improves and eases difficult grinding operations. Here for the first time the amount of magnetic pull of the chuck holding the work to be ground is under the control of the operator. The DoAll Selectron uses electronic power to control the flow of magnetic pull in the chuck and to demagnetize the chuck when the work is to be removed.

The DoAll chuck incorporates many features of construction which are unique in chucks of the electro-magnetic type. The entire unit is made of cast steel with high permeability to provide the maximum of work-holding power with the minimum of current consumption. All parts are precision ground before assembling for positive contact between the parts of the magnetic circuit, thereby eliminating power-wasting air gaps.

The working surface of the chucks



Magnetic chuck and control

are ground to mirror finish with the sides and ends square and parallel so that they form a base to aline the work piece when using the adjustable stop plates on the end and side of the chuck.

The Selectron is an electronic device utilizing tubes for full-wave rectification of alternating current in supplying direct current to the chuck. When demagnetizing, the current is alternately reversed and reduced by the Selectron to withdraw all residual magnetism from the chuck.

This entire process of demagnetizing requires but a few seconds, after which the work is easily removed from the chuck without pulling it against residual magnetism. This saves considerable time in locating the work on the chuck preparatory to grinding as well as in the removal of the work after being ground. In addition, all sides of a job can be ground to high finish without danger of scratching when removed from the chuck.

BRUSH CLEANER

HIGH-PRESSURE research seeking relief from the scarcity of essential products has achieved signal success in the case of the humble paint brush, especially the rock-hard, ready-for-discard kind of brush. The relief agent is a new and different sort of cleaner known as Prestorer. Acting on a different principle from established solutions, Prestorer is reported to be potent, easy to use, economical, and non-hazardous.

Unlike tires, paint brushes cannot be recapped, but by the simple use of Prestorer they can be reclaimed, their lives prolonged, and their mileage records tremendously increased. The use of this cleaner is simplicity itself. All one has to do is to immerse the bristles in the solution. Recently used brushes become clean in a few hours; "hard as rock" old timers cleanse themselves in from 12 to 96 hours. The oldest and toughest of brushes obtain a new lease on life, while frequently used brushes are kept young and free from the slow death that comes from allowing paint to harden in the base.

According to the manufacturers, Technical Development Laboratories, Prestorer will not injure the hands for it contains no high-powered caustic alkalies; it is never a fire hazard since it is non-inflammable. It may be used safely in poorly ventilated rooms, for it gives off no poisonous fumes.

The action by which Prestorer does its work so efficiently is interesting. It

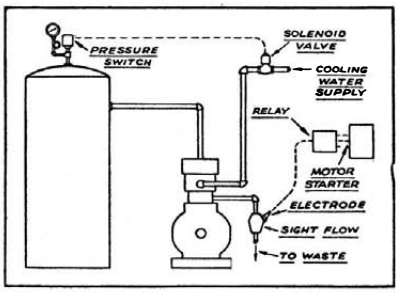
lies in the absorption of part of the solution by the bristles. The bristles swell, causing the hard paint pigment to crack off. After drying, the swelling disappears and the bristle returns to normal size without injury. Since the pigment is not dissolved the solution may be strained through cheese cloth every once in a while and thus is kept clean for reuse.

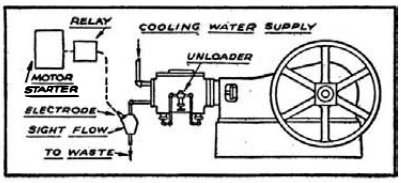
RUBBER BELT SPLICING

BELTING made with the new synthetic rubber from government plants, known as GR-S, can be joined to natural rubber belting with a vulcanized splice. This makes it possible to use sections of the new GR-S synthetic belting to repair existing belting when needed. Standard splicing and repair materials can be used with the synthetic belting.

COMPRESSOR CONTROL

TO PROTECT water-cooled compressors against damaging overheating that results if they are operated without cooling water, and at the same time to prevent unnecessary and costly waste of water, the Johnson Corporation has developed a new automatic compressor control. By permitting the compressor to operate only when water is actually flowing through it, this control guards against failure of water supply from any cause whatsoever, and consequently permits the safe use of automatic water cut-off valves.





