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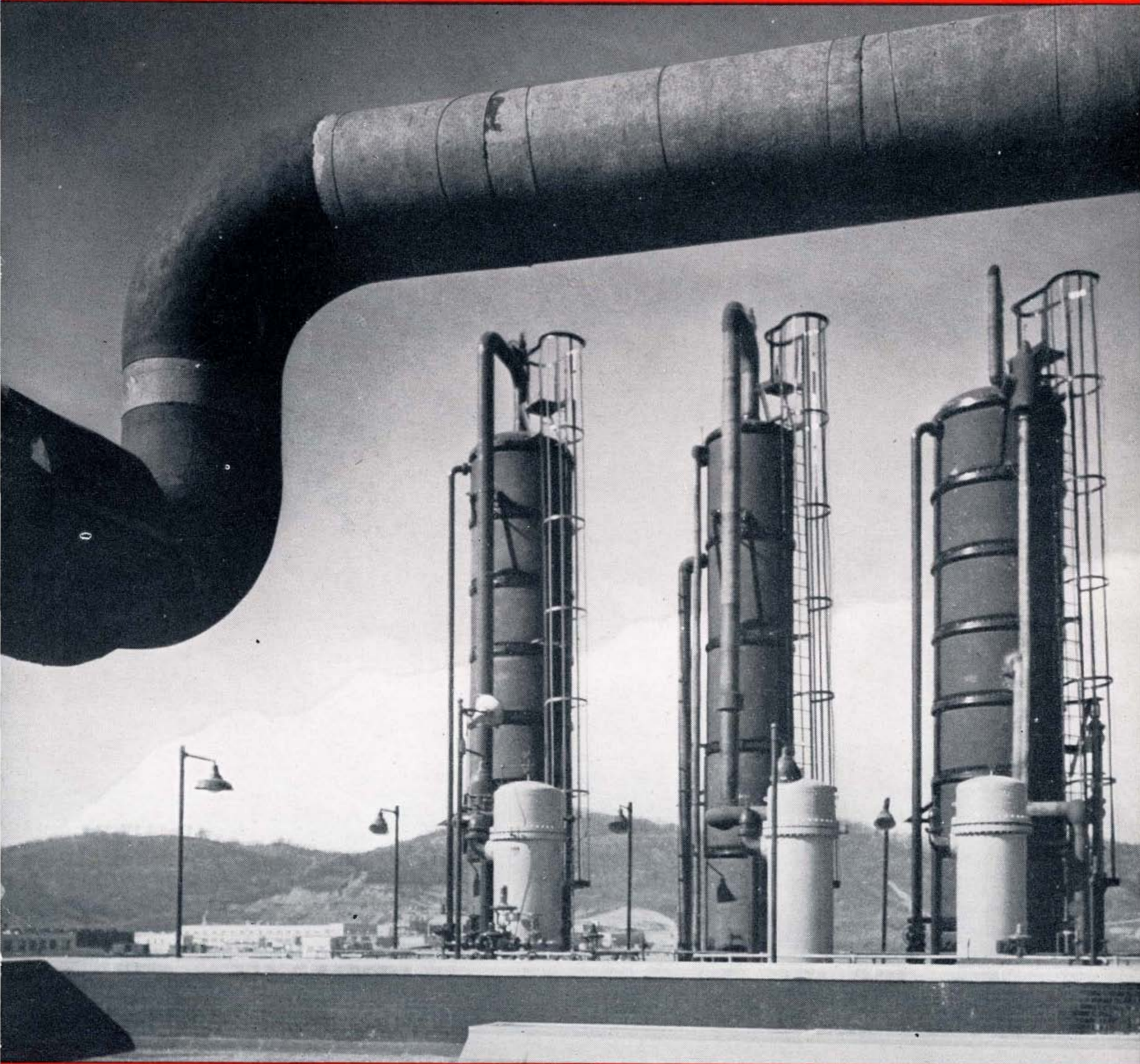
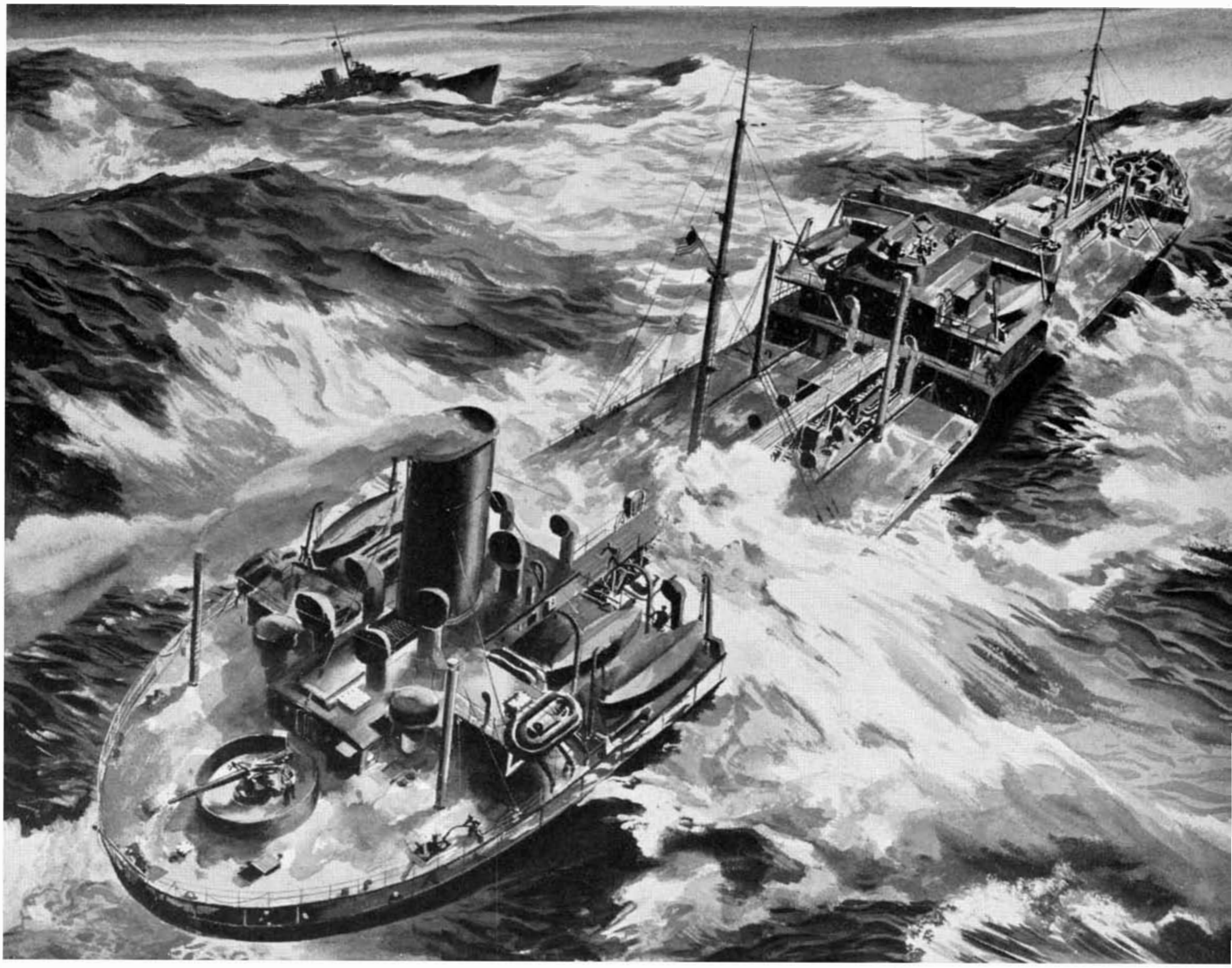
EPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



Starting Point for Synthetic Rubber . . . See page 49



A big tanker like this can carry about 6,300,000 gallons of aviation gasoline. That gallonage of automobile gasoline would be enough normally to supply all the motorists in a city the size of St. Louis for three weeks. And this is but one ship out of the vast fleet now supplying United Nations' fighting forces.

6,300,000 Gallons of Air Raid

... on its way to Berlin

▶ It's easy to see why there's less gasoline in the U.S.A. for civilians.

Also why there's less Ethyl fluid available for your gasoline.

For every gallon of fighting grade aviation gasoline contains a generous portion of Ethyl antiknock fluid. Today, not only is more Ethyl fluid needed for more aviation fuel, but more of it is going into each gallon.

What happens after the war—when most of this high octane gasoline can stay home? You'll have gasoline for *your* automobiles, trucks, buses and farm tractors of higher quality than ever before. And when engines are designed to take full advantage of high-octane fuels, you'll get more work, more power, more economy out of every gallon.

In this post-war development, through its laboratories in Detroit and San Bernardino, the Ethyl Corporation is prepared to play a special part. Though we are not directly engaged in the manufacture of fuels, engines or engine parts, we belong to both the oil and automotive industries. Thus we will be able to co-operate with both groups; to help them unite their individual efforts toward the ultimate peacetime goal of making future transportation better and cheaper.

* * *

ETHYL CORPORATION

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

CHRYSLER BUILDING, NEW YORK CITY

Scientific American

Founded 1845

CONTENTS • FEBRUARY 1944

COVER: Synthetic rubber for automobile tires, and other uses, presents a complex problem involving not only technology but economics and politics as well. An over-all picture of this subject is presented in the article starting on page 58 of this issue. Basic ingredients of one type of synthetic rubber are butadiene and styrene, large quantities of which are being produced in a plant at Institute, West Virginia, part of which is shown in our front cover illustration. This plant was built for the Defense Plant Corporation and is being operated for the Rubber Reserve Company by Carbide and Carbon Chemicals Corporation, a unit of Union Carbide and Carbon Corporation. Butadiene is made from grain alcohol at this plant, while the styrene is made from benzene and ethylene gas.

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Previews of the Industrial Horizon

By A. P. Peck

SHALL RESEARCH BE REGIMENTED?

THERE IS no need to hold forth here on the value of research to the world in general; the technological progress of industry is ample proof of that value. Despite this, however, there is now before Congress a vicious bill—the Kilgore Bill (S. 702)—which, if it becomes law, will throttle without mercy those incentives which have always been the very basis of industrial research and its resulting benefits to mankind.

Briefly stated, the Kilgore Bill would create, under the guise of war-time need, an omnipotent "Office of Scientific and Technical Mobilization" for the alleged purpose of correlating and disseminating the results of research, purportedly for the benefit of everyone, as well as for conducting research programs under its own government-controlled wing.

On the face of it, as is usual with much ill-advised legislation, some of the objectives of this Bill appear to be worthy of support. But more intensive study reveals many undesirable features. What the terms of the Bill could easily bring to pass, in war or peace, would be complete domination, control, and regimentation of *all* research, removing this vital work from the hands of private enterprise and concentrating it under a political set-up. This would unquestionably spell the doom of our established system of free enterprise and industry. Take away the research facilities of industry, place them in the hands of appointed governmental employees, where initiative and incentive are lacking, and you destroy the very backbone of progress.

Then, too, the proposed OSTM would provide an ideal pork-barrel, subject to the whims of the party in power, from which would be drawn far more parasitical political patronage than scientific and technological progress.

There are only a few, a very few, highlights of this proposed legislation and its outrageous shortcomings. If the Kilgore Bill becomes law, the people of this nation are going to pay through the nose. Research will be stultified—as so often has been the case in isolated attempts at government-controlled research. Progress under such an all-inclusive program would come slowly if at all. And industry, under such law, would find itself severely handicapped, to say the least, in the application of research—the one most important tool which it has developed through the years to a point where it has paid huge dividends to industry and to the public alike.

Here, then, in the Kilgore Bill, is an attempt at all-embracing regimentation at its political worst. Efforts to abort the Bill will be efforts directed toward the upholding of the American Way.

SURPLUSES ONCE MORE

RECENTLY reported and verified metal surpluses are giving rise to optimism in some quarters. Stock-piles, both private and governmental, of aluminum, copper, molybdenum, magnesium, cobalt, steel, and others, are full to overflowing, full beyond any emergency and immediate needs. Because of existing controls, however, it is doubtful whether much of these metals will find their ways into even essential civilian uses for some time to come. Still too close for forgetfulness are the hectic days of drastic shortages; still too far off is the certain outcome of the war.

WHEN THE GAS TURBINE?

FIRST proposed a century and a half ago and periodically "re-invented," the gas turbine still largely evades the grasp of the engineer. Recently, much publicity has been given to this form of prime mover, resulting in a number of misconceptions and false impressions. True enough, a few gas turbines have been built and are in operation, but only in large sizes where their efficiency rises to reasonable values. But in smaller sizes—as for motor cars and small planes—the gas turbine still remains in the indeterminate future.

Limiting factor in the design and construction of gas turbines, as mentioned in the article on page 73, is lack of knowledge about materials for use at high temperatures. And strangely enough, as greater knowledge is gained in this field, it is equally as applicable to increasing the efficiencies of steam turbines and Diesel engines as it is to the problems of the gas turbine. When competitors thus gain equally, the net result is maintenance of *status quo*.

The technological race still goes on, and while the time may approach when the gas turbine will be able to compete on equal footing with established prime movers, it is as yet beyond the horizon.

ANOTHER USE FOR CANS

WHILE on the subject of metals, this is as good a place as any to note, for future consideration, a use for tin cans that will create a new market for these ubiquitous containers. When metals are once more available for these lowly cans, they are going to crack the field of packaging dehydrated foods. The tremendous amount of study that has gone into this type of food and the lessons that have been learned the hard way about troubles with them, all point toward the need for more perfect packaging. Cans can do this job. File this prediction until after the war is over.

DOWN ON THE FARM

MECHANIZATION—real and thorough mechanization—of the farm is one of the bright spots for heavy industry in the future. Already proved are new designs for highly efficient self-propelled combines, cotton pickers, sugar-beet harvesters, and a host of other machines. One machinery manufacturer, going whole hog, has set for himself the goal of producing a complete set of mechanized tools for the small farm, the whole to sell for not more than $1000.

BUILDING BOOM

ESTIMATES from informed sources indicate that there will be a potential demand for almost 1,000,000 new private dwellings per year for at least five years after the war. Here alone is one market where new materials, new products, new methods, will find an outlet for the greatest good for the greatest number.

PAINTS FOR MANY PURPOSES

PIGMENTS with vastly increased hiding powers, more effective rust-inhibiting primers, improvements in resin-base paints that are thinned with water, infra-red reflecting paints—improved surface finishes for many uses—are some of the things to be looked for in the not far distant future.

Most interesting of these things to come is the infra-red reflecting paint, since it not only serves the usual purposes of a surface coating but is otherwise valuable. Buildings painted with it are cooler when the sun shines directly on them; evaporation from storage tanks for gasoline and other volatile liquids is reduced through its use; and other heat-reflecting problems can be solved with it.

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of February, 1894)

CANAL TROUBLES — "The Panama Canal still remains in a state of ruin. An extension of the concession has been obtained from the Colombian government up to October, 1894, and attempts have been made to form a new company to go on with the work, but so far without success. The Nicaragua Canal is also in difficulties. Owing to the state of financial matters in America, it was found impossible to raise money to go on with the work, and in order to protect the works and plant, the Nicaragua Canal Construction Company was placed in charge of a receiver."

QUICKSAND FOUNDATIONS — "A novel method of making foundations in quicksand was described by Mr. F. Neukirch. . . . The sand on which the foundation is to rest is converted into solid concrete by blowing into it, by air pressure, dry cement in powder. . . . The concrete formed in this way takes several weeks to harden, and requires months to attain its full strength."

ICE — "The Knickerbocker Ice Company, of Philadelphia, for many years engaged in the business of harvesting, delivering, and shipping ice . . . has recently established in Philadelphia a large plant for making ice artificially. . . . This new establishment . . . has a capacity of sixty tons of ice daily. The company has sought to make this plant a model one for the production of artificial ice."

COATING ALUMINUM — "At a recent meeting of the Berlin Physical Society, Professor Neesen demonstrated a method of coating aluminum with other metals. This consists in dipping the aluminum in a solution of caustic potash or soda. . . . The metal is then placed in a solution of salt of the desired metal. A film of the latter is rapidly formed and is so firmly adherent that, in the case of silver, gold, or copper, the plate can be rolled out or polished."

WATCH — "A remarkably cheap watch has just been put on the market by Messrs. R. H. Ingersoll and Brothers. . . . It is a stem winder and setter, American lever, 240 beats to a minute, steel pinions, patent escapement and regulator, and dust-proof case, handsomely finished in nickel or gilt. The watch is fully guaranteed for one year."

WIRING — "The underground electrical conduits in New York City have now a length of 1,667 miles. In these conduits there are about 32,600 miles of telephone and telegraph wires and 1,300 miles of wires for lighting purposes, with which about 6,790 arc lights and 268,000 incandescent lamps are connected."

MANGANESE STEEL — "Manganese steel plowshares wear six or seven times longer than chilled cast iron shares. . . . It is believed that chilled cast iron railway wheels run about one-third the mileage of manganese steel wheels before the first turning."

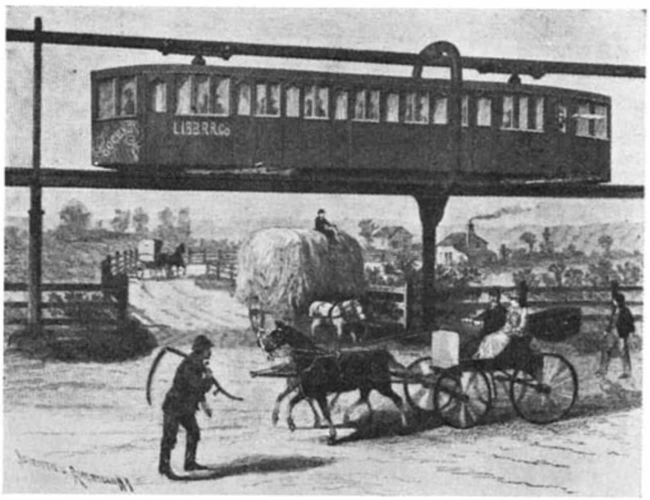
INDUSTRIALISTS — "It has long been our boast that America was able to produce better results in the technical field than those due to any other nation; even where hand work is concerned, this is believed to hold true in many respects. . . . It has long been remarked that where originality and an ability of thinking and working on independent lines is involved, the foreign highly specialized workman yields to the more independent American mechanic, as to one less hampered by tradition. Thus we find our country abounding in self-made men who began at the lathe and bench, and now own and conduct great factories. Their independent habits of thought have opened for them their careers."

TRANS-CHANNEL — "There is at the present moment a question of a new project having for its object the connection of the European continent with England by railway. . . . The solution under consideration is proposed by Sir Edward Reed, a member of the English Parliament and engineer in chief of the Admiralty. His project consists in the establishment, under water, of one or more metallic tubes capable of giving passage to a railway. . . . In case of war, there would be numerous means of inundating the tubes immediately."

ALLOY — "Mr. H. N. Warren, of Liverpool, England, has been experimenting lately with aluminum bronzes, and has found that the presence of a very small admixture of boron makes a denser and more durable alloy. This aluminum boron bronze casts and melts well, and is free from some drawbacks met with in working with the ordinary aluminum bronze."

TELEPHONE — "On the 30th day of January, 1894, the Bell telephone patent expired and the invention became the property of the public; so that whoever desires to do so can make, buy or sell telephones without fear of infringing the rights of any one. This applies only to the hand instrument now used as a receiver. Patents for other telephone apparatus still remain in force; but enough is available for actual service."

BICYCLE RAILWAY — "The need of the day is rapid transit. Steam, cable, and trolley cars each in their own degree contribute to this end. The illustration shows one of the developments in true rapid transit—the Boynton Electric Bicycle Railroad—of which a line is now in process of erection across Long Island, from Bellport to the Sound. The idea of the bicycle railroad is to provide a system of transit whose speed may be from seventy-five to one hundred or more miles an hour. Air resistance being one of the most adverse factors at this velocity, a car of small cross sectional area is preferable. The inequalities of two parallel lines of rail is also a factor of resistance. In the railroad in question a narrow car with sharpened ends is employed, and is mounted upon two wheels, one at each end, and travels upon a single rail. It has the equilibrium of the bicycle, and like the latter disposes at once of the violent transverse wrenching strains which affect four-wheeled vehicles of the everyday type. It is peculiarly well adapted for electric propulsion, the overhead rail giving a place for the current main."



BEET SUGAR — "The problem of handling waste waters from beet sugar factories is by no means settled. The water residuum, most to be dreaded, comes from the diffusion battery and pulp presses. In some special cases, where there is a scarcity of water, this waste water must be used over again. Notwithstanding the precaution of purification, such as employed, after a reasonable time the salts, etc., not eliminated give considerable trouble during manufacture."

A NEW RESOURCE
HAS BEEN DEVELOPED

THE WEALTH of America has been wrought from her natural resources of fertile lands, wide forests and rich mineral deposits by the brains and muscles of her people.

But another resource is now available. A new source of wealth and well-being has been developing gradually and almost unnoticed which is tremendously important today and of still greater importance for tomorrow.

This new resource is the research laboratory.

Today, in hundreds of industrial and college laboratories, trained minds are expanding the world's knowledge, and applying the results of research to industry and to war.

In the Bell System, research has always been a fundamental activity. The telephone was invented in a research laboratory. And for years Bell Telephone Laboratories has been the largest industrial laboratory in the world.