Automatic control on compressor (above) and on unloading compressor (below) prevent operation unless cooling water is actually flowing

The new control consists of a sight-flow fitting, mounted in the water discharge pipe of the compressor, which serves as a holder for a metal electrode. When pressure in the receiver falls below the pre-determined level, the pressure switch on the receiver opens a solenoid-controlled valve to admit cooling water to compressor. Compressor is not started until water flows through it and into the sight-flow, completing circuit with the electrode. If for any reason the water supply fails, compressor will not be started or, if operating, will be stopped immediately.

This arrangement of the control is designated as Type M. By supplying cooling water only while compressor is actually operating, it will prevent costly waste of water in those many installations where cooling water is left running all the time, even though compressor operates only intermittently. The new control is also available as Type U, for use on unloading compressors. It insures that cooling water is flowing before compressor starts, and stops compressor or sounds warning alarm if water supply fails.

ELECTRIC TRUCK CONTROLLER

IMPROVED economy in current consumption is claimed through the use of a new four-speed reversing controller for electric and gas-electric trucks. Experience with this device, manufactured by The Elwell-Parker Electric Company, has shown that when motor current is restricted by introducing resistance on first, second, and third speeds, a wasteful amount of current can be consumed by running the truck for protracted periods on any of these three speeds. The major portion of this possible waste of current is prevented by the new controller, which uses resistance on the first speed only. An additional power saving is attributed to the manipulation of the motor fields, connecting them in series on first and second speeds, which produces greater torque with less current consumption.

INSULATED GENERATOR DRIVE

INDICATIVE of the trend in design of both war and post-war products to save space, to make fewer parts do more work, and to increase general efficiency, is a new splined shaft coupling designed and now being produced for a manufacturer of electric power generators by Bushings, Inc. The coupling is designed to stop the transmission of noise, absorb any shock and impact, and to compensate for misalinement between drive and driven shafting on a 75-horsepower engine-driven generator.

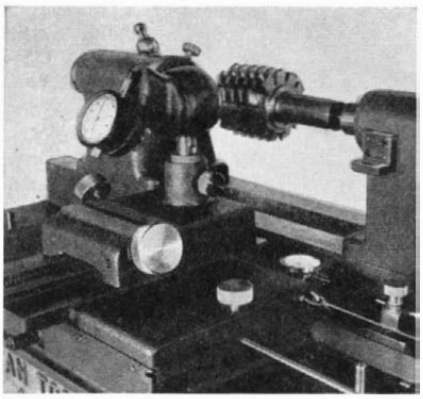
Using synthetic Neoprene as the insulating medium, to permit operation in the presence of lubricant, the new coupling consists of only a splined inner sleeve, a flange, and the separating bushing of synthetic. The new design eliminates a separate flexible coupling and reduces the space that would be required for such a coupling.

The same general design, with either keyway or splines, is capable of handling virtually any load merely by use of the proper hardness and thickness of the rubber or synthetic.

CUTTER CHECKER

A SINGLE machine, designed to check the correct resharpening of hobs or milling cutters, has been added to its "Sine-Line" gear and gear cutting tool checking equipment by Michigan Tool Company.

To simplify setting of indicators for checking rake angle, parallelism, and so on, a ground surface angle block, the top edge of which is in the same horizontal plane as the headstock and tail-



Checking a hob after sharpening

stock centers, and the projecting ledge in a parallel plane, is mounted on the tail-stock and used for initial indicator settings. The projecting ledge is used with "Jo" blocks to set indicator for checking hooked or raked hobs. The indicator base is ball bearing mounted for freedom of movement, and in a plane parallel to the horizontal plane of the centers. Initial settings are accomplished by rolling the indicator opposite the ground surface block, and adjusting the vertical setting of the indicator. "Jo" blocks may be placed on the projecting ledge so that any desired setting may be obtained, on, above, or below center.

After the initial indicator setting, the indicator base is returned opposite the tool for checking sharpening inaccuracies. A small weight, suspended over a pulley, propels the sliding indicator base, when checking parallelism, or lead in the axial plane. A knurled locking screw will hold the base in any desired position.