Underlying modern research is the realization of vast latent values in nature. Although the lone genius does from time to time bring to light some part of these hidden values, only organized scientific research can assure the thorough exploration that will render the full measure of use for human welfare.

Research means imagining and experimenting. It means the searching out and bringing together of facts. It means clear statements of problems, precise measurements and keen analysis. It means tenacious following along unexpected paths.

These are the procedures of research. Its consummation is the grasping by subtle minds of relationships in nature no one has previously known. And on the basis of the broader knowledge so established are built new materials, new methods and new structures to serve the people of America.

The Bell Telephone Laboratories has now concentrated its efforts on communication systems and equipment for the armed forces. When the war is over its researches in communication will again be applied to an ever-improving telephone service in America.

BELL TELEPHONE SYSTEM

"Quotes . . ."

"FOREIGN and domestic demand indicates that post-war business will attain record proportions. The necessary controls, however, must be applied with discretion and understanding. There must be no ceiling upon the successful prosecution of business enterprises if we are to achieve full re-employment of the men in the Armed Services." Lawrence Ottinger, President, United States Plywood Corporation.

" " "

"GRATIFYING PROGRESS has been made in the war on accidents. But the battle against carelessness still is far from won, and even greater effort must be made to win it." *Franklin D. Roosevelt.*

" " "

"COAL IS the predominant source of heating fuel. How soon we will have to depend almost exclusively on it for heating depends on how much oil and natural gas we still can add to our present dwindling supplies. Some day, to be sure, coal has to carry the full load." Robert M. Weidenhammer, President, Cosgrove Coal Company.

" " "

"FACTS ARE indispensable, but they are not enough. Unrelated miscellaneous facts, however odd, quaint, or amazing, are not knowledge, in spite of any impression to the contrary given by the Quiz Kids or Information, Please. The characteristic of knowledge is organization, which implies understanding, ordering, and interpretation." *Dr. Robert Maynard Hutchins, President of the University of Chicago.*

" " "

"YOU MAY expect that five years after the war every community in the country will be within an hour's drive from a point of passenger air service. Most communities of 10,000 population and up will have passenger service and smaller communities will have direct mail and cargo service through pick-up or, possibly, helicopter." C. Bedell Monro, President, Pennsylvania-Central Airlines.

" " "

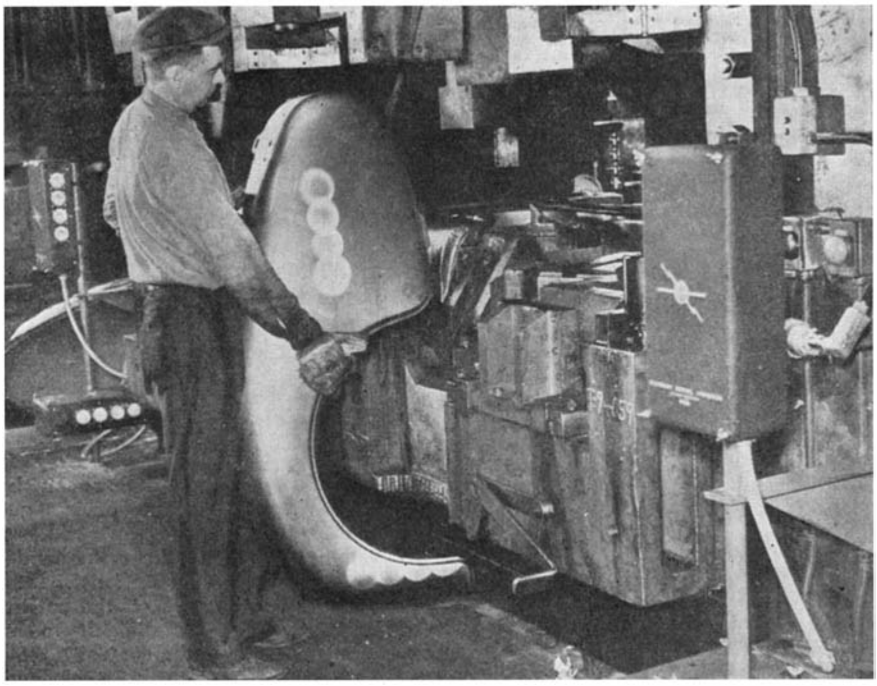
"CERTAINLY there is no more potency in applied chemistry than there is in any other science. The plain fact is that industry has, in recent years, plowed back a larger amount of its earnings for development, improvements, and extension than most others." *C. A. Higgins, President, Hercules Powder Company.*

" " "

"BUSINESS AND other leadership groups must act not only in the light of what is water on their own wheel, but also as to what powers our whole economy. They must recognize that the day of rugged individualism—the day of making moves without regard as to who was hurt—are gone, never to return." Chester J. LaRoche, Chairman, War Advertising Council.

ELECTRONICS

Conducted by KEITH HENNEY



Curtains of light assure worker safety. The horizontal light curtain near the floor assumes control in the event that the operator steps completely inside the vertical curtain. The photocell and light housings for both curtains are at left and right

Supercontrol By Electronics

Because of the Versatility of the Electron Tube—and of the Electron—Physical and Chemical as Well as Electrical Quantities Can Be Measured. And When Quantities Can Be Measured, the Variations Detected by Electronics Can Be Translated into Accurate Control Processes

MANY OF the important industrial jobs done by electron tubes come under the general heading of "measurement and control." The tube is a superlatively sensitive and delicate means of measuring not only electrical quantities but chemical and physical quantities as well. And once one can measure a variable, it is comparatively simple to turn the measuring method into a control system. For example, it is not at all difficult to make a tube measure the output voltage of a generator or other source of electric potential. Having made the measurement, it is easy to make any variations in this potential into a control which may be fed back into the generator, or other source, with the purpose of counteracting the tendency of the potential to change. In this case the electronic apparatus acts as a voltage regulator. There are many similar examples.

The electron tube is such a superlative agency for measuring and control largely because the tube requires almost no power to make it do the job. A fraction of a watt—a few microwatts, in fact—are all the input power required to make a tube operate. The great virtue of this characteristic is the fact that the circuit in which the measurement or control is taking place is not disturbed by the presence of the electron tube.

Then, too, an electron tube will operate in a fraction of a microsecond because of the extreme lightness and mobility of the electron. Since the electron has so little weight or mass, it has very little inertia and can be turned around in its path or started or stopped in its flight, at extremely high speed. To illustrate this point, consider, a 1000-megacycle generator in which the electrons reverse their direction of motion in less than a thousand millionth of a second.

Another reason why tubes are so effective is the fact that they can exercise extreme smoothness of control. No matter how fine a rheostat one makes, it still controls electric current in jumps or broad steps. A tube, however, will control current to a fraction of a thousandth of an ampere.

Still another tube characteristic is its ability to amplify electric voltages or currents. Furthermore, it can be made to act as a rectifier, conducting current only in one direction. Other tubes convert light energy into electric energy (phototubes); still others convert electric energy into light energy (cathode-ray tubes). Also, tubes will operate on alternating or direct currents, will convert alternating to direct current and vice versa, will convert power from one frequency or voltage to another, will mix two frequencies so as to make one act as the carrier for the other, or will separate two frequencies apparently hopelessly intermingled.

One of the first control applications of the electron tube in the laboratory, and later in the shop, was in temperature supervision. An oil bath, for example, can have inserted in it a bimetallic strip or thermostat. When the oil cools, electric contacts actuated by the thermostat turn heat into the bath. But the current which may be handled by the contacts is not very great and, besides, with constant making and breaking of currents, the contacts tend to pit or to stick together. Furthermore, the bath might be some combustible material; here an electric spark at the contacts would be disastrous.

The simple remedy is to use a tube. The contacts of the thermostat merely change the voltage on the control electrode of an amplifier tube. The change in voltage causes a change in the current output of the tube and this change can be as great or as little as desired or needed. The tube then turns on the heat. A set-up of this type will control temperature to within 0.1 degree, Centigrade.

In another simple system a beam of light shines through the glass stem of a thermometer. As the mercury rises, it obscures the beam and a phototube which ordinarily receives the light sent through the thermometer, no longer is illuminated. The change in phototube current stops the heating mechanism.

There are many variations of this simple scheme, some very complex, maintaining temperature within very close limits over long periods of time.

MEASURE, THEN CONTROL—In every case the first thing the tube does is to measure something (voltage in the case of the amplifier, illumination in the case of the phototube) and then this measurement is transferred into a control function.

Automatic leveling of high-speed elevators was another early application of tube control. Again, two general methods are employed, one using an amplifier tube and the other a phototube. In each case the elevator cage may carry the tube apparatus. Suppose it is a phototube. When the car is to stop at a given floor, the operator pushes a button. This turns on a light near the desired floor; when the elevator car approaches this location, the phototube "sees" the light, and the current change in its output sets in motion the leveling mechanism so that the car stops at the exact spot desired.

Job to be done	Stimulus	Tube Type	Indicator or Device Controlled
Elevator control	Light change	Phototube	Relays and motors
Elevator control	Magnetic field change	Amplifier or oscillator	Relays and motors
Vibration control	Piezo-electric voltage crystal	Amplifier	Loud speaker or Recorder
Paper thickness control	Capacitance change	Oscillator	Power relays

Typical examples of control jobs done by electronics. Note that in each case there must be some stimulus, that this stimulus is translated into an electrical quantity, and that this quantity initiates the control function to be accomplished

Suppose the tube is an amplifier with two coils of wire coupled together. The current which the tube passes is a function of this coupling. If the coupling between the coils changes, the current changes. At the push of the control button, a small metallic vane pops up at the proper location in the elevator shaft. When the cage approaches, this vane comes between the two tube coils, the tube current changes, and the leveling mechanism comes into action.

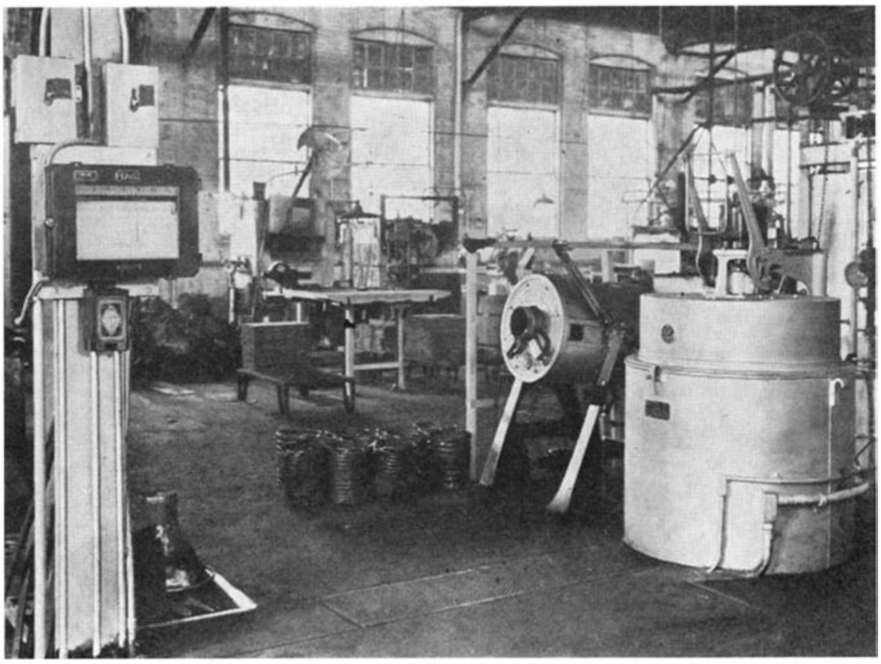
In each case the tube measures and then controls. Also, in each case the amount of electric power released or changed by the device is minute, not sufficient to accomplish much useful work. But a tube, or tubes, interposed between the actuating device and the final work to be done can amplify the electric power as much as is desired.

Anything that varies in magnitude can be measured by a tube of one sort or another—time, time intervals, voltage, current, power, phase, weight, length, stress, color, height, density, viscosity. Any of these physical quantities may be measured by a tube, and once they can be measured it is only a question of properly translating the measurements into control.

For example, if some mechanical device is to be kept on a straight and narrow path in spite of a strong tendency to stray from this path, two phototubes can be arranged so that if the device gets off the path to the right it reduces the illumination into the right-hand tube, and so that it shuts off light into the other tube if it goes off the path to the left. Now it is not difficult to make the right-hand tube control a motor so that it will rotate in a clockwise direction; or to make the left-hand tube force the motor to rotate in a counter-clockwise direction when the left-hand tube is obstructed. The motor can be connected to the mechanical device. So long as the device stays on the path, which can be very narrow, both phototubes get illumination and current tends to flow through the motor in two directions, each half of the current exactly balancing the other half so that the motor does not rotate. But as soon as, say, the left-hand phototube is obscured, it passes current through to the motor, which gets busy and brings the object back to its proper position.

Holding a telescope on a distant star can be done in this way, and the imaginative reader can see many other applications in the activities we are now engaged in abroad. There are literally dozens of uses for a set-up of electron tubes plus a split-field motor. The tubes need not be phototubes, but are used here only as an example. In this case, the unit is a "position" control and can be employed as a "follow-up" system.

ALL-OR-NOTHING—Tubes make excellent limit gages or limit switches. A thyratron tube, for example, has an all-or-nothing characteristic. That is, if the voltage applied to its input circuit is insufficient to produce current output, no current flows, but if the voltage gets beyond this value, all the current the tube can handle will suddenly flow through it. On the other hand, the circuit can be arranged so that, as long as the voltage is high enough, no current flows, and as soon as the voltage drops below this value, current is initiated. By making the critical values of voltage for the under- and over-voltage device close together the actual voltage may be



Electron-tube control of a furnace. The TAG unit at the left regulates the pot type General Electric furnace, at right, in which the teeth of circular saws are hardened

kept quite accurately within close limits.

To understand the simplicity of many electronic devices, consider the elementary job of counting boxes which look exactly alike but contain two different materials. The boxes travel on a moving belt but a separate count is to be made. If a red spot is painted on one type and a green spot on the other, two phototubes properly placed will "see" these spots as they go by. Now if a filter is placed over one phototube which will pass only red light, and if a filter which will pass only green light is placed over the other tube, the red-painted boxes will register only on the red-filtered phototube and the green boxes will be counted by the other.

But suppose the red boxes are to move off to another belt, say to the right, while the green-painted boxes are to move straight along. It is a simple matter to make the red-filtered phototube interpose in the path of the boxes a mechanical arm which forces the red boxes to leave the belt and go off in the new direction. The arm is removed when a green box comes along. Now this is not merely counting—it is controlling the direction or route of the boxes; it is a control job.

COMPLEX FOR ACCURACY—Of course, the complexity of the electronic system employed depends upon the accuracy or perfection with which the control is to operate, as well as upon the variety of the job to be done. Some systems can be simple and others naturally must be more complex. Often the tube apparatus is only a small part of the entire control system. Sometimes a given equipment can exercise several degrees or even several kinds of control in sequence or simultaneously.

For example, an automatic arc welding machine may have its filler electrode fed to the arc by means of a small motor completely under electronic control. Signals taken from arc voltage or other desirable circuit conditions are amplified and handed on to an electronic system which governs the rate at which the welding electrode is fed. Moreover, the same control has provisions for striking the arc by touching the electrode to the work, then quickly backing off or reversing until correct arc length is established.

One of the advantages of electronic devices is the fact that the tube equipment and the push button that puts it into action need not be near each other. Many varying quantities or functions or jobs can be accomplished by remote

Amplifier: Low voltage to high voltage
Rectifier: A.C. to D.C.
Oscillator: D.C. to A.C.
Inverter: D.C. to A.C.
Phototube: Light to electricity
Cathode-ray tube: Electricity to light

Electron tubes are of many types which may be grouped as shown, but the different jobs that can be done by any one group or combination of groups are many and varied

Electron tubes in this set-up automatically time the duration of the current used for resistance welding

control. In fact, there is almost no control job that cannot be performed by some application of the science of electronics.

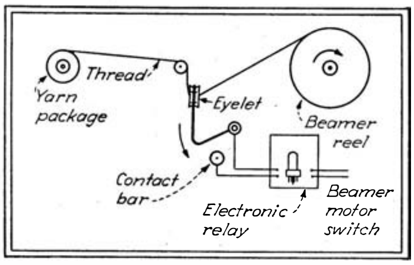
* * *

STATISTICS
Show Some of the Trends In Electronics

A FEW factual figures covering electronic progress are interesting as indicative of what is to come in this field. 25 billion kilowatt-hours of electrical energy flowed through electronic devices in 1943. 6½ billion dollars represents the total war expenditures for electronics by end of 1943. 500 million dollars is the 3-year expenditure for electronic war apparatus, excluding radio. 1½ million kilowatts of electronic rectifiers have been installed by one company alone. 120 million dollars is the total expenditure for rectifier apparatus to date.

ELECTRONIC STOP
Controls Textile Machine When Thread Breaks

AN ELECTRONIC relay recently developed by General Electric stops all the motion in a textile machine the instant a thread breaks. Just before the threads come to the beamer each thread passes through a hinged eyelet, called a drop switch. When the threads are wound on the beamer they are in tension and hold the drop switches in an open position. When a thread breaks it is no longer in tension and the drop switch, its weight unsupported, drops to the metal bar.



Electronic textile machine control

The contact to the metal bar causes a minute current flow in the input circuit of the relay tube. This current, only a a few microamperes, is amplified by the tube which in turn operates a relay in the output circuit. The relay then opens the coil circuit of the motor switch and stops the beamer machine.

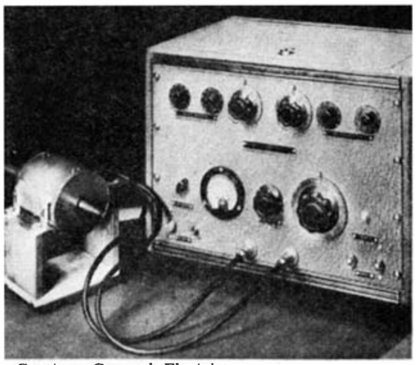
CONNECTIONS CHECKED
By X Rays, Rejections Greatly Reduced

AN X-RAY unit now in use in a large industrial plant has helped reduce rejections, originally as high as 75 percent, to an average of 4 percent. The plant uses a Kelley-Koett X-ray unit for fluoroscopy and radiography to check soldered wire connections within a metal tube, 48 at a time. The cost of fluoroscoping is negligible and it requires no darkroom, films, or chemicals.

FLAW DETECTOR
Applied to Production of Metal Tubing

A NEW high-frequency electronic flaw detector permits production-line detection of longitudinal cracks and seams in non-magnetic metal tubing. The instrument detects and locates imperfections one half inch long, ten mils wide, and one third of the wall thickness in depth, even though they do not appear on either surface.

The tubing to be tested is fed through



Courtesy General Electric
Flaw-detecting tube coil is at left

coils arranged so that they surround it. After the circuit constants for the particular size of tubing being tested are set by means of selector switches located on the panel of a control unit, power is applied to the coils so that eddy currents are induced in the tubing. A flaw in the tubing causes changes in these eddy currents. An electronic circuit in the control unit detects these changes and energizes a signal relay, indicating the existence and location of the flaw.

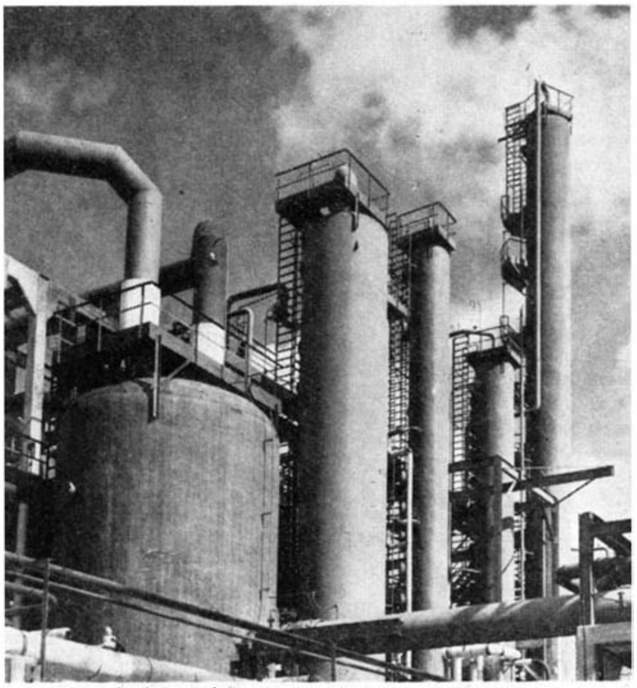
The detector consists of a standard control unit, shown in the photograph, and a coil box which accommodates any one specific size of round, straight tubing of uniform outside diameter from one quarter to two inches, inclusive.

What About Synthetic Tires?

Synthetic Production Outstripped the Rise of Knowledge of Uses, but Something is Being Done About This. Competitive Prices Now Favorable to Synthetics. Politicians Do Not Expect to Protect the Huge Investment in the Synthetic Rubber Industry. Tire Life May Equal Car Life

IF YOUR tire treads are wearing thin and you think something should be done about it, you are dead right. And something is being done. A veritable army of scientists and technologists work day and night on just that problem. Synthetic tires are good now, but will be excellent. After performing the astounding miracle of creating in little more than two years a totally new complex industry able to produce synthetic rubber at a rate faster than Americans have ever used the product of rubber trees, American enterprise and ingenuity are now busy with the next task: That of making synthetics so good and so cheap that we shall never wish to return to Nature's rubber again. Just as production of the new compounds in quantity has been accomplished in an incredibly short time, so we may expect the second part of the problem to be solved with skill and dispatch.