MARKING WITH DRAW DIES

AN IMPROVED method for marking part numbers onto deep-drawn steel and other parts at no additional cost makes use of precision engraved knockout pads, produced by New Method Steel Stamps, Inc.

The necessary figures and numbers are engraved on the upper surface of the pad itself, making the one piece a combination of knockout pad and marking die. When in use, the knockout pad is backed by springs. It numbers the bottom portion of the stamping during the actual drawing process, and then lifts the finished piece out of the die after the male half of forming die has been withdrawn. The incorporation of a stamping device with a knockout pad in this manner makes possible automatic marking at no extra cost.

TOUGH NUTS TAMED

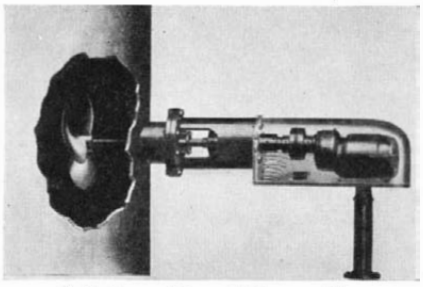
CREEPING into infinitesimal openings, a new chemical combination has already saved time in many war-busy plants and kept hard-to-replace parts from falling under the chisel and hammer. In one case a frozen shaft threatened to tie up production for half a day or more. An application of Kano Kroil resulted in production being resumed in 15 minutes. A bridge had been exposed to the elements for twenty years when the engineer found it necessary to remove some bolts. After applying Kano Kroil the bolts were removed quickly and successfully. Laboratory tests are reported to show that the chemical creeps into spaces as small as a millionth of an inch; actual working tests prove that it saves time, temper, and materials by loosening frozen metal parts quickly and effectively without harm to metal.

LACQUER WAX

SALT SPRAY resistance and moisture proofness of lacquers and varnishes can be greatly increased by the addition of small percentages of Acrawax C, powdered, a synthetic wax produced by the Glyco Products Company, Inc. Unlike natural waxes, Acrawax C does not retard the drying properties of the lacquer or varnish. The Acrawax C, powdered, should be treated as a pigment and ground into the resin. The clarity of the varnish is unaffected.

NEW TANK AGITATOR

OUTSIDE repacking without draining the tank and without loss of liquid, is one feature of a new side-entering agitator introduced by H. K. Porter Company, Inc. The outside repacking



Agitator with outside packing

can be done in five minutes, saving many man hours as well as the expense of draining the tank, airblowing it in cases where toxic fumes make this necesary to permit a workman to enter, and then pumping back the fluid after the packing has been replaced. This is accomplished by using an external packing gland and a seal attached to the shaft inside the tank which is drawn into a seat, hermetically sealing off the tank's contents.

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.)

THE CHEMICAL DIGEST is a semi-annual publication which reviews briefly progress in the chemical industry as seen from the standpoint of the research worker. *Foster D. Snell, Inc., 305 Washington Street, Brooklyn 1, New York.—Gratis. Request this on your business letterhead.*

INDUSTRIAL APPLICATIONS OF "NATIONAL" AND "KARBATE" CARBON AND GRAPHITE PRODUCTS is a 16-page brochure covering these types of materials as supplied in various structural shapes for a number of applications. *National Carbon Company, Inc., P. O. Box 6087, Cleveland 1, Ohio.—Gratis.*

QUALITY CONTROL is a 64-page, fully illustrated booklet covering more than 24 subjects essential to scientific inspection for quality control in industrial plants. Various types of measuring instruments are shown and described, together with their use in every-day production. A number of tables present data pertaining to precision gaging methods. *Continental Machines Inc., 1301 Washington Avenue South, Minneapolis, Minnesota.—Gratis.*

FUEL SAVINGS RESULTING FROM CLOSING OF ROOMS AND FROM USE OF A FIREPLACE is a 36-page booklet outlining the results of studies made on fuel savings, giving the methods and results. Several diagrams, charts, and tables are included. Request Bulletin 348. *The Engineering Experiment Station, University of Illinois, Urbana, Illinois.—40 cents.*

BRITAIN SEES IT THROUGH is a 44-page illustrated report by Frank Gannett, compiled as a result of an inspection tour of American and British army encampments as well as many parts of civilian Great Britain. It is designed especially as a morale builder. *Florence Messman, Secretary, Gannett Newspapers, Rochester, New York.—Single copies gratis, quantities available at 50 cents per hundred.*

THE RIVNUT is a 12-page manual on this internally threaded and counterbored tubular rivet. All details are given including sizes, description of tools, and instructions for application. *The B. F. Goodrich Company, Akron, Ohio.—Gratis.*

MILLING STEEL WITH CARBIDES is a 14-page illustrated technical manual giving detailed information on the high-speed milling of steel with cemented carbide tipped cutters. All of the material presented here is based on practical field work, making the manual a useful guide for handling nearly every type of milling job. Bulletin No. GT-174. *Carboloy Company, Inc., Detroit, Michigan.—Gratis.*

RESULTS WITH TOCCO is a 32-page, well-illustrated booklet covering 16 industrial uses of high-frequency electrical induction for such purposes as heating aviation propeller blades for forging and annealing steel shell cases. Information on the construction of Tocco machines, a brief summary of the process, and its metallurgical effects are given. *The Ohio Crankshaft Company, 3800 Harvard Avenue, Cleveland 1, Ohio.—Gratis.*

GLUE RECOMMENDATIONS FOR U.S. GOVERNMENT SPECIFICATIONS is a chart 11 inches wide by 29 inches long, printed both sides, which lists various types of adhesives, their uses, and the glue requirements which must be met in different applications. *Casein Company of America, 350 Madison Avenue, New York 17, New York.—Gratis.*

KITCHEN PREDICTIONS is a 16-page illustrated booklet which outlines the practical new glass, plastic, and metal products which will be a part of the "dream" kitchen of tomorrow. Glass containers for food and medicine are stressed. *Owens-Illinois Glass Company, Toledo, Ohio.—Gratis.*

HOW TO GET THE MOST FROM YOUR PORTABLE ELECTRIC TOOLS is the title of a special section in a new catalog just issued by an electric tool manufacturer. This maintenance manual is designed as a thorough guide to greater production and longer tool life. *Skilsaw, Inc., 5033-43 Elston Avenue, Chicago 30, Illinois.—Complete catalog gratis.*

CHEMICALS BY GLYCO is a new 144-page catalog, complete with formulas and tables of useful chemical and physical data, which has been completely brought up to date in its listing of plasticizers for synthetic rubber and resins, and esters used in a number of chemical processes. *Glyco Products Company, Inc., 26 Court Street, Brooklyn 2, New York.—Gratis.*

STEEL PRODUCTS MANUAL is a 215-page booklet giving instructions for packaging, marking, and loading steel products for overseas shipment. *American Iron and Steel Institute, 350 Fifth Avenue, New York, New York.—$2.50.*

PACEMAKERS IN PRECISION is a four-page pamphlet which sets forth some of the new uses for surface plates, such as spotting. Standard sizes and weights are listed, as well as special sizes. *The Herman Stone Company, 1238 Leonhard Street, Dayton 4, Ohio.—Gratis.*

FUELS OF THE FUTURE is a 27-page pamphlet which surveys fuel reserves of the United States and offers a glimpse into the probable future of various natural and synthetic fuels. *Battelle Memorial Institute, Columbus, Ohio.—Gratis. Please request this bulletin on your business letterhead.*

Our Book Corner

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

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INDUSTRIAL MANAGEMENT

By Asa S. Knowles and Robert D. Thomson

DIVIDED into six separate but integrated parts, this text is an outstanding attempt to cover the whole broad subject of industrial management in its multitude of aspects. The sections cover: Introduction to the study of management; management of physical property; organization of the physical plant; management of manpower; production control; and cost control. Each section ends with a group of review questions and problems. A selected bibliography will help the reader who wants to dig further into some specific aspect of management. (791 pages, 6 by 9 inches, over 300 illustrations.)—$4.60 postpaid.—*A.P.P.*