Utilization of synthetic rubbers is still a problem because their production was accomplished too swiftly for methods of use to be developed simultaneously. Obviously, when the program of production in this country finally got under way, after the fall of Singapore had cut off supplies from the Far East, haste was vital. The new industry must produce in the shortest possible time, and its products must resemble rubber so closely that existing rubber machinery could be used with the least possible alteration to fabricate them into tires and 30,000 other useful items made of rubber. Speed was essential. Butadiene (pronounced bu-ta-dí-ene) must be derived from both petroleum and grain alcohol, and styrene produced from coal tar, in unprecedented quantities. Their combination, now known as GR-S (Government Rubber-Styrene), offered greatest promise for general utility, particularly in tires. Consequently, this was chosen to receive the greatest emphasis in the production program.



Standard Oil photograph

In these towers and reactors, man-made rubber gets its start with the processing of petroleum gas to obtain butadiene. This is combined with styrene to make GR-S synthetic rubber

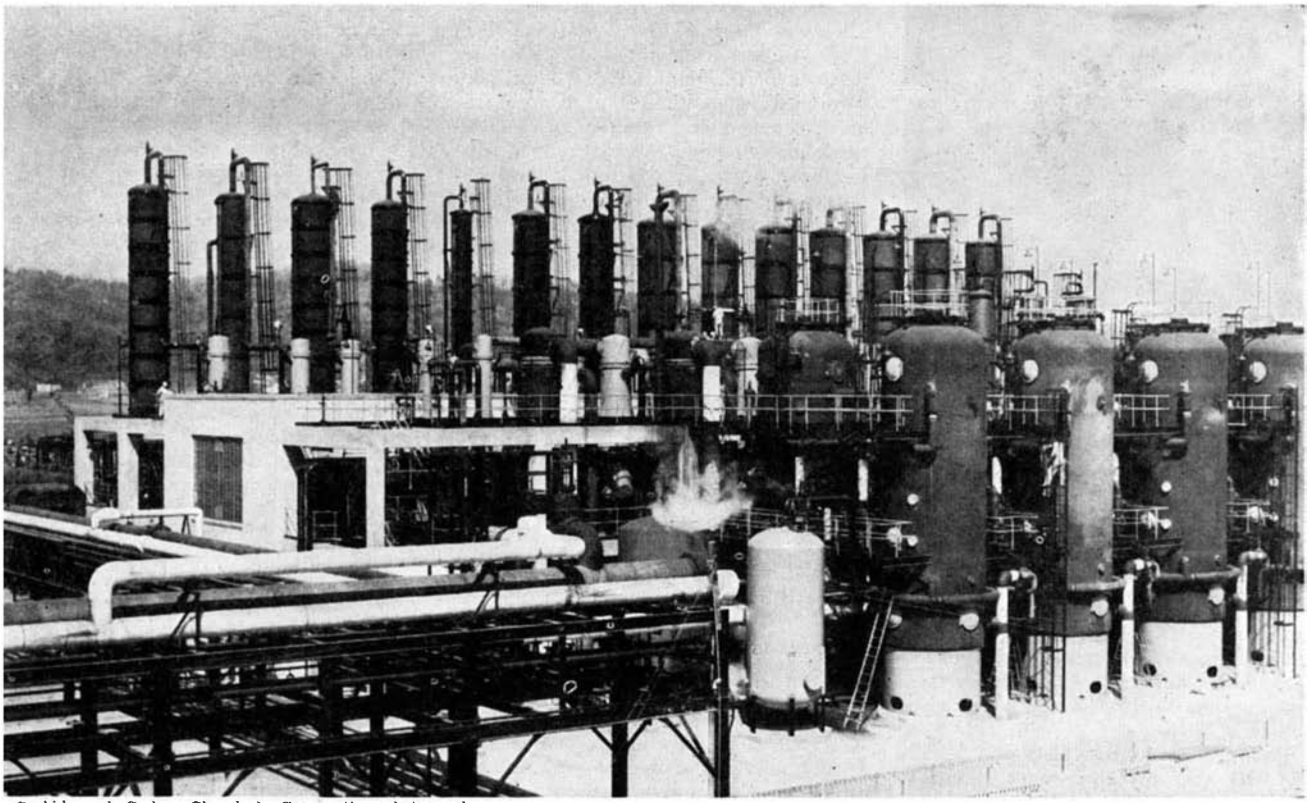
But GR-S is definitely not rubber; it merely bears a close resemblance to its prototype. On that hangs the problem of utilizing it. Such apparently unimportant details as differences in stickiness—technically known as "tack"—complicate the problem of the rubber fabricator. Fundamental differences in the action of various additions to the mix to control the final properties of the product—its strength, its vulcanization, its resistance to wear, among others—require re-evaluation of every phase of rubber technology to bring out the best performance of the new material and adapt it to every-day uses.

Because synthetics resemble rubber closely, many expect them to duplicate it exactly. Unfortunately, that it is not true. But neither is it true that all good qualities reside in Nature's rubber and none in the man-made varieties. Rubber undergoes a subtle transformation when heated with sulfur and becomes a much more useful stuff. So do the synthetics. Colloidal carbon added to rubber before vulcanization increases its strength and resistance to wear. Synthetics are similarly improved. Flexing rubber generates heat. The synthetics treated in the same way generate more heat. Rubber deteriorates through aging in air and sunlight. Synthetics possess much greater natural immunity to aging. Both are benefited by additions of certain chemicals. Rubber deteriorates when soaked in water, while synthetics generally are practically unaffected. Certain synthetics possess high resistance to oil and gasoline not shared by rubber. Some synthetics, particularly GR-S, resist wear better than rubber does. While these statements are generally true of synthetics, the degree of difference varies considerably for the several kinds of synthetics.

Most important difference, from the point of view of tires, between rubber and GR-S is in the amount of heat generated under severe flexing, like that characteristic of balloon tires in use. Both materials are poor conductors of heat and both deteriorate rapidly when over-heated. Thus an important problem confronting tire builders is to find a way to get rid of the greater amount of heat formed within the synthetic tire in service. Several possibilities suggest themselves: Thinning the tire sidewall, introducing heat-conducting substances into the side walls to carry the heat away, or, what may be far more important, changing the entire geometry and construction of the tire itself.

In other words, the technology of rubber, built up painstakingly over the century following Goodyear's original discovery of vulcanization, must be duplicated for synthetics but with no time in which to do it.

Rubber, itself, became useful by slow degrees. Tires, for example, were originally mere strips of rubber wound around a buggy wheel to replace its steel rim. Subsequently they acquired a pneumatic center. Each step in tire development, after that, was taken to adapt rubber better to the job of ab-



Carbide and Carbon Chemicals Corporation photograph

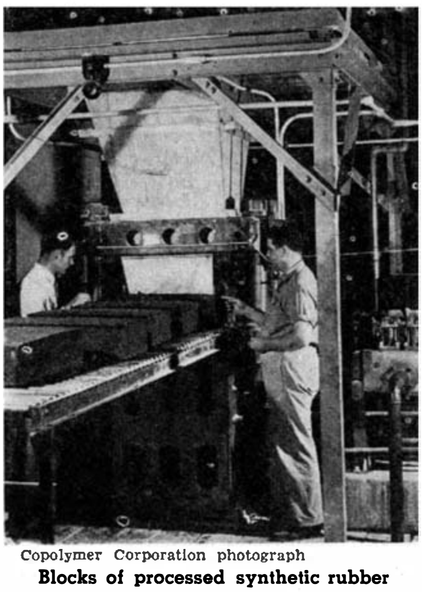
Butadiene, made from grain alcohol, is produced in this section of a government synthetic-rubber plant in West Virginia

sorbing shocks from the uneven surface of the roadway. Demountable tires were devised to allow for repairing punctures frequent in the early days of automobiling.

But all of that must be re-examined and can be changed when peace releases industry for new tasks. There is no reason to believe that the present tire and tube combination is by any means the best that can be devised for synthetics. It must serve for the present, but tomorrow's tires need bear no particular resemblance to yesterday's. The technique of bullet-proofing can be applied to banish all danger of punctures and thus any need for removing tires for repair. Blowouts can be made a memory by utilizing in tire construction some of the super-strong fibers—stretched rayons, nylon, even glass and steel—to reinforce the tire carcass beyond fear of blowouts in operation. Thus the necessity for removing tires from wheel centers can become obsolete, and the possibility of building tire and wheel center as a unit becomes practical. Already the wearing qualities of tire treads made of synthetics equal or even surpass those of rubber, and it is easily within vision that tires having lives approaching that of the car itself can soon be made.

SUPERIOR SYNTHETICS — Handicapping the realization of these possibilities now are: More complete technology of synthetics for best possible results in tires, and, what may be equally important, restrictions on machines and tools which prevent rubber fabricators from completely revising or replacing such equipment of their plants as may be necessary to meet new needs. For the time being, both of these handicaps prevent available synthetic tires from being as good as they can, and soon will, be. It can confidently be said that the time is not far distant when quality of product from synthetics will be actually superior to that from rubber.

Political views on the future of American synthetic rubber production have already indicated that no special consideration for this industry can be expected after the war. Official pronouncements on the subject from the present Washington administration suggest: That natural rubber will be encouraged to come back at war's end, presumably to cheapen rubber products and to provide markets for plantation rubber; and that no measures are contemplated to protect the huge investment in this new industry and the insurance it affords against repetition of our present rubber troubles. One might expect that preserving the new jobs for American workers created by the industry to be a vital factor, but this aspect of the problem seems to have been completely neglected. Indeed the whole situation is far from simple.



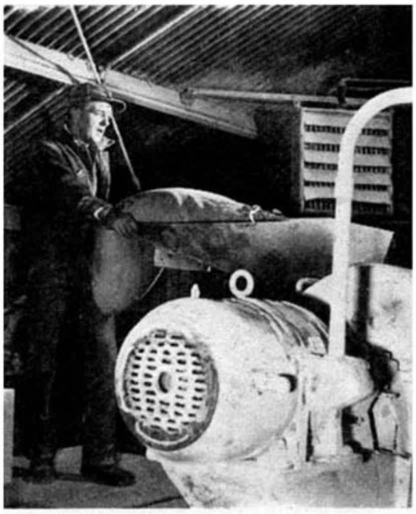
Copolymer Corporation photograph

Blocks of processed synthetic rubber emerging from a power baling press

Since price looms large in political thinking, it is worth while to point out here that the present price of GR-S synthetic is already a little lower than the average of several pre-war years' prices of plantation rubber. Furthermore, the trend of this price, as of all other chemical prices, is definitely downward. Depending upon the length of the Pacific war and the time required after the peace to reestablish our rubber supplies from plantations in Malaya, competition by synthetic production here may even force prices to levels unprofitably low for plantation operators.

TIRE PRICES—Rubber cost forms only a minor fraction of the cost of tires to consumers, since fabrication, other ingredients, and labor make up by far the greater share of the selling price of the finished tire. Thus doubling the price of rubber may necessitate a change of only a few percent in tire cost.

Often overlooked in planning for the future of rubber, but definitely vital, is the condition of the plantations at a future date when their output will again become available to us. Just what steps are being taken by the Japanese conquerors to preserve the productivity of rubber plantations is now hidden behind the enemy's censorship. Neglect can quickly damage rubber plantings beyond repair. Indeed, even the short period since the Japanese invasion of the rubber producing areas is ample for serious damage to have been done.



New England Alcohol Company photograph
Grinding grains in an alcohol plant, a step toward synthetic rubber making

It is even probable that the immense stores of crude rubber acquired by the invaders exceeded their needs to an extent that would discourage them from sparing men to care for the trees themselves.

Enemies of rubber trees are legion, but the two principal ones likely to gain ascendency through neglect, are: Several types of blights and insects which require frequent spraying of the trees for control; and invasion of cultivated plantation lands by the jungle. The first destroy the trees themselves, and encroachment of jungle growth on cultivated lands would prevent access to such trees as remained uninjured otherwise. These destructive agencies are seriously to be feared because the rubber trees (*Hevea brasiliensis*) require seven to ten years from planting to grow to productive maturity. Thus, any plantation which has lost its ability to produce through neglect cannot be immediately rehabilitated. Newly planted trees would require years to reach productivity, and meanwhile our synthetic industry would have time to mature in its own ight before it faced the necessity of defending itself against the foreign natural product.

Present efforts to promote the growing of rubber trees in more accessible areas must necessarily continue, lest even at peace we find the natural product impossible to obtain. At the present time, fabricators still need a certain amount of natural rubber to include in their compounds with synthetics to yield best results. This may not always be true but, meanwhile, prudence requires that we continue to plan on this basis.

While the foregoing discussion deals principally with pneumatic tires and with GR-S synthetic, applications to rubber's former uses of this and a wide variety of other synthetics are succeeding much more easily and completely. For example, the vinyl resins are proving valuable in electrical insulation; polyvinyl acetals make excellent "rubberized" sheetings for moisture and rain resistance; hose for water, steam, oil, and a variety of solvents is better when made of a number of synthetics than when made of rubber; and so with practically the whole list of rubber's applications. Most of these markets seem likely to be permanently lost to rubber because of the definitely superior performance of synthetics and quite regardless of their relative prices. All these miscellaneous applications of rubber have normally consumed barely 20 percent of our imports of the elastic, while tires account for the remaining 80 percent.

Obviously the final solution of the problems of synthetic tires is a matter of general concern, but it is already well on the way.

PENICILLIN PRODUCTION

Approaches the Synthesis Stage

PRODUCTION of penicillin is increasing so rapidly that, by late spring of the present year, supplies are expected to reach a point where the vital drug will be available to the civilian medical profession generally. Recent progress includes development of methods of growing the drug-producing mold in large vessels instead of laboratory bottles as heretofore and the preparation of a pure crystalline sodium salt of penicillin which has been proved to be its active principle. This isolation of the drug in pure form is considered the most important step toward its ultimate chemical synthesis, which will avoid the need for cultivating mold to produce it.

SOAP IN LUBRICANTS

Put to Many Uses in Industry

USED AS a lubricant, soap is assisting in the production of shell and cartridge cases, barbed wire, cables, springs, and cold-drawn bars, wires, and steel blanks of many kinds. In fact, most of the metal that is cold-fabricated for war utilizes soap at some stage in its manufacture, according to Roscoe C. Edlund, Manager, Association of American Soap and Glycerine Producers, Inc.

Practically no metal object is produced without being drilled, turned on a lathe, or drawn. In each of these operations, a lubricant is necessary to reduce friction, remove heat, prevent corrosion, and produce a smooth, accurate finish. In drawing wire, there is a friction of approximately 18,000 to 30,000 pounds per square inch within the die, which must be reduced by various methods of lubrication.

Soap is almost universally used for this purpose because it is clean, easy to handle, concentrated, and more easily adaptable to a wide variety of conditions. Dry drawing calls for powdered soap; wet drawing uses flake and powdered soaps as well as soft soaps. These are used in conjunction with other substances, depending upon local practices and conditions.

In dry drawing, the powdered soap is made generally from a tallow, although, when available, palm oil and a combination of palm oil and tallow are used. In wet drawing the wire and die are either submerged under a soap solution in water or the soap solution drips over the die and wire while drawing. The purpose is to reduce the friction between the moving wire and the die surface, to lessen the force required to pull the wire through, to reduce the wear on the die, and to give a smoother finish.

Soap coating eliminates the need for copper plating in the manufacture of 37mm cartridge cases, now made by cold drawing from steel blanks.

Soap is used extensively in the preparation of lubricants for drawing copper and brass tubes and wire, also of cups in the production of shell cases for ammunition.

Soap is a vital component of a large number of new greases with which technicians are meeting new production problems. The addition of soap produces a grease which will not leak away from points of friction and which adheres to rotating surfaces better than straight oil. These new lubricants are especially useful in pumps and carburetor valves that come in contact with gasoline which quickly dissolves ordinary greases.

Soap is also used in cutting oils which have been developed to meet the exacting requirements of many kinds of high-speed war production. When used in such cutting oils the soap acts as an emulsifying and stabilizing agent. It improves the stability of the oil emulsion and increases its film strength.

A certain proportion of soap added to airplane grease lubricants makes them more resistant to extreme cold and to sudden changes in temperature.

GLASS WASHERS

Help Signal Corps Develop New Lip Microphone

TINY WASHERS made of glass fibers bonded together and pressed into a wafer-like mat have helped the United States Signal Corps solve one of the many problems involved in developing a noise-canceling lip microphone now used by the Marine Corps.

The Fiberglas washers were adopted after the Signal Corps, working with Electro-Voice Manufacturing Company, had tried out numerous materials in a search for one that would remain resilient and exert even pressure on the metal diaphragm of the "mike" under combat conditions such as those encountered in the moisture-sodden jungles of the South Seas.

The new microphone prevents the thunderous noise inside a tank, or the rattle of machine-gun fire, from interfering with clear transmission of speech. As its name implies, it is worn on the upper lip, leaving the hands free. It is part of the radio equipment which enables scouting parties or armored vehicles to maintain communication with each other and headquarters.

The wafer-like mats from which the washers are made are manufactured by Owens-Corning Fiberglas Corporation.

Materials Must Move

Costs Go Down, Production Goes Up, When Materials-Handling Problems are Correctly Solved. Management Thinking is Changing and is Placing Emphasis on this Vital Phase of Industry. Exact Control Achieved While Maintaining Flexibility and Adaptability of Equipment

When Pearl Harbor so rudely interrupted United States peace-time factory management, one subject had long been first on the engineering docket. It was the fact that materials handling never accounted for less than 50 percent of all production costs and often made up 80 percent or more. Greater savings, and often greater increases in out-put, could be made by solving materials-handling problems than by any other "short-cut."

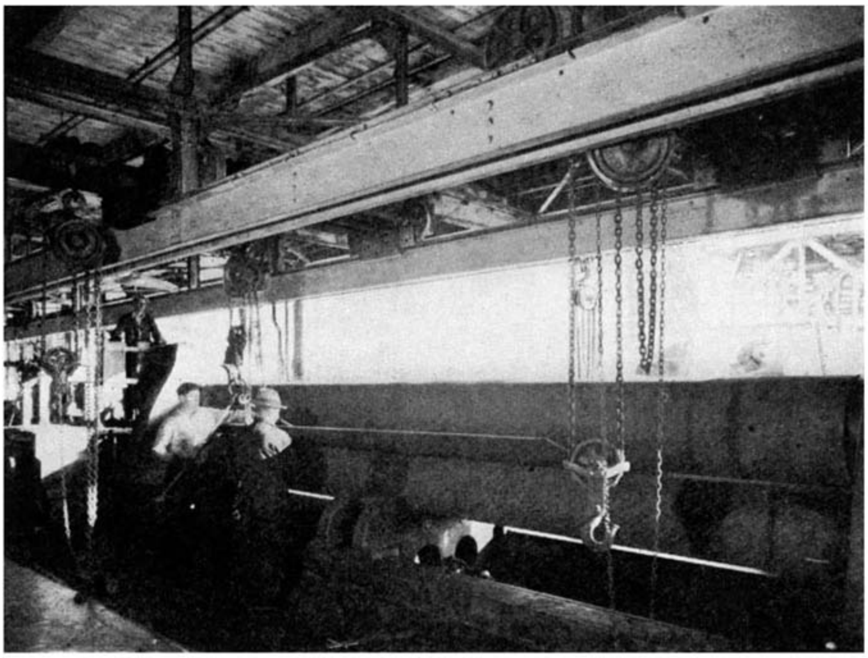
War-production thinking paid less attention to costs than to quantities and speeds, but from the first moment when factories began expanding to war time proportions, one fact was clear: This was to be a materials-handling war. Beginning with the instant when the scoop of a power shovel lifted iron ore from the ground and ending with the dropping of the resultant steel in a block-buster on Berlin, materials-handling skill would decide who got "thar fustest with the mostest." Materials had to move or machines and man-power would be useless.

Large companies already had shown the way. Bendix Aviation, with one good factory available, had erected a new one, largely because a different size and shape of building was needed for adequate handling of materials. Westinghouse had some 27 miles of conveyors in just one plant. Bell Aircraft had built a special factory so that airplanes could be towed down the assembly lines by hooks fastened to chains which ran below the floor level. And when Ford Motors built its Willow Run plant largely because the mazes of materials-handling equipment in automobile shops could not be adapted to aircraft, and General Motors and others whipped up new buildings for the same reason, the great change in management thinking became clear. Henceforth machining and other production methods were to be adapted to materials handling at least as often as materials handling was correlated with the other functions.