CHEMICAL SPECTROSCOPY

By Wallace R. Brode

SINCE 1939, when Professor Brode's book was first published, the study and applications of chemical spectroscopy have increased greatly. This second edition becomes one of a very few general treatises which are readily available today. While familiarity with general and analytical chemistry on the reader's part is assumed, many who have not formally covered these courses find and have found that they can make good use of it as an aid, but it is not an elementary work in a popular sense. Its first 397 pages cover methods and theory and give a large bibliography. The chapter on the apparatus does not tell how to make it; no book does. The remaining pages are occupied chiefly by working tables of lines and by spectrum charts. (677 pages, 5½ by 8¼ inches, many illustrations.)—$7.60 postpaid.—*A.G.I.*

SHOPWORK

By Edward C. Wicks, John Poliacik, Jr., and John Ellberg

HOW to use all the tools common to wood working and metal working is the basis of this text prepared to conform to the Preinduction Training Course laid down by the War Department. Its utter simplicity will appeal to those who want to be able to handle tools correctly, yet have never had access to a suitable guide. General subjects covered include: Wood working; measuring and gaging; metal working; wiring and wire splicing; ropes; splices and knots. (160 pages, 6½ by 10 inches, 139 illustrations.)—$1.20 postpaid.—*A.P.P.*

WORLD WIDE PLANISPHERE

By Wm. H. Barton, Jr.

OF ALL the star and constellation finders thus far devised, this one seems the most versatile, yet it is simple. Over neat, orderly, attractive, eight-inch, black-on-white, centrally pivoted, rotating constellation maps with hour circles you fold any one of four attached cut-out masks for the latitudes 20, 40, 60, or 80 degrees, wherever you are, and there is your sky aspect. Since there is a second constellation map for the southern hemisphere you can go all the way from Spitzbergen to Antarctica on this elastic planisphere. In addition, there are two corresponding rotating maps for navigators, showing navigation stars and trans-constellation guide lines. An auxiliary table gives planet positions 1943-52. This ingenious new star finder was devised by the Curator at the Hayden Planetarium, New York. (10 by 10½ inches.)—$2.60 postpaid.—*A.G.I.*

ILLUSTRATED TECHNICAL DICTIONARY

By Maxim Newmark

STANDARD technical definitions of current terms in the applied sciences, graphic and industrial arts, and mechanical trades, are here presented in quite comprehensive form. The word "illustrated" in the title may lead the reader to expect more than he actually gets; however, there is a sufficient number of illustrations to be of assistance in some respects. (352 pages, 6 by 9 inches.)—$5.10 postpaid.—*A.P.P.*

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By D'arcy Wentworth Thompson

NEW edition of a famous work long out of print and long available only at second hand and at fabulous prices. It occupies an area of science where

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MACHINERY'S HANDBOOK — ***12th Edition.*** "Bible of the mechanical industry," 1815 pages of latest standards, data, and information required daily in the shop and drafting room. **$6.10**

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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"

FREEDOM from vibration in a telescope is usually secured—or partly secured, since this is a relative term—at the expense of added weight and loss of portability. Lyle T. Johnson had built his first telescope when in high school and found it vibrated badly in the slightest breeze. Later, when an undergraduate at the University of Wisconsin and majoring in physics, he resolved to beat the vibration devil but at the same time found that he required a portable telescope. Often these two aims tend to conflict. Figures 1 to 4 show how he worked out this practical problem on an 8″ reflector.

He lived in a university dormitory with a flat deck roof and could store his telescope in the attic. To use it he had each time to carry it in five knocked-down parts up a ladder, through a small trap door in the roof, and assemble it on the roof, reversing the same patient processes after observation. He built the telescope mainly of wood, and its knock-down was made possible by removing five wing nuts and loosening some others.

The pier is made of two-by-fours and opens up like a jaw when the wing nuts that attach the diagonals (Figures 1, 2) are removed. Polar axis drops out.

The polar axis is a composite of steel and wood. Apparent in the photographs is its box truss made of one two-by-ten, two two-by-sixes, and a two-by-four, the first three of these being neatly tapered. Within this box truss is a 1¼″ steel shaft with a two-roll ball bearing at either end. Later, when a clock drive is added, it will drive the shaft continuously but the wooden truss will be movable on it to permit pointing the telescope at different objects.