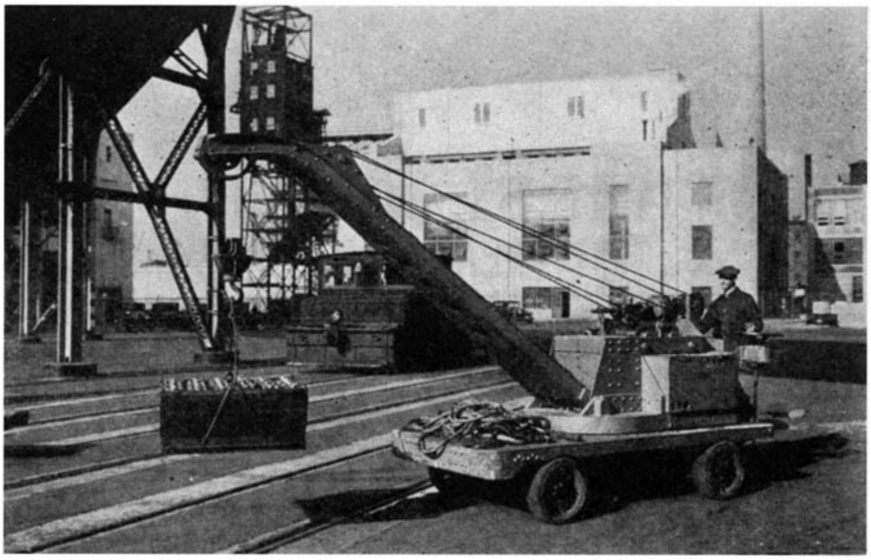
The ideal of the perfect factory built around the perfect materials handling system is an old one. Before 1930 a factory had been built by the A. O. Smith Corporation to turn out automobile chassis frames without human hands touching them. Steel went into one end of the building, was cut, formed, shaped, and welded, traveling several hundred yards through the successive machines and emerged all painted and ready to be mounted in automobiles, all without a human being in the building; although, later on, a small crew of maintenance men had to be kept in the plant. The Gillette Safety Razor Company fed Swedish strip steel into one end of a long line of machines and had it emerge as packaged razor blades, with only a few men to keep the machines in adjustment.

PRODUCTION HEADACHES—But the war brought new problems. First was the insistence of the armed forces that they be able to change almost anything upon a minute's notice. When the bazooka and other rocket guns lessened the utility of tanks or one type of fighting plane made another obsolete, the war factories had to change over to something new at once. Perfect set-ups based upon the expectation of years of making just one thing in just one way were out. Second, materials supplies were tighter; there could be fewer "pools" of semi-finished parts and of supplies held at points along the production lines so that a process would not be stopped if the flow of materials to it were interrupted; that flow had to be interruption-proof. Third, scrap from every process had to be kept segregated as never before; scrap handling no longer was a question of separating the materials which could be sold at a profit and letting the rest get mixed, but became one of protecting all waste as strategic and critical materials. Yet in spite of these troubles—and plenty more—materials handling had to keep on performing its function of reducing the man hours per thousand parts produced and of saving floor space.

The effect of the abrupt changeovers of factories was to require everything to be adaptable to changing conditions. In nearly every big factory today, the moving of machines from one position in the production line to another is so common as to be a specialized function of the materials-handling department. In one big factory, machine bases are painted with identifying markings to show the methods to be used in moving them; those having green stripes to be lifted by overhead cranes, white stripes indicating that the machine is neither topheavy nor delicate and may be towed by tractor either on its own base or after mounting on skids, and



Gangs of chain hoists handle sheet steel at rolls



Electric crane, yard locomotive, elevator, silo, all handle materials

red stripes warning that jacks and rollers are to be used and the moving supervised by the foreman of the department which uses the machine.

PORTABILITY THE KEY — Some lightweight equipment such as drill presses, grinders, welders, and small furnaces, is kept permanently mounted on steel skids so that it may be moved at will by lift trucks. Materials-handling equipment also is kept fully portable or semi-portable, gravity roller lines being in sections which can be disconnected, and often being mounted on frames supported by steel wheels so that it can be rolled from position to position; belt conveyors being in sections which feed to each other rather than the longest practical single lengths being installed; and even the overhead tramrail systems being supported by easily moveable special pillars instead of permanently suspended from the ceiling.

Scrap segregation has posed peculiar problems. The trend toward equipping each machine with its own vacuum evacuator to suck up the chips and dusts as fast as produced and deposit them in a chamber right at the machine, instead of using one long vacuum line with ports at many machines, is promoted by the fact that the individual chambers can be dumped into special wheeled materials-handling bins and the scrap of various alloys thus kept from becoming mixed. In extreme cases, such as machines which cut tungsten alloys, the cutting oil from the sumps is pumped into individual portable tanks rather than into a single "dirty oil collector," the segregated oil being cleaned in special settling tanks and centrifugals.

A manufacturer of steam turbines has placed all producers of metal scrap, except the very heaviest machines, on galleries along the main production line. Stock rooms running along the outer edges of these galleries feed materials to the machines and receive the scrap from the machines they feed. Thus the same men who keep new materials separated also keep the scrap of those materials segregated. Materials go to the lines on the upper decks of roller conveyors; the scrap comes back in tote boxes and bins on the lower decks of the same conveyors and is carried at floor level to the outer wall where it is stored until collected.

A brass and bronze castings plant long has had a system by which molding sand is carried on conveyor belts spaced at intervals across the foundry floor, these belts being reversed to take spent sand back to sifters and thence to a main conveyor belt leading to the sand mixing and tempering equipment when the flasks are being emptied. Several different alloys may be handled at one pouring. In the pre-war days the system could be run easily, since a little mixing of the bits of metal remaining in the spent sand and caught at the sifters resulted only in "random" scrap which could be melted for castings in which exact alloying is not too important. But with scrap segregation so important in war-time and the government demanding that every ounce of the precious copper alloys be accounted for, the materials-handling department had to designate some belts to handle definite alloys and to regulate the use of others so that only one alloy is on a belt at a time.

The lack of pools of materials to compensate for failures of materials-handling systems to keep up with the lines, has been solved by two methods. One of these is to spot stock rooms about the plants rather than to hold all materials in single big rooms; the small stock room can be close to the point of use of the supplies and tools it holds and the haul from it to an emergency point is short and accordingly quick. The other method is to use more electric lift trucks and other completely portable materials-handling devices.

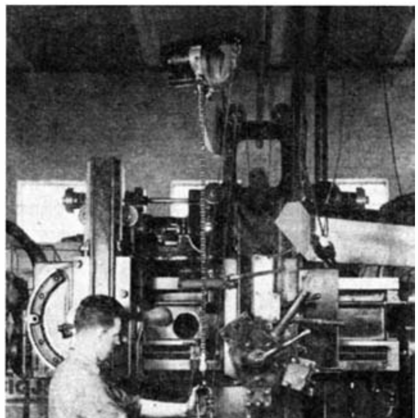
Use of trailers, to be towed by powered lift trucks or by tractors, is increasing materials-handling flexibility. As ordinarily used, long trains of these trailers are towed down the factory aisles, individual trailers being disconnected and left where the goods they carry are needed. A foreman, seeing that a shortage of a material is likely to occur in his department, simply picks up the shop telehpone and calls the materials-handling department which then arranges to have an extra trailer or so hooked on to the next train going his way.

When trailer systems are well worked out, constantly moving chains often are substituted for the tractors. In original designs of these systems the chains were run overhead, but modern ones are more likely to run them in channels just below the floor level. A trailer may be loaded at a dispatching station and hooked to the chain, to be towed to its destination and unhooked.

BOXES STACKED—The use of stackable boxes or bins increases lift truck or trailer flexibility. In one factory as many as six heavily loaded steel boxes are stacked on a single trailer and taken to the head of a production line. The trailer is then unhooked from the tractor train and towed by hand from machine to machine, each successive box being lifted off by chain hoist and placed by the machine operator who needs it. Emptied boxes are placed on a gravity roller conveyor, which takes them back to the despatch station. The emptied trailer, if not needed for conveying materials away from the department, is turned upside down, mounted on an empty box on the gravity line, and so carried back to the reloading point.

A feature of modern materials handling is the increased use of locked or sealed containers to insure exact count and control of quantities, protect against theft and sabotage, maintain exact temperatures, insure cleanliness, and the like. Highly accurate parts are delivered in packages which are wire strapped and sealed by the inspectors; no faulty parts can be slipped on down the production line by machine operators who wish to avoid the losses of incentive bonus earnings entailed by doing work which would not pass inspection.

WHERE WEIGHT COUNTS—More scales are used in materials handling than ever before. Scales are an old story on everything from tramrail conveyors to lift trucks and trailers when handling chemicals which must be mixed accurately. Now they are found also on equipment which handles tools and metal parts. One large machine shop



Every large machine in a modern machine shop has its service hoist

Hooking up a live roller conveyor drive belt

has the exact weight of every important jig, die, set of micrometers, and so on, written down at the place where the device is carried; when issuing or receiving one of these tools the stock clerk weighs it and, if the weight does not correspond with the stock tag, he finds out what is wrong; the management estimates that this system saves up to 1000 machine hours per month of time that formerly was wasted by errors in tool deliveries. Exact weighings of forgings tell foremen how much stock must be removed in machining them, lead to closer estimates of machining time and better control of production schedules. Weighing of finished parts gives a quick check on machine-by-machine output, permits all production to be kept up to levels which could not be attained when output was known only by counting the gross quantities which batteries of machines delivered to the stock room.

Materials handling is achieving more exact control of everything while maintaining the kind of flexibility and adaptability of equipment which ordinarily would lead to inexactness. It is obtaining this control as a result of war pressure accompanied by many headaches. But this is not anything which will die out on Victory Day. Rather, the development will be carried further when equipment is easier to get. The materials-handling war will end in the most skilful materials-handling era of all time.

COPPER SAVED

Power Gained by Use of High-Voltage Lines

AN ELECTRICAL distribution method, originally designed to use less copper and less costly transforming equipment, is saving the power costs which voltage drops can cause, and is permitting greater flexibility in moving equipment about the plant.

The method is to run high-voltage lines, say 2200 volts, direct to small transformers at the distribution panels throughout the plant instead of having a single large transformer out in the open and running low voltage lines from it.

The high-voltage transmission line needs less copper for the same power rating than the lower voltage, and the substations with their switchgear also cost less. In one direct comparison, cost of the old type outdoor transformer, plus switchgear, secondary switchgear, and cables, was estimated at $57,000, while cost of the indoor system with its substations was about $45,000, a clear saving of some $12,000. Most of this saving, of course, represented copper and other strategic materials.

Biggest gain of all is that, although it has moved machines, changed production layouts at will, employed green labor which would misuse power-driven equipment, and done all the other undesirable things which are unavoidable under war production conditions, the plant has yet to experience its first voltage-drop troubles.

COLOR CODES

Serve in Minor but Important Ways

A LARGE user of electric motors mixes a little coloring matter with the insulation varnish used when overhauling these motors. A different color is used each year. As a result, the electrician can tell at a glance the year during which any motor had its last overhaul. This method causes no trouble whatever, and short cuts some of the elaborate record-keeping which is common to all electrical maintenance departments.

A plastics plant, having trouble with unskilled labor installing special valves backward so the water would enter the discharge instead of the intake ends, painted the intake ends green and the discharge ends red, put small arrows on pipes to show the direction of flow.

An aviation materials plant uses an egg-shell white paint on the parts of machines, or on whole machines, which are most easily damaged by improper use of wrenches, by being bumped by materials handling trucks, and the like. If one of these white areas is marred or soiled in any way an immediate investigation is made, the foreman being held responsible. Damage to the housings of highly accurate bearings, and so on, is at an all-time low.

FROM THE OFFICE

Comes Equipment that Aids Factory Workers

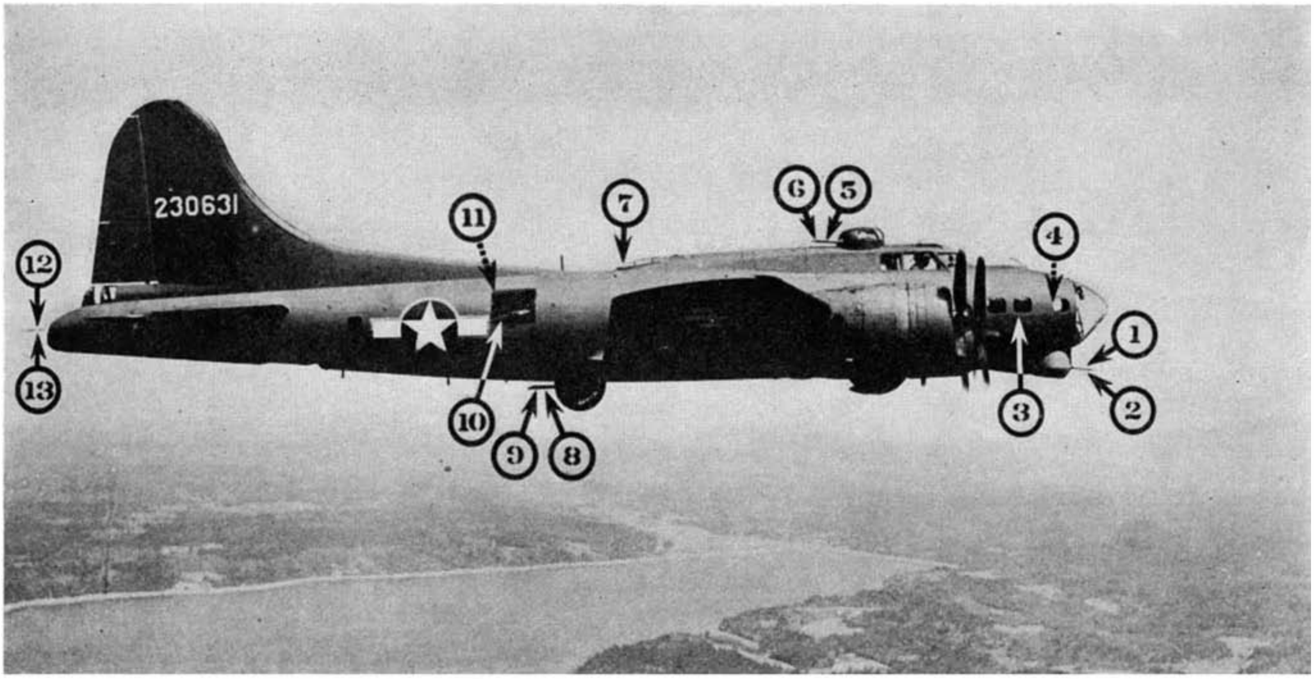
MANY A factory manager, learning for the first time how to get along with women employees, has gone to that veteran in the art, the office manager, to learn the tricks that work with stenographers.

One device taken straight from the office to the shop is the posture chair. Women keep more alert, do better work, and have higher output in the tired end-of-shift hours, if given chairs which encourage healthful posture.

Fact is, no woman wants any part of a job that will leave her at all mishapen. A man does not mind if the use of his muscles causes him to bulge in a few of the wrong places; he is likely to regard shoulders permanently stooped from leaning over a lathe as a natural mark of a machinist's calling. But his gal co-worker likes to come off the job better looking than when she went on.

Production managers first paid attention to these points as necesssary parts of personnel recruiting programs, but now regard them highly as direct promoters of efficiency. Posture corrective devices will out-last the war.

Posture is important



Gun-fire control on the weapons of the Flying Fortress may have post-war applications to peaceful pursuits

AVIATION

Conducted by ALEXANDER KLEMIN

Aviation's Hot-House

Civil Aviation of Tomorrow Will Inherit a Rich Legacy of Important Advances from the Forced-Draught Military Researches of Today. Giant Planes with New Landing Gears, Flying Wings and Tail-First Planes, Crewless Gliders, and Rocket Planes are Conservative Possibilities

It is a mistaken notion that supremacy in the air can be attained by mere quantity production of aircraft and the training of great numbers of airmen. Certainly great numbers of both planes and men are needed, but the freezing of military airplane designs to secure maximum production is fatal. Some recent remarks of J. Carlon Ward, Jr., President of Fairchild Engine and Airplane Corporation, will clarify this statement. Mr. Ward, after an inspection trip to England, believes that the Nazis are losing the war largely because the Army, Navy, and aviation industries of the United States and Great Britain adopted the principle of day-to-day development and improvement of aerial combat craft to meet all types of aerial warfare. On the other hand, Germany approached the aviation problem with the idea that designs could be frozen and that their designs, carefully developed in the years before the war, would suit the everchanging progress of the war. Therein was made a fatal error.

Moreover, it is not only on the airplane itself that the two English-speaking countries have concentrated their efforts. They have fostered research in all of the thousand and one instruments and accessories which go to make up the coördinated whole of military aeronautics.

Many of the multiple advances now being made in military aeronautics will undoubtedly redound to the benefit of post-war civil aviation. The airplane itself comes first, of course. Details of many new designs are rightly shrouded in secrecy, but hints come from the highest authorities and are freely released to the press.

Thus General H. H. Arnold, Commanding General of the Army Air Forces, speaks guardedly of the B-29. Writing in *Army Ordnance*, the General says: "If you will glance into the near future you can see a very different picture than the one of today. The bombers will dwarf our present Flying Fortresses. They will carry half a carload of bombs across the Atlantic and fly home without a stop. The bomber's skin will have numerous blisters which in reality will be multiple-gun power turrets controllable from sighting stations." This super-bomber, the B-29, while it will not in any way slacken the production of the B-17 Flying Fortress and the B-24 Liberator, will outrank them because it will have a far greater effective range, will fly faster, will carry a far heavier bomb-load, and will employ far more powerful engines.

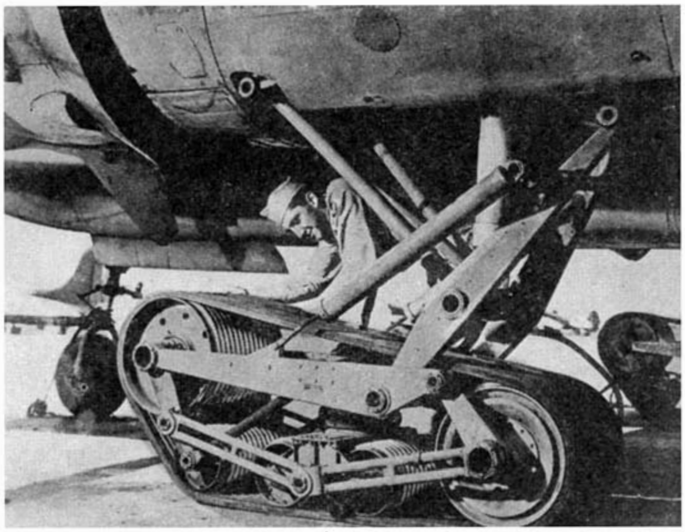
GIANT PLANES COMING—The B-29 will be received in combat areas with immense satisfaction, since it will combine the bombing power of the giant British machines with greater speed and gunfire. But the implications of the B-29 to post-war civil aviation will be many. For transport aviation to be commercially profitable, to carry a really effective percentage of payload, we must use very large airplanes with as few and as large power units as possible. The B-29 itself may ultimately be converted to commercial uses, but its design, development, and service testing have already taught us how to build giants of long range and carrying capacity. Engines have grown immensely in power, but when the Wright engine goes above 2000 horsepower, special difficulties in cooling appear. The development of the B-29 has taught us how to take the bugs out of these huge power units. Again, the design of Hamilton-Standard controllable-pitch propellers is no mean task; the B-29 provides a proving ground for large propeller design.

The B-29 super-bomber is stated to be but one of many military types to appear shortly on the scene, and Wright Field, the experimental field of the Army Air Forces Materiel Command is sponsoring or fostering them all. Details cannot be disclosed, but announcements have been made of a "flying wing" and of a "tail-first plane." Neither idea is new, but if Wright Field and the industry succeed in perfecting the flying wing, benefits may accrue for post-war flying. Since with the flying wing the fuselage is eliminated, there will be lower first cost and greater efficiency. For cargo carrying, the flying wing should have huge volumetric capacity and also permit rapid loading and unloading.

Main fuselage sections of Flying Fortresses advancing on the production line

TAIL FIRST—In the tail-first plane, announced from Wright Field recently, the horizontal tail surfaces are placed at the nose of the fuselage, while the passengers are seated quite far back from the nose. Therein lie two elements of safety. The horizontal surfaces placed ahead and at a larger angle of incidence than the main wings, stall first and lose their lift first. Hence the machine noses down well before a dangerous stalling of the main wings can follow, and recovery is aided.

While the advent of the B-29 will make the Flying Fortress merely a medium bomber, it should not be thought that the Fortress is itself standing still. Emphasis must be placed on the great fire-power of the Boeing B-17 G which now carries thirteen .50-caliber machine guns as shown in the picture on the opposite page. Guns One and Two, located in the new and deadly chin turret, and Guns Three and Four, are used by bombardier and navigator to ward off frontal attack. Guns Five and Six are operated by the first engineer in the power turret, for frontal, lateral, and rear attacks. Gun Seven, a top gun located midway in the fuselage, is operated by the first radio operator against enemies from above. Guns Eight and Nine are used by the second radio operator in the ball turret against attacks from below. Ten and Eleven, in the waist position, are operated by the second engineer and first radio operator for lateral attacks. Twelve and Thirteen are used by the photographer and tail gunner to ward off attacks from the rear. All these guns can be worked independently or simultaneously. Electric or hydraulic control can be employed and it is perfectly certain that at least some of the methods developed in gun-fire control will be applied post-war in actuating control surfaces, landing gear, and the like.



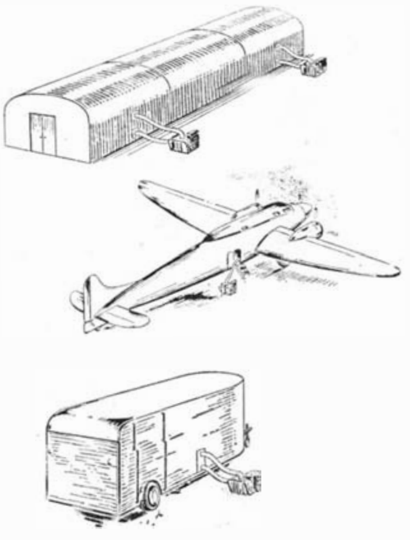
Track landing gear for giant planes will replace wheels, reducing heavy concentrated loads on airport landing strips

Perhaps even more important is the development of the new Sperry automatic gun sight—a mechanical "brain" housed in a little black box. With the new sight, the gunner seems to aim directly at his target, but the mechanical brain makes the necessary allowances for the speed of the plane, the speed of the enemy, the wind, and a number of other factors. The result is that the guesswork is now taken out of aerial gunnery by the computing sight which, no doubt, takes advantage of the principles of short-wave radio and of complicated mechanically integrating mechanisms. Such a mechanical brain should certainly prove helpful in aerial navigation after the war and certainly has possibilities in other industries. It is not difficult to imagine a whole series of intricate chemical or metallurgical processes controlled by an appliance of this sort.

While gun-control methods have significance for civil aviation, the same cannot be said for the weapons themselves—except for the glider-rocket. A rocket-propelled glider, carrying a bomb or bombs, launched from a parent aircraft and steered to the target by remote control, is a close approach to the winged bomb or winged torpedo and has decided peace-time possibilities. The use of towed glider trains is frequently and seriously discussed for air-transport purposes; the commercial possibilities of such glider trains would be much greater if the gliders themselves were crewless. If it is possible to control a glider as a species of flying torpedo, why could not gliders be released from the air train and landed at a field without the use of a pilot? Expense of operation would thus be appreciably reduced.

The Germans are said to be using rocket motors to take heavily loaded Dornier bombers off the ground; the British are launching their Catafighter planes from the decks of merchant ships with rocket power. While nothing as yet foreshadows the application of rockets in commercial aviation, there has come intense interest in rocket research along a number of different lines. These researches, not of conclusive value at the moment, may ultimately enable heavily loaded land craft to fly across the Atlantic with real payloads, and commercial aircraft of novel types to fly at great altitudes and fantastically high speeds.

Large and heavy airplanes—the larger the better—mean heavy and concentrated loads. Can even the best airports support the loads involved? Under the spur of military necessity and the use of rough terrain in combat areas, there has been developed by co-operation of Hub Industries and the A.A.F., a track landing gear such as that shown in one of our photographs. This gear employs principles somewhat similar to those used on tanks. The belt is tensioned so that it acts as a shock-absorbing medium, and Firestone Air Springs, with a levered suspension of the whole track mechanism, constitute an effective unit. With the ever increasing weight of modern aircraft, contact pressure on landing becomes so great as to be impractical. The track landing gear appears to



Mobile air conditioner for airplane cabins can also be applied to jobs of reducing temperature and humidity in buildings, trucks, and the like

be one useful expedient to meet the difficulty.

In still another derivative of war-time aviation lies an introduction to the comfortization of the passenger cabin. As Consolidated's *Plane Talk* has it: "A big bomber today is not only an elaborate fighting machine; it is also a hotel, prepared to feed, sleep, and otherwise attend to the personal necessities of a crew of from 6 to 12 men—and perhaps a few passengers—for a day and a night at a time. For instance, it houses an auxiliary power plant to supply electricity to operate lights, radio, instruments, the inter-communicating telephone system, power turrets, and battery chargers. It also has a heating and ventilating system."

There could be no better training for the design of an airliner than taking care of these complexities. Moreover, the necessities of the armed forces constantly bring out new devices directed to some aspect of comfortization. Passengers on the airlines have noticed in the summertime that, while the planes are thoroughly comfortable in flight when cool air is drawn in by the ventilating system, their interiors become intolerably hot when they are standing still in the hot sun. In combat areas it has been found that efficiency of mechanics, the development of aerial photographs, communications, care of sick men, all suffer under such conditions. Accordingly, the Carrier Corporation has developed for the A.A.F. a light-weight mobile cooling and dehumidifying unit which can be wheeled up to the plane to deliver conditioned air through canvas ducts.

NAVIGATION AIDS—The automatic pilot has deservedly earned a great reputation for itself. But there has always been the feeling that it would not quite do the job in very rough weather, that pilots then had to cut out the automatic pilot and trust to their individual skill. Now Wright Field has permitted the announcement to be made of a new electronically controlled automatic pilot developed by the Minneapolis-Honeywell Company. The new pilot is said to take over completely the duties of the pilot on bombing runs, to hold the plane on a designated course without wavering. The sensitivity of the electronic mechanism is such that it returns the plane almost immediately to its course despite cross currents, wind variations, and air blasts from exploding anti-aircraft shells. The possibilities of such an automatic pilot for commercial aviation are obvious.

Another aspect of aviation which has been immeasurably developed by the war is production, tooling, and manufacturing capacity, which have advanced to a degree which would not have been believed possible a year or two ago. This means that when civil aviation once more gets under way, it will be able to count on considerably reduced cost of the airframe. Nothing could be more encouraging in this regard than the photograph of the main fuselage sections of the Boeing Flying Fortress advancing steadily in production lines. As the long lines of bomber bodies pass through this section of the factory, they are fitted with complete installations. Next they are moved forward by great cranes, where they are joined to wings, tail sections, and engines.

In this brief review it is not possible to touch upon a number of important phases of aviation such as fuels, the aircraft engine, and new materials. But surely enough has been said to indicate that in the hot-house temperature of total warfare, progress in aviation is rapid and multifarious. From a technological point of view the post-war outlook for commercial aviation is bright indeed.

TOOL GRINDING

Automatic Process Reduces Metal Loss, Extends Tool Life

A PROCESS for grinding machine tools that promises to be of the greatest importance to American industry has been developed by Wright Aeronautical Corporation. Very little high-grade tool steel is lost during actual cutting operations; the real loss comes during the grinding necessary to sharpen the tools after they become dulled by use. Besides the loss of valuable strategic material, time is lost in the usual manual grinding.

Under the new process, special fixtures hold the cutting tools for automatic grinding, 18 at a time. Additional fixtures hold the tools one at a time for a slight final grind on a very fine stone; the last operation is ultra-fine polishing. Under the microscope the edge of a hand-ground tool appears as a saw-tooth profile. In use, an uneven stream of the metal being machined is forced through the saw-tooth crevices, with local concentration of high stress and high heat. Hence the tool edge has to be reground frequently.

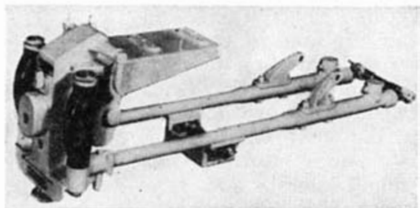
When the edge is precision ground and almost perfect, clean and straight under the microscope, these difficulties disappear. The result is that tool life is extended to a remarkable degree and less metal is lost over a given period of time. Where it was possible to cut 13 gears per grind with one type of hand-ground tool, it is now possible to cut 200 to 500 of the same gears with a machine-ground tool. Another tool had to be re-ground after each cut on one of the larger parts of a Cyclone engine. Precision ground, the same tool now machines 28 forgings of the same part before regrinding is necessary. Obviously, this new technique will be equally as valuable to other industries as to aviation and it is understood that full details are being released for use by other manufacturers and tool users.

Aviation has benefitted greatly by help derived from other industries; now in many ways it is returning such benefits.

GUN RECOIL

Reduced by Hydraulic Light-Weight Unit

BUILDERS of the P-39, Bell Aircraft has now developed a gun-recoil device which is being used by gunners on many types of bombing planes. The device is a portable, light-weight cradle consisting of two steel tubes and a hydraulic absorption unit which can be attached to a .50 caliber aircraft machine gun in a few minutes. It adds less



Above: The light-weight cradle of the hydraulic gun-recoil device described in the accompanying note. Below: The waist gunner of a Martin B-26 Maurader lining up a target by the use of the new absorption unit

than an inch to the overall dimensions of the gun and but three pounds to the weight of the mounting. The normal recoil force generated by a .50 caliber gun is so great that, without a damping unit, accurate fire is difficult to achieve. When the recoil is absorbed in the hydraulic mechanism, the gunner tires less quickly, his aim becomes more accurate, and the strain on the structure of the airplane is lessened.

Refrigerated Metals

Heat Treatment Has a New and Highly Important Partner in the Cold-Treatment of Metals. Sub-Zero Temperatures are Now Used in Treating and Storing Aluminum Rivets, Shrink-Fitting Mating Parts, Seasoning Steel Gages, and Elsewhere. New Equipment Has Been Developed

AMERICA's fighting men all over the world, times without number, have wordlessly thanked the metallurgists and engineers back home for armor plate that successfully withstood shell fire, for shot that pierced the enemy's armament and went on to destroy him, for aircraft engine parts that kept their planes fast and maneuverable during the bitterest dogfights and brought them home safely from the farthest missions.

Virtually everyone knows that we have all these—the most resistant armor, the most penetrating ammunition, the most durable and reliable aircraft and ordnance parts—primarily because of our highly developed *heat* treating methods. But few outside of the metal-working field are aware of the important part that *cold* treatment of metals and alloys is playing in the production of vital war goods, and of its certain continuing expansion into the post-war period.

Cold treatment—the chilling of metal parts to sub-zero temperatures—is applied to produce a desired effect in the properties or structure of the metal on one hand or to prevent an undesirable change on the other. It is sometimes used (1) following a heat treatment to keep the metal in the heat-treated condition. Often (2) it is employed in conjunction with heating to produce a special result. Or again (3) it may be used to overcome an undesirable effect of a particular heating operation. Sometimes (4) cold treatment is used entirely by itself.

The refrigeration of aluminum alloy rivets and parts to keep them from age-hardening (and thus to preserve them in the soft and workable condition in which a heat treatment had left them) is an example of the first use just mentioned. Metal chilling to produce "shrink fits"—that is, permanently fitting mating machine parts one inside the other by chilling the inside member before the fit is made—falls in either the fourth or second group above, depending on whether the outer member is heated while the inner is chilled. The cold treatment of tool steel and of precision gages during their manufacture to prevent them from warping and distorting over a period of time are applications that would be classed in the second group, for reasons that will be given later.

Sub-zero chilling may be accomplished in a variety of ways. The simplest is to place the part to be cold-treated in a chamber surrounded with "dry ice" (solid carbon dioxide) or liquid air, or to immerse it directly in liquid air. These methods provide temperatures lower than —108 degrees, Fahrenheit, and are entirely satisfactory where the chilling of metals is only occasionally or intermittently performed in a plant, and where the control of the sub-zero temperature used need not be highly accurate.

FAST COOLING — The considerable growth in use of metal-chilling, much of it on a continuous high-production basis and requiring cooling to closely specified temperatures to produce special effects, has, however, impelled the development of mechanical equipment that can provide very fast cooling and a range of controllable low temperatures, and whose refrigerants are not expensively consumed (as is dry ice) during use. This equipment is fundamentally similar in principle to mechanical refrigeration units used in the process and food industries for years, but is specially designed for these newer metal-working applications.

The three largest manufacturers of mechanical chilling equipment designed for a wide variety of metal-working applications are Deepfreeze Division, Motor Products Corporation; Kold-Hold Manufacturing Company; and Revco, Inc. With the exception of two or three special models that use propane as the refrigerant, all the units made by these companies employ simple mechanical refrigeration systems, either single-stage or two-stage, using Freon 12 or Freon 22 as the refrigerant that is compressed and then allowed to expand and thus absorb heat from the chamber or parts to be cooled. Most of the Kold-Hold and Revco units are mobile whereas most of the Deepfreeze machines are high-heat-removing-capacity, stationary units; certain Deepfreeze models provide the lowest temperatures of all—down to —150 degrees, Fahrenheit.

The accompanying table lists some of the common means employed commercially for chilling metal parts, and indicates the approximate lower limit of the temperatures obtained with each.

The cold treatment of metals finds one of its widest applications today in aircraft plants, where aluminum alloy rivets and sheets are cooled to low tem-

Refrigerators at a Douglas aircraft plant keep aluminum rivets cold and soft peratures immediately after quenching and held there to keep them in the "as-quenched" condition—soft, easy-to-drive. The metallurgical reason for this is simple: Certain strong aluminum alloys (17S and 24S) may be heated to 910-950 degrees, Fahrenheit, and quenched to put them in a soft condition; on aging at room temperature they rapidly develop increased strength and hardness. This extra strength and

Portable containers, refrigerated by dry ice, are used to distribute aluminum rivets throughout a factory

hardness are highly desirable in the finished product but they interfere with workability, so the fabricator likes to drive his rivets or form his sheets in the as-quenched condition, before they can age-harden.

If the rivets, for example, can be driven in the "as-quenched" condition, the speed of driving is increased and the danger of rivet cracking is practically eliminated. Therefore, to keep them in this easy-to-drive condition until use, they are refrigerated to temperatures so low that virtually no age-hardening occurs. After the cold, soft rivets are driven they age-harden in place, thereby increasing the strength of the joints.

Refrigeration does not change the final strength of the metal, but merely provides a period of "suspended animation" during which it can be worked with maximum efficiency. Contrary to popular opinion, rivets are *not* refrigerated to provide tighter (shrink) fits in their holes, since at the conclusion of driving the small rivets have reached the same temperature as the parent metal; tight fit is assured by the swelling of the rivet shank under the pressure of driving.

Latest research shows that a prompt reduction in temperature after quenching and a continuously low storage temperature before use are essential to maximum workability. Age-hardening starts immediately at room temperature (+ 70 degrees, Fahrenheit) and is complete after four days, but if a temperature of + 32 degrees is maintained, no age-hardening will start until 16 hours have passed. Still lower, at 0 degrees, there will be no apparent aging for a week. At the temperature of dry ice (— 108 degrees, Fahrenheit) apparently no aging takes place for a period much longer than that. Because tests have shown that practically no aging occurs after 100 hours at — 40 degrees, temperatures between — 30 and — 40 degrees, Fahrenheit, are most common for the cold treatment of aluminum rivets.

REFRIGERATED ALCOHOL—These low temperatures are obtained by mechanical refrigeration in individual units or by the use of dry ice. Many fabricators promote rapid cooling by using refrigerated quenching water followed by immersion in refrigerated alcohol to remove moisture, since the latter causes a batch of rivets to freeze together like quick-frozen peas in a box.

In large plants, riveting may proceed simultaneously at scores of locations scattered over a large area. For this situation rivets are heat-treated and quenched at a central location and transported to the riveting stations either immediately or after refrigerated storage. The portable containers (many of them similar to the tricycle-type ice-cream dispensers that once dotted our city streets) for distributing rivets to operators throughout a plant are more often refrigerated by dry ice than by mechanical units.

Cooling Method or Mixture	Approximate Lowest Temperature Degrees Fahrenheit
Salt and cracked ice	—6
Mechanical refrigeration (single stage)	—50
Mixture of dry ice and alcohol	—98
Dry ice alone	—108
Mechanical refrigeration (2-stage)	—120
Liquid air	—314
Liquid nitrogen	—410

At the riveting station, however, the rivets are usually stored in large mechanical refrigerators. These are often provided with ingenious and automatic devices for selecting and feeding the right size or type of rivet at the press of a button. One manufacturer provides a canister transfer unit refrigerated with eutectic "hold-over" plates that keep the canisters of rivets refrigerated for two to three hours so that rivets never leave their — 40-degree container from quench to final assembly.

The use of cold treatment for making shrink-fit assemblies involves the broadest temperature ranges to which metal chilling is applied, since each shrink fit involves a different combination of alloys and of part sizes. The technique itself is simple: The inside member—a metal bushing, sleeve, liner—is formed or machined to an outside diameter slightly larger (0.001 to 0.003 of an inch) than the diameter of the hole in which it is to be permanently fitted, then chilled to a predetermined temperature by one of the methods listed in the table. When sufficiently shrunk it is removed from the cold environment and slipped into its mating part. As the temperature of the inside part returns to normal it expands and makes a perfectly tight, permanent fit against the outer member.

The engineer must calculate in advance, from available data on the thermal expansion coefficients of the materials involved and the low temperatures he may use, what allowances and mating-part tolerances should be applied. Sometimes (with very long bushings, for example) the shrinkage may have to be several times the actual difference in dimensions to achieve perfect assembly. Excessively large shrinkage of the male part may be obviated by moderate heating of the female member to make up the difference.

RAPID ASSEMBLY—Shrink fits have several advantages over press fits, in which the two parts are driven or pressed together. The assembly can be much more rapidly produced, neither presses nor skilled press operators are required, and there is no scoring whatever of either the male or female member of the assembly. The latter remains tight under operating conditions involving vibration, reversing stresses, changes in temperature, and so on, much longer than if made by press-fitting. The process will become increasingly important as handling methods improve and liquefied gases, with the ultra-low temperatures they provide, become available in greater amounts.

Generally speaking, cooling for shrink fits is obtained by one of four principal means—mechanical refrigeration, dry ice, indirect cooling by liquid air, and direct immersion in liquid air. The recent development of the two-stage mechanical units giving temperatures down to — 150 degrees, Fahrenheit, has greatly increased the applicability of mechanical equipment to shrink fits and the trend is now toward this type of equipment.

Here are some typical experiences:

A machine tool builder who formerly press-fitted bearing cups into their assemblies, now has four mechanical units operating at —50 degrees, Fahrenheit. He turns out each assembly in one third the time formerly required, and the bearing faces are free of the burrs that often accompanied drive fits.

Cold-shrinking the male part of an airplane landing strut assembly

The Ohio Piston Company fitted bronze bushings into pistons back in 1932 by heating the piston and expanding it. This was slow and expensive, so the bushings were pre-cooled in dry ice and shrunk in liquid air—a process that was still more expensive but much faster. Now the company uses two large mechanical sub-zero machines, turns out 17,000 units per month and has brought its costs 'way down despite the added original cost of the two machines

Dodge Division of Chrysler Corporation uses dry ice at — 108 degrees, Fahrenheit, to shrink a 1.5-inch high-alloy cast-iron valve insert and a mechanical unit at — 120 degrees, Fahrenheit, to shrink an 8-inch alloy steel bearing cup; each is soaked 15 minutes at the low temperature and both shrink 0.002 inch. Other parts treated by Dodge in its mechanical refrigerators are seals, gear hubs, drive shafts, spring lever pins, and shock spring pins.

Ford Motor Company has been shrink-fitting valve seats in cylinder blocks for 10 years. For some work requiring the greatest amount of shrinkage, direct immersion in liquid air is employed. For example, a bronze sleeve for a gun mount, 10 inches long, 6.880, 0.002 of an inch outside diameter, 0.205 of an inch wall—is shrink-fitted into a tube whose inside diameter is 6.875 + 0.002 inch by immersing it for 15 minutes in liquid air. Other prominent shrink-fit jobs at Ford are the assembly of small aluminum bushings in aluminum castings, steel sleeves in aluminum cylinder blocks, iron sleeves in iron cylinder blocks, bronze bushings in steel castings, and steel inserts in aluminum forgings.

Another manufacturer assembles airplane landing struts by shrinking a 4.843-inch inside member 0.003 of an inch with a five-minute treatment in a — 120 degree, Fahrenheit, mechanical unit and expanding the same-size outer member 0.005 of an inch with a five-minute immersion in a 450 degree, Fahrenheit, oil bath.

Liquid nitrogen, whose temperatures may be as low as — 410 degrees, Fahrenheit, is used by General Electric's Schenectady works to over-shrink steel parts that must be fitted into tungsten carbide cylinders.

GAGE TREATMENT—The stabilization of precision gages and machine parts is a cold-treating application that is many years old but which has recently received new prominence and a sudden expansion in use. These have come about through the development of mechanical refrigerators that go down to — 150 degrees and which thus synchronized cold-stabilization with the tempo of war production, and through new metallurgical understanding of the structural changes ocurring inside the steel.

Practical men have known for decades that the dimensions of a gage block, for example, are unlikely to remain stable after its manufacture is completed but will change, through distortion and growth, as much as 20 times the tolerance over a period of time. For this reason heat-treated gage blocks were traditionally stabilized by leaving them outdoors for several years until all warping had spent itself, after which they could be finish-machined to final, precise dimensions and would be perfectly stable from that time on. More recently the practice has been to rough-machine and harden the block, then allow it to age for one to three years, and finally hold for a matter of hours at — 50 degrees, Fahrenheit, before finish-machining.

Rapid assembly of bronze piston bushings is accomplished by chilling the bushing prior to insertion

Modern gage manufacturers have tremendously speeded up the necessary stabilizing process by applying the most recent research findings on steel transformations, together with chilling temperatures as low as — 120 degrees, Fahrenheit. The trouble with the gages in the first place is that the change in structure that quenching and tempering of the steel is supposed to produce is not completely accomplished when the quenching temperature is the conventional + 60 to 200 degrees, Fahrenheit. The "suppressed desire" of the steel to complete that change then proceeds to find release very slowly over a period of years at normal temperatures, and in doing so warps the gage out of size. However, as Dr. Morris Cohen and his associates at Massachusetts Institute of Technology have recently demonstrated, this change will be completed at the beginning if the steel immediately after quenching is brought down to — 100 to — 150 degrees, Fahrenheit, for a suitable time.