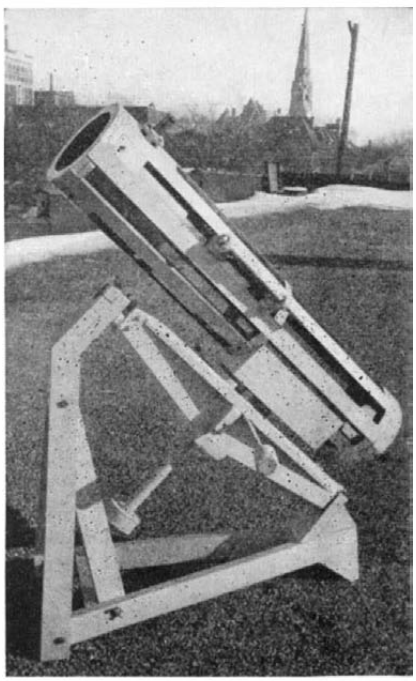

Figure 1: Johnson's reflector

The declination axis is 25″ of 1¼″ shafting with a narrow 9″ pulley on the tubeward end, to which the tube cradle (Figure 3) is attached. This pulley rolls on three ball-bearing rollers (Figure 4) mounted on the wooden truss of the polar axis and there is a second bearing on the opposite side of the truss. The end thrust is taken by brass plates on the truss and there is a simple wooden declination clamp.

Because two things cannot occupy the same space at the same time, the 1¼″ declination axis had to be offset 1¼″ from the 1¼″ polar axis shaft. This

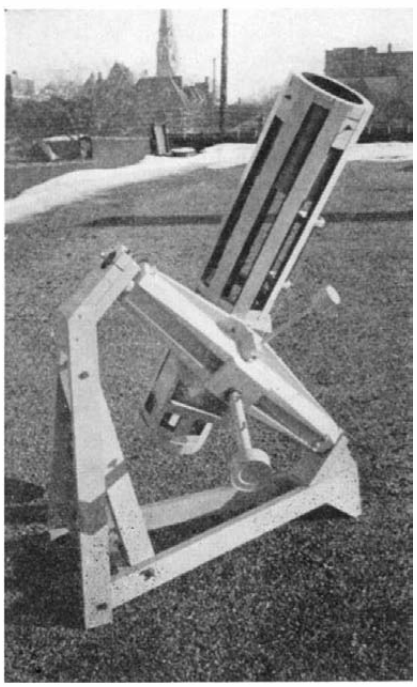

Figure 2: Note polar axis

necessitated the addition of a small auxiliary counterweight and this, Johnson states, was found to vibrate when touched—a pointer for others.

The tube is all wood, made of eight pieces each ¾″ by 2¼″, attached to three doubled, grain-crossed, and glued wooden rings. The cell is also of wood. The tube is attached to its cradle by means of four wooden turn-buttons with wing nuts to snug them up. If, during observation, the eyepiece position becomes awkward, it is but a moment's work to remove the tube, rotate it in the hands and re-attach it in a new position—a fairly good and simple substitution for a turning ring.

The mirror will pass the diffraction test, Johnson says, and when analyzed by the Wright method ("A.T.M.", p. 257) the maximum departure is less than half a millionth inch. It is mounted on a three-point support.

The telescope is now at the Washburn Observatory, University of Wisconsin, Madison, Wisconsin, where it is used by members of the Madison Astronomical Society. Johnson (Box 236, La Plata, Md.) is now a Junior Physicist at the National Bureau of Standards.

The impression created by close examination of the original photographs under a glass is that all details of this telescope are neat and shapely—there

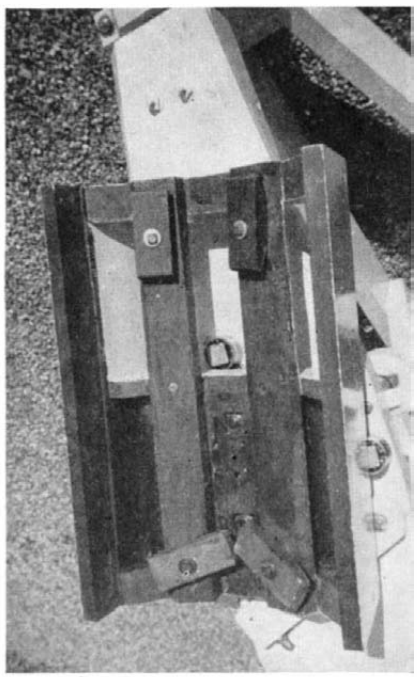

Figure 3: Cradle and buttons

are no cobbled-up messes—yet the cost of such a mounting should be low. This telescope is not presented as spectacular or remarkable but rather as one good, inexpensive model for a solid telescope of modest size that is within the range of the average beginner or near beginner—near beginner because it perhaps is best, all things considered, deliberately to cobble-up the first telescope and use it for a time in order to let certain practical facts sink in. As Johnson says, "This 8″ telescope is superior in every way to my old 6″, due to the application of experience gained in the construction and use of the first one."

STILL another variation on the original theme of the conventional pitch lap is offered by C. R. West, Timpas, Colorado, who simply ladles melted pitch on the tool from a spoon and in the desired pattern of pitch and spaces. If the pitch is placed in the correct quantities at the correct places, no channeling is necessary—just some preliminary re-heating and pressing to spread it and flatten it.

First attempts at such a lap probably wouldn't look exactly artistic but practice teaches much. For a regular polishing lap West extends a number of parallel wavy lines continuously across the lap and finds it produces a smooth mirror surface free from zones. For mirror defects he pours special laps having whatever outline he wishes. It's all quick and simple.

In the kitchen the ladies add frills to cake frostings with a kind of squirtgun loaded with sugary goo, and something of this kind might be used for

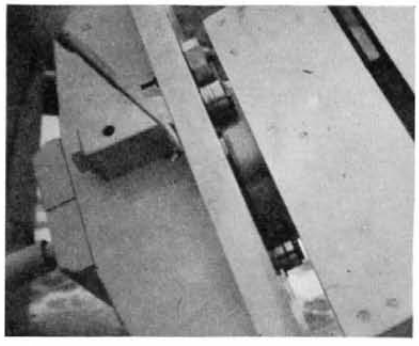

Figure 4: Pulley and rollers

making laps similar to those of West; or this may be only a half-baked idea of your scribe's. It hasn't been tried out. A danger would be from explosion if a load of chilled pitch in it were remelted incautiously. One amateur spent several helpless weeks with his hands in big bandages as a result of applying heat to the bottom of a can of pitch. As the bottom layer melted and expanded, the pitch had no place to go and the can blew up in his face. He was really pretty seriously injured. Thereafter, when re-melting pitch in a container, he started by melting an escape channel from the top down, at one side. Worth remembering, he thinks.

THIS MONTH we have a new addition to the turret telescope family, a simple refractor (Figure 5) with an auxiliary optical flat, designed by Winston C. Juengst, New York, N. Y.

As in all turret telescope designs, Juengst's idea aims at comfort and ease of observation, as a turret is sealed equally to winter's cold and summer's 'skeeters. A simpler and neater design, from both optical and mechanical standpoints, is the chief contribution.

In Juengst's design only one extra optic, in addition to the usual refractor, would be required. This is an aluminized optical flat about 1.5 times as large as the O.G. diameter. As Porter well emphasizes, such a flat would have to be a good one, say to a tenth wave or better. However, a good reflecting telescope should be made to one eighth wave to give maximum performance, so this should not stump anyone who can make a first class reflector. Furthermore, the flat will be a valuable aid in constructing the O.G., so the same effort will serve two purposes.

Other advantages to the design are fairly obvious. All parts of the heavens and horizons can be reached with ease, and with the eyepiece always in a comfortable position below the horizontal. A large part of the telescope is within the turret, rotating upon its own axis for the declination setting, hence awkward projecting parts and weights are avoided. Both axes are as stable as could be desired, hence both ease of operation and steadiness are assured, if the construction details are well attended to. The instrument is made ready for instant use merely by removing the cap from the flat housing. Auxiliary instruments, such as a camera or spectographic equipment, may easily be supported by the turret at the focus.