Commercial processes have therefore now been developed whereby steel gages, gage blocks, mandrels, spindles and so on are completely "seasoned" or "stabilized" in about 48 hours by hardening and quenching in the usual way, chilling to — 120 degrees, Fahrenheit, tempering at a selected temperature above 300 degrees, and then repeating this cycle five times. Satisfactory stabilization for most purposes is also claimed for similar cycles using chilling temperatures in the neighborhood of — 50 degrees.

What this has meant in faster production of war equipment and in greater precision and therefore better quality defies description. But of greater interest to some is Dr. Cohen's belief that sub-zero hardening and tempering of high-speed tool steel will produce combinations of hardness, strength, and ductility unattainable by ordinary methods.

Post-war planners are watching refrigeration in the metal industries with interest, for in addition to all the foregoing growing and evidently permanent uses there are many others, such as the chilling of cooling and quenching oils to improve metal-cutting and heat treating operations, that have intriguing possibilities.

VIBRATION FAILURE

Reduced Through Surface Stressing

NOTABLE among recent engineering trends in the metal industries has been the growing use of surface strengthening treatments to improve the "fatigue resistance" of metal parts and thus cut down vibration failures in service. A fatigue failure is the breakage that results after a tiny surface crack or disparity has been enlarged progressively, through the debilitating effects of vibration or cyclic stress reversals, until it reaches across the part. Fatigue failures are responsible for a large portion of the breaks that occur in axles, airplane components, overhead cables, electrical machinery, bearings, shafts, and so on.

The fatigue strength of a part, declares J. O. Almen of Research Laboratories Division, General Motors Corporation, will be increased if a thin layer of the material is pre-stressed in compression by peen-hammering, swaging, shot blasting, tumbling, and so on. Possibly the most widely used of these treatments for this purpose is shot blasting which is now frequently specified as a final cleaning operation because of its salutary effect on fatigue strength.

Case hardening may also be used to improve surface fatigue properties. Of all the case hardening methods, nitriding seems to be the most desirable from the fatigue resistance standpoint.

CAST CRANKSHAFTS

Replace Forged Units, Prove Adequate

A STRIKING illustration of the great improvement in the quality of iron castings in recent years, and of the heavy-duty applicability of specially processed cast iron, is afforded by the current replacement of forged steel by Meehanite iron castings for Diesel crankshafts made by Cooper-Bessemer Corporation. The iron castings are easier to obtain, require less machining, involve less waste metal, and have adequate properties for this type of service.

In one series of operating tests forged shafts of 0.45 percent carbon steel were replaced with cast Meehanite shafts. The crankshafts were six-throw units 7 feet 8 inches long and were run at 1000 pounds head pressure for 40,000,000 revolutions at 900 revolutions per minute without any damage to the cast crankshaft or its bearings.

Plastic Flow and Creep

Not Enough is Yet Known About the Exact Mechanism of Metal Flow and Forming. More Knowledge Will Bring Metal Improvements, also Financial Savings. The Immediate Need for New Knowledge of the Plastic Flow in Metals is for the Rapidly Evolving Gas Turbine

By A. NADAI
Consulting Mechanical Engineer, Westinghouse Research Laboratories, East Pittsburgh, Pennsylvania

IN PEACE and war the machine industry requires vast quantities of metallic bars, plates, sheets, and tubes. Each day the steel mills must supply thousands of tons of these simple bodies, which must be forged, rolled, drawn, and shaped from ingots. Anybody who has watched the rolling of broad steel sheets for automobile bodies in one of the huge continuous strip mills must have admired the high precision of the operation. A wide, hot sheet goes through one roll stand after another at ever-increasing speeds and emerges finally with a velocity of 20 to 30 miles per hour, ready to be wound on a reel. In wartime, huge quantities of thin, light metal sheets are needed to build airplanes. Also, much thicker plates of ship steel and armor plate are in heavy demand.

Great progress has been made during the last 10 to 15 years in the mass production of metal shapes, but this progress has been mainly of a practical nature. When comparing it with the great developments in other branches of mechanical engineering—for example, in building large steam turbines, generators, combustion engines, or planes, the designs of which are all based on exact mechanical knowledge—it is rather surprising to note how little, comparatively, is known about the exact mechanics of metal forming. The flow of steel under heavy concentrated pressures exerted by a rolling mill is not well understood. Little also is known about the power losses through friction during rolling, or concerning the true forces required to deform cold or hot steel. This is the more surprising since the power requirements of large rolling mills run into many thousands of horsepower and these power requirements can be judged, therefore, only in an empirical way.

These plastic flowlines on steel after permanent deformation tell us a tale

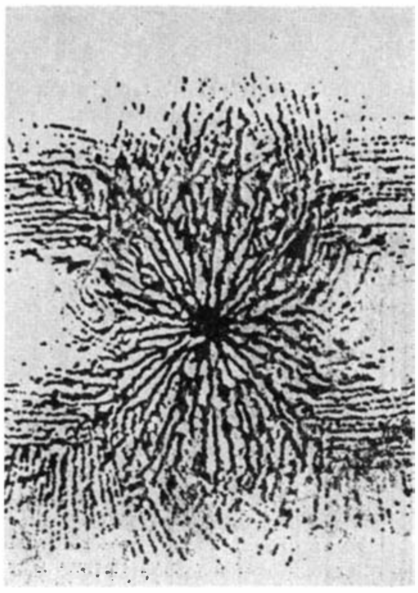
When a wire is drawn, or a bar or a wide sheet is rolled, or a seamless tube is formed, or a billet is pierced, or a high-explosive shell is nosed in some of the many ingenious and intricate forging machines of a steel mill, heavy localized pressures are utilized. Usually these pressures are combined with other forces to pull or to push the piece under the rolls or dies. Although the metals are in the solid state, they flow easily at forging temperatures under concentrated pressures without breaking, not unlike soft wax or wet clay being extruded from an orifice. Use is made of their "ductility" or "plasticity."

POWER SAVINGS—The art of forging is as old as the making of the first metallic implement of earlier man, yet many important cases of the plastic flow of solid materials under concentrated pressures have barely been investigated mechanically. A better understanding of this flow of metals should result in steel-mill power savings and improvements in the structure of the metals produced.

A wonderful mechanism is hidden in the plastic deformations of a metal. This is illustrated by the accompanying photographs which show examples of remarkably regular patterns. These "flowlines" appear on the surface of mild steel plates after a small plastic deformation. Should these regular designs not inspire the mechanically inclined observer to further thinking? Engineers have often called attention to these fine markings. The geometry of these lines seemed to disclose to them that simple mechanical or physical laws must control these phenomena. Other examples of a striking regularity are known to the physics or mechanics student, such as the force lines of Faraday around magnets, or the streamlines in a moving fluid around solid bodies; yet to forestall any confusion, the flowlines in a metal should not be identified with some of these well-known patterns in physics. They have their own and a different mechanical meaning. Just as Faraday's magnetic force lines have attracted the attention of mathematicians and inspired them to analyze the electric or magnetic static fields, it is believed that these patterns of flow may help to analyze the plastic states of equilibrium when solid bodies are deformed permanently.

Reasons why engineers should be interested in the phenomena of the plastic flow of materials, other than those involved in the forming of metals previously mentioned, will be found in the following paragraphs.

Many of us have seen how the con-



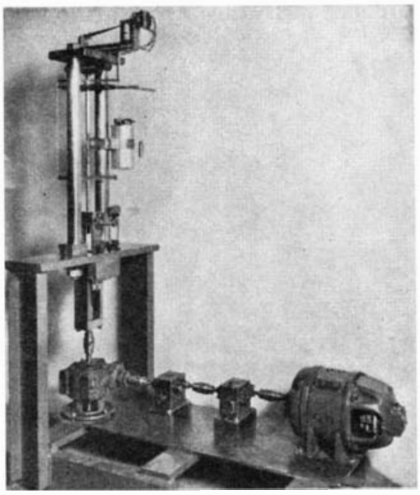
Another flow picture on a steel plate. Its black lines are the traces of instantaneous differential slip motions under a concentrated central force. Plate supported on four margins tinuous strip mills revolutionized steel-making but only the older engineers remember another revolution that was even more astounding—the rise of the steam turbine which almost overnight replaced the bulky and slow triple-expansion steam engine. This sudden eclipse could not have occurred if engineers and scientists had not prepared the ground to solve the problems which presented themselves suddenly with the steam turbine. Thermodynamics was well advanced. There was an excellent contemporary knowledge of the thermomechanical properties of water vapor. Engineers were able to solve a number of difficult mechanical problems which were raised by the steam turbine.

Many present signs of development indicate that something similar may possibly occur in the next few years, with the gas turbine replacing its older steam-driven rival for many purposes. It does not require the costly installation of boilers and condensers and it is much simpler in design. It needs, however, a rotary compressor of high efficiency for compressing the air. Strange as it may sound, aerodynamics was partially instrumental in perfecting this auxiliary machine. Rotary pumps and steam and gas turbines all contain hundreds of blades in their wheels, and their efficiency has been improved greatly through the better knowledge of the flow of air around the wings of planes studied in the aerodynamic laboratories.

The theoretical means for predicting and controlling the flow of steam through nozzles and around blades, the designs of the highly stressed rotating disks, the method for computing the critical speeds of the flexible shafts, and many other difficult problems, were clearly stated or solved for the steam turbine by the great engineer and scientist Aurel Stodola, who died a year ago in Switzerland. He developed the theory of the steam turbine when De Laval, Parsons, Rateau, and others succeeded in building the first practical steam turbines. Stodola had foreseen the theoretical means for designing gas turbines 30 to 40 years ago when the first noteworthy efforts were made to build experimental gas turbines. He constructed the first graphical entropy—temperature chart for the valuation of the efficiencies of thermal cycles. This was based on the variable specific heats of gases.

WHAT DELAYED IT?—Since the theoretical means for building gas turbines have been available for so long, why then has the gas turbine not already replaced the steam turbine? Mainly because of the lack of materials which will resist the high temperatures at which the gas turbine must operate to make it the economic superior of the steam turbine. Alloy steels capable of standing the punishment handed out in the gas turbine have been developed only recently and satisfactory means of predicting the mechanical properties of these steels are comparatively quite new. The engineer designing a gas turbine, which must operate at 1200 up to 1500 degrees, Fahrenheit, encounters these difficulties. He has to give up some of the conservative ideas of former times; for example that the dimensions of highly stressed machine parts will remain the same during the lifetime of his machine. Parts made of the strongest alloy steels start and continue to yield under these high temperatures. The slow "creep" which could be checked in steam turbine design becomes disturbingly fast in gas turbine disks or blades.

The property of the ductile metals of flowing plastically is most desirable in



The constant strain tension machine

making steel products. But when it occurs as "creep" in machine parts under heavy loads at high temperatures it is dangerous and detrimental. The blades of a steam turbine, whirling continuously for years at a temperature of 900 degrees, Fahrenheit, with their tips clearing the stationary part of the machine by only a few thousandths of an inch, creep so slowly that they need not be exchanged during the life of the turbine—20 years or more. Gas turbine blades spinning at 1500 degrees, Fahrenheit, present the same problem under very much more difficult conditions. This is true also in other applications. Engineers designing containers, petroleum distilling equipment, steam boilers designed for high pressures, and many other types of apparatus must know as exactly as possible how their materials will behave and creep under stress at high temperatures. The structure of metals exposed to hot air or gases may also be so weakened that the danger of fracture may become quite a determining factor.

Mechanically trained and similarly interested readers probably will conclude from the preceding remarks that the strength of solids in general and of engineering materials in particular must embrace a complex group of mechanical properties which must be associated with a variety of phenomena. More precisely, "strength" is not just *one* mechanical property. Several important cases representing types of "strength" must be differentiated. In each case "strength" may depend on a number of important variables.

Statics teaches that if the external forces acting on a body are in equilibrium, any portion or small element of material in the body must also be in such a state. The interior of solid bodies carrying external loads must therefore be internally "stressed." Tension, compression, shear, and hydrostatic pressure are such states of "internal stress."

It is an accepted practice that constructions made of steel, which have to carry a permanent load at normal temperatures, are to be designed so that the yield-point is not reached in them at the most stressed point.

Solids under stress may change their shape either by very small amounts which are recoverable after the loads are removed (elastic distortion) or they may start to deform permanently. A geometry of all these changes of shapes of solid bodies has long been developed and serves as a tool in engineering design. The term "strain," so much used by engineers, serves to designate the general status of deformation, either elastic or plastic. If time also plays an important part, as under elevated temperatures, apart from "stress" and "strain," a third variable becomes quite important. A glass rod held in a horizontal position in a gas flame will start to sag under its own weight when it has become soft. The more weight it has to carry the faster it will sag. Thus we see that stress in this case does not depend on the permanent strains but on the *rates* at which they are changing, that is, *on the rates of flow or of strain.*

In sum, then, stress, strain (elastic or permanent), the rate of permanent strain, temperature, and time are the principal variables to be considered and the study of strength and of the mechanical behavior of solids must mainly be concerned with defining the relations connecting stress with strain and with the rate of plastic strain. The conditions under which materials rupture, break, and fatigue embrace other important chapters of the theories of strength.

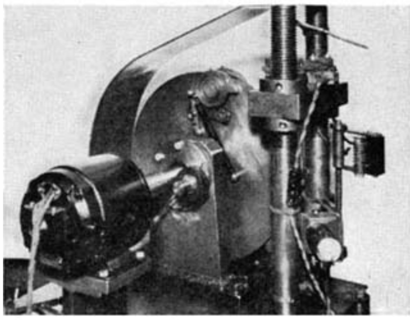
ROCKS THAT FLOW—Although the strength of solids is deeply anchored in the atomic structure of matter, and that of certain important metals or alloys is materially influenced, improved, or altered through metallurgic (heat) treatment, it is equally true that certain frequently used and familiar designations expressing important material properties depend on the mechanical states under which these properties are being compared. An example will illustrate this. A test cylinder of marble or of sandstone under a simple compression load deforms very little before it breaks. Such materials are called "brittle." If, however, the test cylinder is surrounded by a fluid in which a high pressure has been generated and if the fluid is prevented from penetrating into the pores of the cylinder, then the cylinder can be deformed in a plastic state quite continuously under an additional axial compression load without fracturing. The celebrated Swiss geologist, Albert Heim, perceived long ago, with other geologists, that something similar must have occurred in the depths below ground in certain rock formations. Geologists are familiar with this behavior of rock materials in the interior of the earth's crust today.

Many symptoms point to the fact that the rocks have been deformed continuously and permanently without showing any signs of fracture. "Brittleness" in marble or sandstone thus does not seem to represent an inherent property of these materials. A brittle marble can be continuously deformed plastically under the proper conditions.

Another example of varying mechanical states can be found if a steel ball is laid on the surface of solid asphalt which fills a vertical tube of which both ends are open. After a few sufficiently hot summer days have passed, the ball will be found at the bottom of the tube. The solid asphalt must have yielded under the weight of the ball and behaved like a viscous liquid since it could continuously flow around the ball. A piece of the same natural pitch, on the other hand, if it is thrown violently against a wall or the floor, will break into many fragments. The same material behaves in one case like a "viscous liquid," and in the other like a "brittle solid."

SLOW AND FAST TESTS—We shall now concentrate on one of the fundamental variables: The permanent *rate* of strain. Let us investigate the magnitudes of this rate under difficult testing conditions encountered in slow and in very fast tests. A very slow test is, for example, a long-time creep test run at an elevated temperature. Toward the other extreme, the flow accompanying the penetration of a projectile hitting an armorplate must occur under extremely rapid rates of straining. A bar of a ductile metal, such as copper under a tension load, can stretch by an amount which is 30 to 50 percent of its original length before it will break. If a bar is stretched by 100 percent, this is equivalent to saying that the strain is equal to "1". If strain=1 is produced in one second the rate of strain is equal to 1/sec. If strain=1 is produced in one year the rate of strain is equal to 1/year. Therefore, assuming that an ordinary tension lasts 15 minutes (900 seconds), the rate of strain is of the order of 0.001/sec. or a fraction thereof. During a fast impact test a bar may on the other hand be stretched by 50 percent in a ten-thousandth of a second. Plastic rates of strain in impact testing may reach the order of 10,000 1/sec. Steam turbine engineers require that no essential part of a turbine should change its shape by more than 0.001 of its original dimensions in 10 years of service. This corresponds to the very slow rate of strain or of creep of 0.0001 1/year, or 3.2 times one billion billions 1/sec. (that is, 3.2 x 10^{-12} 1/sec.).

Geophysicists are interested in many times smaller rates of flow. Creep in rocks must evidently have a significant part in the mechanism of mountain building. The temperatures below ground increase an average of 1 degree, Fahrenheit, for every 60 feet of depth. At depths of a few kilometers temperatures must reach several hundred degrees, Centigrade. Under such temperatures, granitic or igneous rocks certainly must creep even if they are subjected to extremely small gradients of differential stress. According to geophysics, the whole geologic history of



High-speed tension machine. Its flywheel carries two horns which can be released during rapid rotation, hitting an anvil and delivering a powerful blow to the test bar

the earth from the times of beginning (forming of the oceans) covers not more than 2000 million years. If we take perhaps one twentieth, or 100 million years, as the average length of a geologic epoch and if a fraction of this latter, say 10 million years, was sufficient to produce a mighty mountain range like the Himalayas, and if we finally assume arbitrarily that all horizontal lengths in the direction perpendicular to this mountain chain have been reduced to 50 percent of their orignal values, a rate of flow in the rocks in horizontal direction would be found equal to 5 times 10^{-8} 1/year. Thus the slow creep rates in a steam turbine disk are more than 10,000 times faster than the geologic flow which caused the lifting of a high mountain range. The total range of the rates of plastic strains of interest to engineers covers a range 10^{16}:1 and if geophysics also is to be included in our discussion, this may well be extended to 10^{20}:1 or more.

We have noted that at the higher temperatures stresses which deform materials depend on the rates of flow, rather than on the strains. We can now add that the inner resistance of solids against a rapid permanent deformation at sufficiently high temperatures must increase quite considerably with the rate of strain. This has recently been shown in some high-speed tension tests which were run at the Westinghouse Laboratories in Pittsburgh with copper at the very rapid (impact) rate of 1000 1/sec. near the melting point of the copper. It was found that copper at 1000 degrees, Centigrade, (it melts at 1083 degrees, Centigrade), when stretched violently at such a high velocity (a copper bar one inch long was broken in 1/1000 second), resists with a strength that is as large as a third of the strength of copper at 20 degrees, Centigrade. Copper under normal or slow rates of pulling at 1000 degrees, Centigrade, would not be able to carry any substantial load.

Among the physical phenomena, plastic flow of solids attracts interest because of the extremely wide range over which one important variable on which it depends can vary. Few phenomena are known to the writer in physics for which the variables change over a range of 10^{20} in the applications. Only the electromagnetic spectrum surpasses this scale. This is further illustrated through a comparison of equally spaced phenomena in both scales, as in the accompanying table.

LONG TESTS—Readers will perhaps be interested to know whether experiments have been carried out for testing engineering materials at some of the above-mentioned extremes of the velocities. This question can be answered affirmatively. In the engineering laboratories many careful investigations are carried out at present on the long-time creep strength of metals, particularly on alloy steels. The slowest tests of this kind may need many months for their completion. Creep rates will be of the order appearing in the second column of the table. One of the photographs shows a constant strain rate machine, in which a small test bar seen between the two vertical columns can be pulled under the rather fast strain rates of 10^{-3} to 1 1/sec. Extremely rapid plastic deformations approaching those accompanying an explosion or corresponding to impacts in steel pieces are produced in the high-speed tension machine shown in another photograph, in which a one-inch-long tension bar can be broken in one thousandth of a second.

In sum, we can then perhaps state that in forging operations, strain rates are reached of the order of 100 1/sec. Metals at the forging temperatures flow easily under these rates without breaking. Metal forming is based on the ease with which metals can be deformed at the forging heat. Under impact, even one hundred times faster flow rates can be attained. In other applications of engineering, however, creep and plastic flow are undesirable. If they cannot be prevented, as in the applications in which machine parts have to withstand very high temperatures, the engineer, through his tests, must in advance determine the stresses under which the strain rates in his constructions will not exceed permissible limits.

Flow Of Solids	Rate of flow per sec.	10^{-16}	10^{-12}	10^{-3}	10^{4}
		(geology)	creep in steam turbines	ordinary material testing	explosion damages
Electro-magnetic Phenomena	Frequency per sec.	10^{2}	10^{6}	10^{15}	10^{22}
		low frequency electric heating	high frequency	visible light	cosmic rays

Plastic flow and electromagnetic spectrum, for comparison of ranges

Gasoline From Coal

Highly Important in this Solution to the Problem of Our Dwindling Petroleum Reserves is the Study of Coals and their Adaptability to Processing into Liquid Fuels. Technical Data Must be Acquired Before the Crisis Arrives; Experimental Plants Will Provide Data for Industry

By REPRESENTATIVE JENNINGS RANDOLPH
Chairman of the House Sub-committee of the Committee on Mines and Mining

In the post-war era millions of new automobiles will travel on improved highways; helicopters and planes by the thousands will be piloted by men now flying fighters and bombers; larger and faster commercial transport aircraft will span oceans and continents on hourly schedules. All these planes and automobiles must be powered with liquid fuels.

On one hand there is a promising future for our country, with a vast increase in air transportation, fast aerial service to foreign lands, rapid development in the use of private planes, and the resumption of our normal automobile manufacture and use. On the other hand, the picture may be changed entirely if our petroleum reserves become seriously depleted and if, in the meantime, we fail to develop ways for producing fuel from other materials.

The recent decline in the rate of discovery of new petroleum fields in this country has given rise to the question of what we can do to meet the demands of an air-minded and automotive post-war age. Since 1939, petroleum has been consumed at a greater rate than it has been discovered in new fields not previously known. Also, oil fields discovered in recent years have been of relatively small capacity. With an all-time high (1,402,228,000 barrels in 1941, and higher now), we cannot continue to drain sources which are already being depleted. Last year the new oil found was a half-billion barrels less than we produced. Since 1937 the number of new pools found has increased but the quantity of oil has consistently fallen off.

While our oil reserves, tucked away in strata of the earth's crust, is estimated at 20 billion barrels and we are now using less than one and six-tenths billion barrels a year, geologists maintain that it will take 50 years to get today's known reserve supply above ground, and some say that a century will be required to bring it up.

MANY FIELDS EXHAUSTED—Oil men do not have much to offer in the way of encouragement; the big fields have apparently been discovered and many have already been exhausted. The newer fields are smaller and the costs of exploration and drilling are necessarily higher. To estimate exactly how long the available supply of oil will last this nation is virtually impossible. Experts in the oil industry say that there will be an acute shortage in 20 years. Others equally qualified say that new fields will delay this shortage for 50 years.

But there is a reasonable prospect for securing the liquid fuel necessary for the construction and expansion of automotive transportation on land and sea and in the air from other sources which will be available for many years. Great Britain, Germany, and Japan are making synthetic oil and gasoline by processes that are known to have passed the experimental stage. Great Britain produces enough gasoline by coal hydrogenation to keep 100 to 200 bombers over Germany every night; a lower octane gasoline and Diesel oil is obtained from oil shale. Germany is said to produce over half of her liquid fuel from coal and coal tar, while Japan is likewise reported to produce large amounts of liquid fuel from coal and oil shale.

In order to round out the over-all picture of motor fuels from coal, we should first review the by-product processes. Of these there are two: (1) The high-temperature carbonization of coal, including that used by the gas-and-coke-manufacturing industry; and (2) The low-temperature carbonization of coal.

In coke and gas works about 2.5 gallons of refined motor benzol can be obtained from the ten gallons of tar produced in the high-temperature carbonization of one ton of coal. On this basis, 207,000,000 gallons of motor benzol could have been obtained from the total coal coked in by-product ovens in the United States during 1941, or about 0.7 percent of the 29,000,000,000 gallons of motor fuel produced.

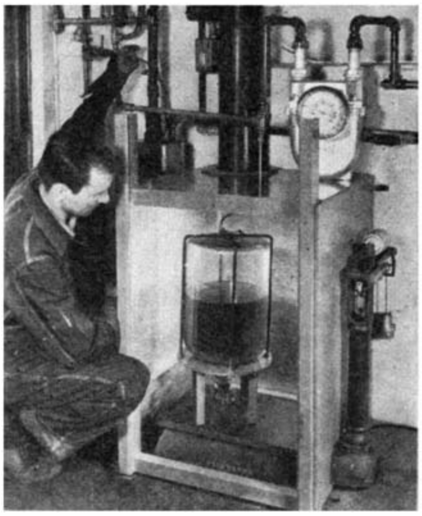
Low-temperature carbonization is

Left to right: Secretary of the Interior Ickes, Representative Randolph (author of the accompanying article), Senator Murdock of Utah, and Senator Gurney of South Dakota, with a gasoline motor being operated on synthetic fuel produced from coal at an experimental plant (see diagram, next page) operated by the Bureau of Mines often cited as the process that will solve the problem of our future motor-fuel supply. In this process coal is heated to about 1100 degrees, Fahrenheit, instead of the approximate 2000 degrees used in high-temperature carbonization. The tar yield is 20 to 35 gallons a ton, or two to three times that obtained by high-temperature carbonization. From one to two gallons of liquid fuel can be scrubbed from the furnace gas, and another gallon or two distilled from the tar, the total yield being two to four gallons. Refining losses would bring the net yield of motor fuel from gas scrubbing and straight distillation of the tar to about 2.5 gallons a ton, or about the same as is obtained in high-temperature carbonization. However, this low-temperature tar may be subjected to pressure-cracking similar to that applied to petroleum, and thus made to yield 20 to 30 percent of motor fuel. It is, therefore, reasonable to assume a possible yield by this process of 7 to 12 gallons of motor fuel per ton of coal.

TEN GALLONS PER TON—If 100,000,000 tons of bituminous coal, about one fifth of the output in 1941, had been carbonized at low temperatures, the motor-fuel yield on the basis of ten gallons to the ton would have been one billion gallons, or about 4 percent of the gasoline production in that year.

It is evident that the maximum probable development of the production of motor fuel as a by-product of low-temperature carbonization of coal, while furnishing a material quantity, cannot satisfy the entire demand. We must turn, therefore, to other processes, including hydrogenation, in which motor-fuel is the principal product rather than a by-product.

Coal hydrogenation is similar to other forms of coal utilization, in that among the major factors involved are the nature and properties of the coal. Choosing the best coal for the job is most important. By using coal of optimum properties, the yield of oil is increased, the amount of inert residue is decreased, operating difficulties and maintenance costs are minimized, and the capital investment and cost per gallon of the product are lowered.



Gasoline from coal flows directly into containers from the converter room where the coal is hydrogenated

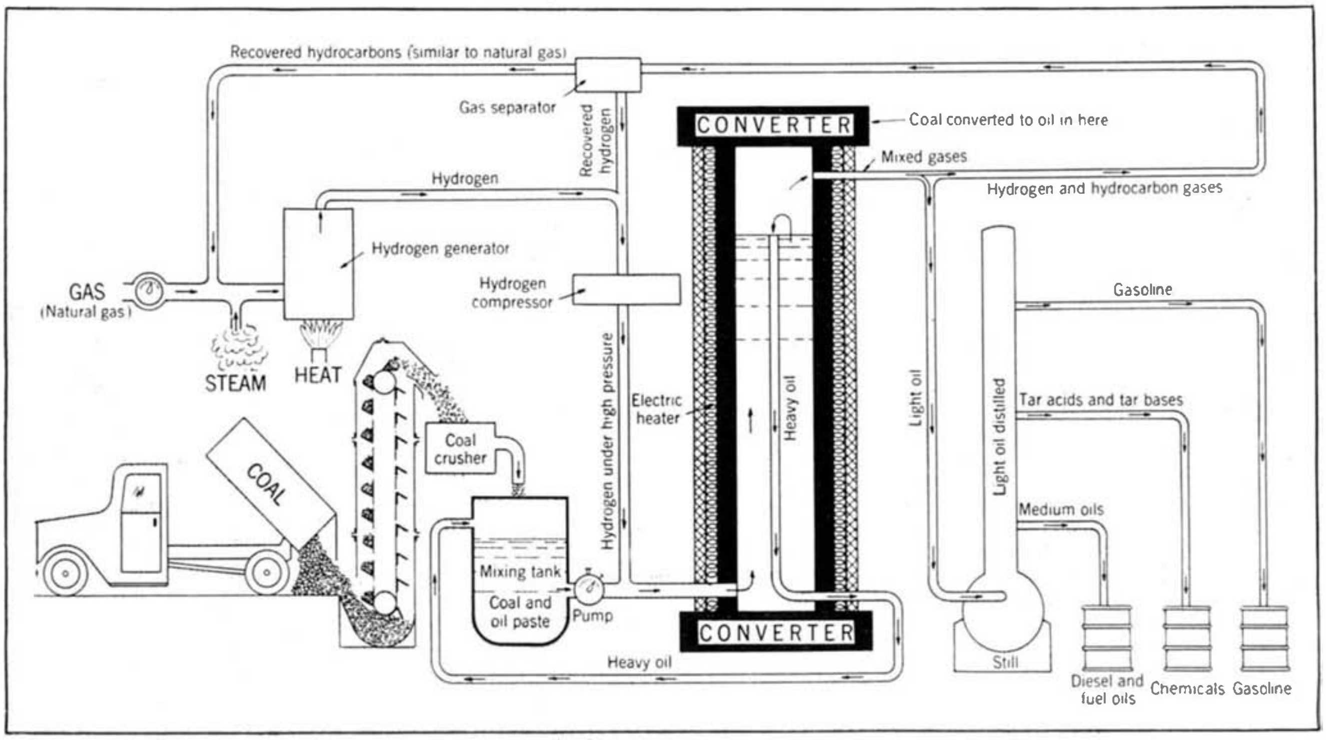
Data obtained in the hydrogenation of about 130 samples of pure constituents of coal or of coals of known petrographic composition show that some of the constituents differ enormously in ease of liquefaction and yield of the various products.

Continuous hydrogenation tests of low-rank coals in the Bureau of Mines Experimental Plant, in which no undue operating difficulties were experienced, show that the coals in some of the vast deposits of the western states are potential sources of enormous quantities of liquified fuels, solvents, synthetic resins, and industrial chemicals.

In bituminous and lower-rank coals the constituent that usually has the highest degree of opacity and the highest carbon content is fusain. This constituent, which resembles charcoal in appearance, is a mixture of opaque fibers, called "fusinite," and about 10 to 30 percent translucent or semi-opaque material. The "fusinite" is virtually inert to hydrogenation, but the material associated with the opaque fibers is partly, sometimes almost completely, liquefied by hydrogenation. The liquefaction yield, which depends primarily on the quantity and nature of the translucent fraction, usually ranges from 5 to 25 percent.

As may be concluded from the foregoing, bright coals, which contain high percentages of translucent material and comprise the greater part of the Nation's coal reserves, usually are suitable for hydrogenation. The liquefaction yield obtained upon hydrogenation of bright coals containing less than about 10 percent total opaque matter is related to the carbon content. A high liquefaction yield is obtained with bright coals having less than about 89 percent carbon. The yield of oil decreases and that of water and carbon dioxide increases with a decrease in the carbon content of the bright coal hydrogenated.

As a class, splint coals (banded coals containing 30 percent or more of opaque attritus, the latter being the characteristic constituent of splint coals) are less suitable for hydrogenation than bright coals. In contrast with bright coals, splint coals are highly heterogeneous; their carbon content, volatile-matter content, and other characteristics are only averages for all the constituents. Hence, upon the basis of carbon content and opacity, the constituents of splint coals differ enor-



Simplified flow diagram of the conversion of coal to liquid fuel, as accomplished at the Bureau of Mines' hydrogenation plant

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The results obtained with the low-rank coals from the Western States, which comprise the greater part of the United States coal reserves, are of special interest. Of the low-rank coals examined, the majority contained only small quantities of opaque matter and gave a low yield of inert residue upon hydrogenation. The opaque-matter content of some coals was so low that virtually all of the organic part of the coal was liquefied.

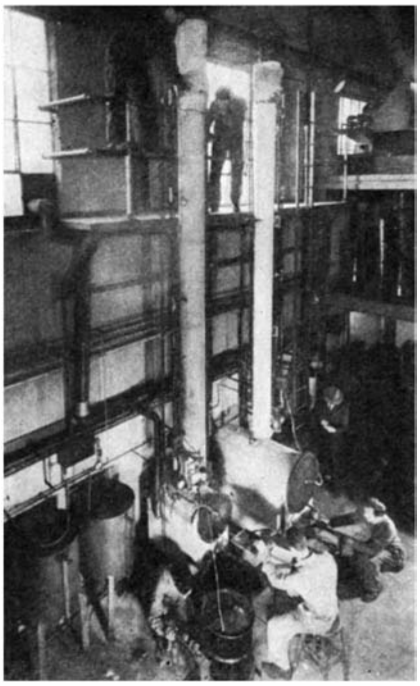
Since the beginning of coal-hydrogenation research (about 1913), one important objective has been to determine which coals will give the highest yields and fewest operating difficulties when processed to produce liquid motor fuels. This brings us to a brief description of the two direct processes which have been developed for this purpose:

(1) The hydrogenation and liquefaction of coal by the modified Bergius process which produces gasoline, Diesel fuel, and fuel oil. This process was developed by the I. G. Farbenindustrie A.g. of Germany.

(2) The complete gasification of coal and catalytic conversion at varying pressures, as stated below, of the resulting mixture of hydrogen and carbon monoxide into gasoline, Diesel fuel, lubricating and fuel oils, and paraffin wax. This is known as the Fischer-Tropsch process.

HYDROGENATION—In the modified Bergius process a coal-oil-catalyst mixture containing 40 to 50 percent of powdered coal and 0.1 to 1 percent of a powdered catalyst is forced into a high-pressure vessel with hydrogen gas at over 200 atmospheres pressure and at a temperature of about 860 degrees, Fahrenheit. After some two hours contact time the coal is liquefied and the product is separated into gasoline, middle oil, and heavy oil. The latter is recycled to provide oil for mixing with coal at the start of the process. The middle oil is hydrogenated further, using a catalyst held in place in the converter rather than pumped in with the raw material. The final products are gasoline and Diesel fuel. About 50 percent of the coal that is hydrogenated is obtained as a motor fuel and about five tons of coal are necessary, per ton of gasoline produced, to provide fuel for all purposes, including power, steam, and so forth.

In the Fischer-Tropsch process, developed by Dr. F. Fischer in Germany in 1926, the raw material is a mixture of hydrogen and carbon monoxide gases produced from coal or coke. This gas mixture, after purification to remove all sulfur compounds, is passed over a solid catalyst such as a mixture of cobalt and thoria with diatomaceous earth. The temperature is maintained between 356 and 410 degrees, Fahrenheit, and the pressure between 1 and 50 atmospheres. The valuable products are propane, butane, gasoline, Diesel fuel, and paraffin wax. About four to five tons of coal are necessary per ton of products. The cost of production probably is in the same range as that for direct coal hydrogenation.



Small cracking plant where medium oil obtained from the first stage of coal liquefaction is fractionated to produce more gasoline, Diesel oil

The Bureau of Mines' experimental coal-hydrogenation plant at Pittsburgh, Pennsylvania, has a capacity of 100 pounds of coal in 24 hours. The main objective of the plant's operation thus far has been to study the hydrogenation of coals from the most important coal beds in the United States.

While motor fuels can now be produced from coal and oil shale, these sources do not offer as cheap a supply as does petroleum. But I feel certain that our people will back the extra effort and the extra cost when the alternatives are ample or restricted supplies of gasoline. Furthermore, even though production cost is higher, further technological developments undoubtedly will reduce it.

But with all the pioneering work that has been done, we cannot say to American industry: "Here is a coal liquefying process that will work on a particular coal. Here is the way to build a plant. Here are the plans for operating it." Such facts cannot be obtained from the equipment the Bureau of Mines has had up to the present time. I saw the little laboratory in Pittsburgh when we were holding our recent hearings. It's small—I would almost call it a toy plant. But I saw coal going in at one end and gasoline coming out at the other end. We took some of the gasoline and put it in standard-make automobiles and drove the cars through the city streets. It performed like any gasoline made from petroleum.

Other satisfactory tests were made recently of gasoline produced from coal in an experimental flight from Morgantown, West Virginia. On the first flight by an airplane in this country, using motor fuel made from American coal, I accompanied Major Arthur C. Hyde, Wing Commander of the Maryland-District of Columbia Civil Air Patrol, on the 175-mile journey to Washington, D. C. The motor performed perfectly on the coal-processed gasoline.

COMMERCIAL-SCALE PLANTS—Thus I believe that now is the time to conduct a vigorous research program so that methods will be available to supply necessary liquid fuels when the petroleum supply begins to fail. Such data can be made available only from plants which approach commercial-scale operations. These plants must be of minimum size and for the sole purpose of furnishing industry with the necessary cost and engineering data for the development of synthetic liquid fuel by private enterprise.

I have unshakable faith in the ability of our scientists and engineers to provide the best coal-liquefaction methods for American industry and American coals, but I know that the necessary answers will not be supplied overnight. Years of additional research may be required, even with commercial-scale levels. American industry cannot be asked to risk the time and money on these experiments in coal liquefaction; and since the end-result is to the advantage of all the people, it obviously is the Government's responsibility to undertake the development work to the point where industry can profitably enter.

When we are required to turn to coal and oil shale as the chief source of motor fuels in the United States we should have the processes at hand for immediate application. We certainly do not want to empty our natural petroleum reserves of every drop while waiting for satisfactory coal liquefaction methods to be developed.

POLYVINYL ALCOHOL

A Resin With a Bright Future

A PLASTIC so versatile that its uses vary from grease- and gas-proof coatings for paper to rubber-like molded articles and from adhesives to "sizes" for nylon and rayon will be available in large quantities for postwar applications, according to the Electrochemicals Department of E. I. du Pont de Nemours and Company.

Characterized by exceptional toughness and resistance to oil, grease, and many solvents, this plastic—polyvinyl-alcohol resin—now is employed in hose assemblies for airplanes, trucks, and tanks, oil and grease-resistant aprons and gloves for war workers, printing plates, adhesives, emulsifying agents for waxes, resins, and oils, textile "sizes," and a variety of vital military articles.

All polyvinyl alcohol today is allocated by the War Production Board for military and certain critical civilian needs. Polyvinyl alcohol is a member of the vinyl resin family, which is annually replacing 22,000 tons of crude rubber.

Polyvinyl alcohol was introduced commercially shortly before the war started, after several years of intensive research. Military demands for it have necessitated rapid expansion of production facilities.

Postwar possibilities are numerous. Tough, transparent film, for example, will be available for gas and grease-proof containers, garment covers, hat boxes, and lamp shade covers. Under investigation are printing rolls of polyvinyl alcohol to withstand the chemicals in new fast-drying inks, where rolls of other materials quickly deteriorate.

Sheets of polyvinyl alcohol may be used for lining fuel tanks or other petroleum containers. Gaskets, washers, and molded articles of all descriptions, made of this plastic, can be immersed indefinitely in oil or most solvents without harmful effect.

As a paper adhesive it may eliminate the bother of postage stamps sticking together or of a flap adhering to the envelope before moistening. Already it has been used successfully on telegraph tape, where the layers often stick together in humid climates and ruin the rolls. It is also a good adhesive for cork, cloth, pigments, ceramics, and other materials. Certain war uses have shown polyvinyl-alcohol adhesives to be ideally suited for use in the fabrication of paper and paper-board boxes and cartons where strength and weather resistance are important.

Lithographic printing plates made from polyvinyl alcohol save from three to eight times their weight in critical aluminum and zinc, give approximately the same number of impressions as metal plates, and carry about 25 percent more ink without smudging. These will be available for peacetime printing.

As an infinitesimally thin "size" coating on nylon, rayon, and other fibers. this plastic gives required protection to the fibers and prevents their breaking during weaving and knitting. Polyvinyl alcohol is used to make paper grease- and gas-proof, and is accordingly valuable in the manufacture of containers for such varied items as oil, food, asphalt, and paint. And it has been shown that films, obtained by dipping or spraying, will protect polished metal surfaces against tarnishing and abrasion.

Surgical sutures, photo-sensitive films, stencil screens, binders for water paints, priming coats for adhesive tape, stiffener for nylon catheters, water-soluble sewing threads, and oil-resistant thread for industry—this list indicates the wide variety of potential applications for polyvinyl alcohol.

BETTER COKE

Made With Use of Anthracite Slack

PARTIAL substitution of anthracite slack for low volatile coal will effect a saving of 225 tons of "hard-to-get" coal a day at the Rouge plant of the Ford Motor Company. In addition, tests reveal an improvement in the quality of resulting coke.

Formerly regarded as impractical for coking purposes, since coke made exclusively from anthracite slack is lacking in metallurgical structural properties, laboratory tests reveal that when it is fused in small quantities with other coal, anthracite imparts added toughness to the coke, a highly desirable feature.

SHIP TURBINES

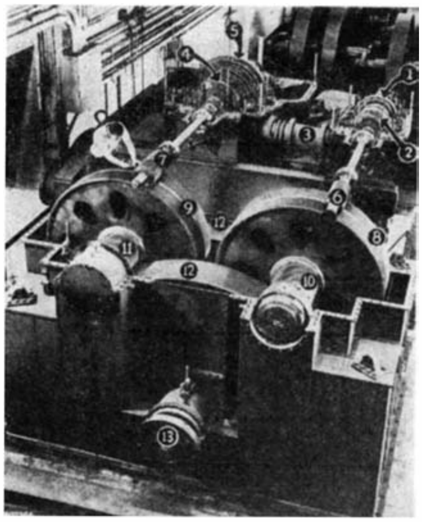
Increase Speed and Hence Capacity

PROPULSION machinery for nearly 1,000,000 tons of ocean shipping—enough to land and continuously supply two divisions of modern fighting men—was delivered from the new Westinghouse Merchant Marine plant during the first year of production, according to Ellis L. Spray, manager.

In terms of ship tonnage, he said, this represents an output nearly two and a half times as large as the plant's original promise to the Maritime Commission for performance to this date. Current production is at a rate of more than 1,000,000 horsepower a year.