Two amateurs to whom the above description was shown, previous to publication, debated about it thus:

Nip: "This turret reflector of Juengst's is really a modified Hartness telescope in principle; see 'A.T.M.', page 50. What Juengst really does is to push Hartness' diagonal out to and beyond the objective. The telescope would be simpler to make than the Hartness type, but is not so stable; also, errors in the small flat would be magnified more than in the Hartness type with diagonal close to the focus."

Tuck: "Nip is partly right. However, most of the turret and related systems in 'A.T.M.' page 50 do just this. The Gerrish telescope at Harvard is identical optically to Juengst's. It is an old-timer, and appears to have been a success. The use of a flat outside the objective is old stuff, not a radical new idea."

The Nip-and-Tuck debate was then referred to Juengst who commented: "The only reasons I submitted this idea were to provide a more elegant design mechanically, free from overhanging tubes, big counterweights, and so on; also to stimulate post-war trends toward turret telescopes, especially refracting types. Too many good observ-

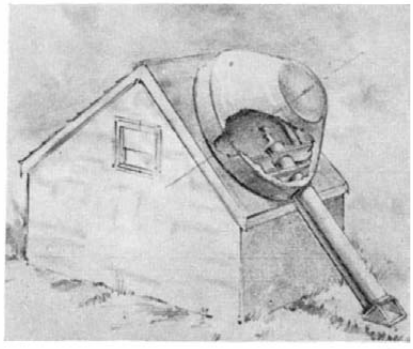

Figure 5: Juengst's proposal

ing nights are lost because one's courage is not equal to the weather. The standard tolerance for a plane outside the O.G. is 0.1 wave. Anyone competent to do a good job on the rest of the telescope should be able to make a flat of that quality. But I can't see how this design resembles the Hartness turret."

Unfortunately, on March 25, after the above item was prepared, Juengst died. He had turned professional, and was doing optical ordnance work for the Navy. He was one of our earliest amateur telescope makers and came annually to the Stellafane conventions from the time he was a boy, 15 years ago. He was a graduate optometrist, University of Rochester.

INDEX TO VOLUME 170, JANUARY—JUNE, 1944

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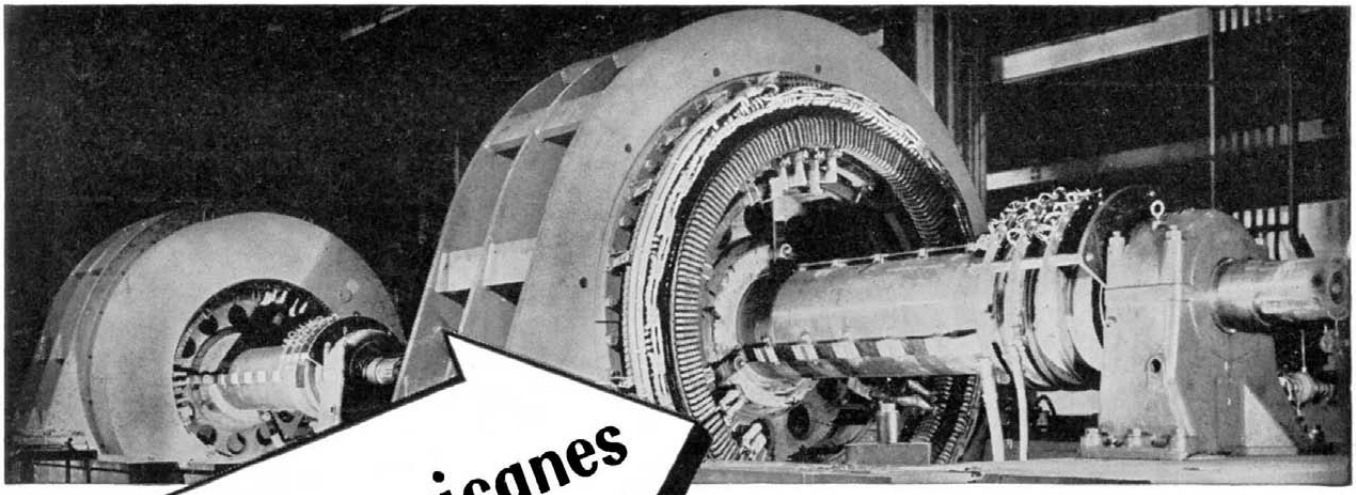

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