Mr. Spray emphasized that all production from the plant to date—about three times the number of units originally scheduled as "capacity"—has consisted of complete propulsion units. Each such unit is made up of a high and a low pressure steam turbine and a set of huge speed reducing gears to transmit the power generated by the turbines to the ship's slow-turning propeller.

He pointed out that one factor which helped to increase the horsepower output from the huge new plant was the



Turbines and gears of a ship propulsion unit of the type discussed in the accompanying article. Super-heated, high-pressure steam enters the far end of the high-pressure turbine (1), urged by its 400 pounds pressure and 740 degrees, Fahrenheit, temperature. Here it generates 4250 horsepower, using some 410 pounds of its original pressure and some 480 degrees of its original heat. From the exhaust (2) of the first turbine, the partially "deflated" steam passes through the connecting pipe (3) to a low-pressure unit (4) where an additional 4250 horsepower is generated. By this time the steam has lost almost all its heat and pressure and is sucked into a condenser at (5), where it returns to liquid form. Both turbines transmit their power—the high-pressure unit revolves at 5300 and the low-pressure one at 4400 revolutions per minute at full speed—to the ship's propeller—which turns at only about 100 revolutions per minute—through a train of speed-reducing gears. The small pinions (6) and (7), of different sizes to compensate for the difference in speeds of the two turbines, drive a pair of intermediate reduction gears (8) and (9) which, in turn, through other pinions (10) and 11), turn the huge "bull" gear (12). The ship's propeller is attached by a shaft directly to the center of the "bull" gear at the point (13)

change in Maritime Commission production schedules to put greatly increased emphasis on the building of Victory model cargo ships. This model is a new, fast design with powerful turbine propulsion equipment to enable it to dodge subs and make approximately three times as many ocean crossings a year as the slower, less powerful Liberty ships.

The Liberty ships — powered with 2500 horsepower reciprocating steam engines which are simple and easy to produce in quantity — are "emergency" vessels designed to provide the maximum number of usable bottoms in the shortest possible time. Their low power — and consequent slow speed — are drawbacks, however, in sailing sub-infested waters, Mr. Spray said. Their low speed also severely limits the annual tonnage of war goods each vessel can haul by reducing the number of round-trips it can make to foreign ports.

"Each of the new, fast Victory ships for which we are now producing modern geared turbine power plants provides the cargo-carrying capacity of approximately three Liberty ships, although both designs are of about equal size," he said. This is because the Victory ships are so much faster than the Liberty design.

COTTON HYDROPONICS

May Point Way to Better Material for Tires

OUT OF a series of gravel and water filled tanks may come a revolution in the methods of growing cotton, added prosperity for the cotton growers of America, better cotton that the world has even seen, and improved tires.

The tanks, situated in a greenhouse in Barberton, a suburb of Akron, Ohio, are part of a fundamental research program in cotton which is being carried on by The Goodyear Tire and Rubber Company. The program, which has been under way since 1937, has already resulted in much new knowledge about cotton, about the physical characteristics of cotton most desirable for the tire industry, and in the introduction of several new strains of cotton into the American Cotton Belt.

While this program is being carried on by a rubber manufacturer, it promises to benefit the entire cotton and rubber industries. Its aims are as follows:

First: Co-operation with cotton breeders and state experiment stations to help them find better strains of quality producing cottons.

Second: Setting up cotton variety tests at representative points across the Cotton Belt to see which varieties produce the most and best cotton under various environments.

Third: Carry through a fundamental series of hydroponics experiments.

Fourth: Translate the results of these hydroponics experiments into field fertilizer practices in the Cotton Belt.

Fifth: Urge, by example, the growing of better cottons.

Part of the research in this program goes on in the new Goodyear Research Laboratory in Akron, part of it in the Barberton greenhouse already mentioned, the rest on cotton plantations at representative points across the entire Cotton Belt of America. The researches are under the direction of Dr. Burt Johnson, a member of the staff of The Goodyear Research Laboratory.

It is possible that the experiments at the Barberton greenhouse will result in a revolution in methods of fertilizing cotton. In these studies, Dr. Johnson is seeking to find the correlation between methods of fertilizing and the resulting characteristics of the cotton lint as well as yield of the plant.

Heretofore, much attention has been centered on developing new strains of cotton as a means of attaining desirable characteristics. These fertilizer experiments seek to bring out fully all the best potentialities of the fibers that the cotton experts had bred into the plant.

The gravel and water filled tanks already alluded to are used for experiments in so-called hydroponics or "water culture." These tanks, large, flat, shallow affairs, are in a greenhouse where temperature and humidity approach those of a cotton field.

A series of pumps at stated intervals flood the tanks with water in which fertilizers, the so-called "plant foods," are dissolved. Then, in due time, the fertilizer solution runs off. The gravel merely acts as a means of support for the cotton plants growing in the tanks and furnishes no food to the cotton plants; the fertilizer solution furnishes the entire mineral nutrition for the plants. Preliminary results indicate that fiber properties may be influenced by

Hydroponics, applied to cotton culture in this greenhouse, may lead to better tires

mineral nutrition and that this can be accompanied by increased yields as well.

The public may be surprised at the interest of a rubber company in an agricultural approach to cotton research but it must be remembered that the so-called rubber tire is actually a combination of rubber and fabric and the so-called cords, the strands of fabric on which the rubber is spread, are fully as important to the life and performance of the tire as the rubber.

OUT-RUBBERING RUBBER

New Synthetics Offer Advantages in Manufacture and Use

A NEW material that promises to outmode natural rubber in automobile inner tubes and numerous other products has been developed in the Martin Plastics Research Laboratory, by Clayton F. Ruebensaal and Earl H. Sorg. The new elasto-plastic, known as Marvinol, has already demonstrated its superiority to both natural and synthetic rubber for such varied applications as automobile inner tubes, elastic gloves for home, hospital, and laboratory use, and many general household and industrial uses.

Marvinol is not a synthetic rubber, but a completely new material which is better suited for many of the purposes for which rubber has previously been used than rubber, itself, as well as bridging many gaps not hitherto filled by the synthetic rubbers. Inner tubes, for example, can be fabricated from Marvinol more easily than from rubber, and because of the absolute impermeability of the elasto-plastic, the seepage of air through the sidewall of the tube is entirely eliminated—an accomplishment which could not be obtained with even the finest gum rubber.

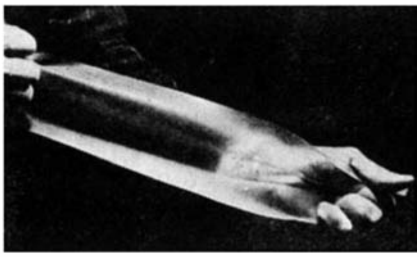
Most important of all from the standpoint of the tube user, however, is the fact that Marvinol is 100 percent reclaimable. In cases where a tube is damaged, the motorist, instead of discarding it as a total loss, will be able to trade it in on a new tube.

A second application in which the new elasto-plastic has demonstrated a marked superiority over rubber and synthetic rubber is stated to be in "rubber" gloves for surgical, laboratory, and household use. Marvinol gloves made up in the Martin laboratories have not only been tried out in actual service conditions by surgeons in hospitals, but they have been extensively tested in the chemical and industrial laboratories, where their ability to resist alkalis and acids in water solution resulted in a longevity and standard of performance unobtainable with similar gloves made from any other known material.

While attention so far has been concentrated on the application of Marvinol for inner tubes, gloves, and certain aircraft uses which cannot be talked about for reasons of military security, many other products that are now made only from rubber have also been duplicated. Among these have been nipples for nursing bottles, molded goods, fountain pen sacks which ink will not stain or adhere to, bulbs for eye droppers, hot water bottles, soles, heels, and even pencil erasers. Further development on these and many other products such as flexible gas and air lines, garden hose, raincoats, overshoes, and innumberable other articles, will, however, have to wait until after the war.

Marvinol is neither a synthetic rubber nor a rubber substitute, but a new material with properties all its own. Actually it is a vinyl-type plastic. Like other vinyl plastics that have been developed, the basic ingredients of Marvinol are coal, air, salt, and water; and the manufacturing processes involved in its production are far less complicated and expensive than those used to produce Buna and other synthetic rubbers.

Furtheremore, in common with the vinyl plastics, Marvinol has properties of reclaimability due to its thermoplastic nature, superior abrasion resistance, ability to withstand constant flexing without fatigue and impermeability to gasses and liquids—properties which for years have been attracting the attention of scientists to this type of plastic as the ideal material to supersede rubber. Up to now the one stumbling block standing in the way has been the failure of vinyl materials to remain stable at high temperatures, in strong sunlight, or when in contact with even dilute acid or alkaline solutions. In the case of Marvinol, however, this supposedly unsurmountable obstacle has been overcome by the inclu-



Compar flexes even at low temperatures

sion of a sealed-in, non-extractable plasticizer in the compound. Air, water, sunlight, acid and alkaline solutions, and temperatures up to 250 degrees, Fahrenheit, do not have any effect on this plasticizer, and as a result the compound retains its elasticity, resiliency, and flexibility just as pure gum rubber does, with the added advantage that Marvinol does not have rubber's tendency to oxidize or age.

The new material can be processed on standard rubber working machinery. Marvinol stocks can be compounded and mixed on a regular open rubber mill, and extruded, molded, and calendered on the same machines used to extrude, mold, and calender regular natural rubbers. The sole exception is the fact that with Marvinol the vulcanization process, or heat treating and compounding with sulfur, is completely eliminated.

Another name to add to this same list of synthetic plastics is "compar"—a group of coal-limestone-and-air derivatives which might be called the missing link between plastics and synthetic rubber—notable for unparalleled immunity to the new hard-to-handle aviation "super-fuels." The development of an almost endless chain of compar variations, announced recently by Resistoflex Corporation, grew out of the demand by warplane designers for a flexible material to handle toluol, xylol, and benzol—which give the new United States super-gasolines their tremendous power but which quickly destroy most organic materials.

The compars are described by Resistoflex officials as "transparent, flexible, rubber-like plastic materials, 5 to 20 times more wear-resistant than natural rubber, and the most solvent-proof rubber substitute yet developed."

RUGGED PACKAGES
Needed for Preservation of Dehydrated Foods

THE NEED for rugged packaging materials for dehydrated vegetables, that will stand up not only under severe laboratory tests but will also meet the demands of actual performance, is stressed by Dr. J. R. Sanborn and Dr. G. J. Hucker of the New York State Experiment Station. The scientists have studied over 150 different materials for such purposes. When a long series of tests, increasing in severity, were applied, less than five of the materials showed sufficient resistance to warrant their inclusion in the final trials on bulk-packaging of dehydrated vegetables.

"The proper preservation of dehydrated foods is not simple nor can it be readily attained by providing elaborate packages," say the Station scientists. "While development of suitable packages is necessary as a means of insuring adequate protection of the contents under severe conditions of handling and storage, careful consideration of the requirements of the foods themselves is basically important. Past neglect of this approach, even in years of 'peace and plenty,' left us destitute of a reliable working basis with which to meet the demands of wartime emergencies satisfactorily and promptly."

Sufficient ruggedness to withstand impact and tumbling, particularly at low temperatures, is the specification most difficult to meet in the case of most packaging materials, it is said. Resistance to the deleterious effects of high and low temperatures and to moisture permeability at high humidity levels and when submersed are other "musts" of a suitable material for packaging bulk dehydrated vegetables.

PROPELLER CHECKING
Done by Automatic X-Ray Equipment

A NEW "studio" fitted with one of the most powerful X-ray machines in the aviation industry is speeding-up the process checking of hollow steel propeller blades for combat aircraft by taking "pictures" of three entire blades simultaneously.

Since this 400,000-volt X-ray unit has gone into service at the American Propeller Corporation, it has been possible to secure the required nine negatives of three blades (three for each blade) in the same time formerly required for one negative, with the same crew doing the job. The crew consists of four women, whose work is further facilitated by the fact that delivery of the blades to the "studio," taking of the exposures, and removal of the blades from the X-ray room are entirely automatic.

The blades, X-rayed after the fillets have been brazed in order to check on the work up to that point, are received in trucks at the X-ray laboratory and placed in groups of three on special cars that run on a roughly oval track. Just

X-ray studio for propellers

outside the door to the "studio," the women operators put X-ray plates in position—there are three such plates to each blade—and place the various pieces of metal that are used for identification and to indicate on the finished negative the intensity of the X-ray penetration.

When all is ready, a button is pushed on the control panel and the heavy door in the side wall of the lead-lined chamber rises. As it reaches the end of its travel the door trips a relay that starts the motors that draw the blade-loaded car into the chamber. This car trips another relay as it passes a given point and the door closes behind it. The car stops in position under the X-ray unit which is set at a predetermined distance, vertically from the car. The exposure is made automatically. As the X-ray machine is shut off, a relay starts the mechanism that raises another door in the farther wall. As this door reaches the end of its travel, it causes a motor to draw the car, laden with the now X-rayed propellers, to the outside of the chamber, and the door slides shut.

The car is pushed manually to a convenient point and unloaded. In the meantime, the women operators have made another car ready to go through the process. The X-ray plates are developed quickly and are studied by women inspectors. No further work is done on a blade until it has passed this inspection. This is the second of three X-rays made of each blade, the first being an X-ray of the resistance weld of the small section of blade tip and trailing edge that has to be welded, and the third being of the tip near the completion of the manufacturing process.

AIRCRAFT HEATER

Operates at Extremes of Temperature and Pressure

SAID BY aeronautical engineers to be the only high-altitude combustion type airplane heater that meets every requirement of modern aviation, a new type of aircraft heater lights and burns almost instantly at any temperature down to 70 degrees below zero, Fahrenheit, and at any altitude up to 57,000 feet in simulated pressure chamber. Its major purposes are to de-fog, de-ice, and anti-ice windshields, gunners' side windows, and turrets, to prevent ice from forming on wings and empennage surfaces, to keep bombsights clear, and to keep instruments, gun breeches, and other equipment operative—even to keep the crew alive.

Difficulties in the way of designing this heater, known as the Surface Combustion "Janitrol," included: The air at 30,000 feet is so thin that a candle will not burn because there is insufficient oxygen; to support combustion, a surplus of air must be mixed with the fuel, as in the cylinder of a supercharged engine. Other problems encountered were: The necessity of operation at both high levels and at ground level; the capability of being lighted at 70 degrees below zero; ability to stay lit in a long dive when the air pressure suddenly increases and may build up to ten times the pressure encountered before the dive starts; assurance of sustained operation regardless of any angle which the plane may take or altitude to which it may climb.

Although the heater usually operates from the air supplied by the motion of the plane, an auxiliary blower can be installed for use in flight and for service when the plane is on the ground.

The principle of operation engineered into the design of the Surface Combustion "Janitrol" aircraft heater has proved to be the simplest and most efficient for this type of service. This unit uses liquid fuel, generally high octane gasoline. It operates equally well, with minor modifications, on lower octane gasolines and other liquid fuels.

The heater operates on the principle of burning a vaporized or atomized fuel in the center of a column of spinning air. The whirling action of the combustion air is produced by introducing the air into the cylindrical combustion tube tangentially to its inner surface.

The liquid fuel enters the combustion tube through a vaporizer or spray nozzle ahead of the combustion air inlet. This vaporized or atomized fuel is mixed with the spinning column of air, forming a long, tapering core of enriched gases completely surrounded by the whirling air column. The combustion process is thus prolonged or delayed for maximum efficiency and heat liberation throughout the full length of the combustion tube. Since the fuel and air are mixed within the heater, its operation is independent of additional mechanical devices.

The resulting flame is stable and sustains combustion under the most adverse conditions. The long luminous "whirl flame" is swirled around itself many times; thus re-ignition is continuous and the combustion process is "self-piloting." There is no "blowing off" of the flame as experienced on the conventional burner system when greater volumes of air are admitted.

New light-weight aircraft heater

The annulus or blanket of hot combustion air which surrounds the flame core not only provides an adequate supply of oxygen but actually scrubs the inside surface of the combustion tube and prevents direct flame impingement on the inner metal surface. At the same time, it effectively minimizes the accumulation of carbon, lead salts, or any other combustion products on heating surfaces.

RAYON TANKS

Save Weight in Fighting Planes

MANY FLIERS' lives have been saved in this war because their planes were equipped with bullet-sealing gasoline tanks made of a rayon fabric coated with rubber. Rayon is used in the self-sealing tanks primarily because it provides the required strength and tear or bursting resistance together with the light weight needed for use in fighting planes. Expressed more technically, rayon fabrics can be made with a strength-weight ratio that is greater than that of many other fabrics. Every pound saved in the permanent equipment of a plane may be applied to provide heavier armament, a larger supply of ammunition, greater gasoline capacity, or higher horsepower.

NAVAL STORES

Conservation Program Being Carried On

CONTINUATION of naval stores conservation as a part of the general program for the conservation and use of agricultural and resources has been approved by the War Food Administration.

Objectives of the 1944 program are conservation of timber resources and prevention of their non-economic use and wasteful exploitation through the adoption of approved turpentining practices, including better fire protection and better cutting practices. Voluntary participation in the program is open to gum naval stores (turpentine and rosin) farmers in North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. Payments may be earned by working only the larger trees and protecting the growth of pines by accepted conservation methods. Since both gum turpentine and gum rosin are recognized as strategic war materials, the new program contains no limitation on maximum production consistent with the preservation of the productiveness of existing resources.

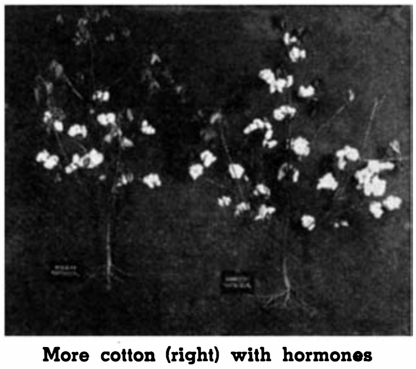
Protective measures include the provision that producers do not work trees under nine inches in diameter and that only one face be worked during the 1944 season on trees less than 14 inches in diameter at breast height. No payment will be made for faces measuring more than 90 inches in height at the beginning of the 1944 season. The program utilizes practices based upon research and experiments carried on for years by the Forest Service, Bureau of Agricultural and Industrial Chemistry. and other Department of Agriculture agencies.

BEATING THE BOLL WEEVIL

Early Maturity of Cotton Seems To be One Answer

THE BOLL weevil is the most important limiting factor in cotton production; its ravages have cost the cotton growers of the South untold millions. Hot, dry summers seem to be its most effective control, while wet summers aid its rapid development. But if "safe" bolls can be set ahead of the multiplication of the weevil—between the latter part of July and the first part of August—control can be greatly assisted.

Research and experience have shown that early planting of cotton seed of early maturing varieties, accompanied by early poisoning, have greatly helped in this race. Another factor which bids fair to play an important part in this speeding-up process is the use of plant hormones stabilized in the fertilizer. Such a combination, known as Hormo-Fert, has been reported previously in the November 1941 and November 1943 issues of Scientific American.



More cotton (right) with hormones

This special fertilizer, due to its rapid action in promoting root formation, advances maturity of cotton squares, blooms, and bolls, bringing them to this point ahead of the ravages of the boll weevil.

Using Hormo-Fert in many test plots, together with the planting of a number of cotton crops extending over several years, it has been possible to secure, on both test plots and crops, ten days earlier cotton with a greater yield as compared with results using the same fertilizer without hormones.

In normal years with practically no boll weevil damage, test plots have shown 10 to 12 percent increase in yield of seed cotton. In 1943, a bad boll weevil year, tests conducted by D. J. Murray, Assistant County Agent of Wayne County, showed double this increase with Hormo-Fert.

Comparing the planting on farms of approximately 400 acres, in Wayne County, North Carolina, for the years 1939 and 1940, two years before using the special fertilizer, with the years 1941 and 1942, two years after using Hormo-Fert, there was an average increase of lint cotton per acre of 53 pounds, or just a little over 12 percent. In 1943, a total of 519 acres of cotton was planted using Hormo-Fert at the rate of about 650 to 700 pounds per acre. An average of 510 pounds of lint cotton was obtained per acre, or 530 five-hundred-pound bales on the total acreage. This is a significant result when contrasted with the county estimate of 325 pounds per acre.

The extra cost per acre of Hormo-Fert over regular fertilizer, using 600 to 800 pounds per acre—usually a desirable amount—is 75 cents to $1, with a probable net return of $12 per acre during a normal season, or approximately $25 to $30 during a bad boll weevil year.— *Lionel Weil.*

SYNTHETIC RUBBER

Can Render Natural Rubber Supplies Immaterial

THE SUPPLY of natural rubber is not coming back quickly, if at all, in the opinion of Dr. John T. Blake, chief chemist of the Simplex Wire and Cable Company. In an address before the American Chemical Society, he had this to say:

"Synthetic rubber must be developed to the point where the restoration of natural rubber is a matter of indifference. I have confidence that this can and will be done.

"Shortly we shall have available as much [synthetic] as is needed for war and essential civilian purposes. The rubber industry is now substantially converted to its use, although synthetic rubber is not all that we might wish it to be when we use it in the production of useful articles. However, we are manufacturing from it things that are serviceable.

"Ordinary tires, insulated wire, and other items are capable. They will work. They insure that our civilian economy will not collapse and that we can keep our Army and Navy fighting.

"Three years ago the rubber industry had to a large extent reached an equilibrium. The big accomplishments had already been completed. Acceleration, antioxidents, reinforcing agencies, and other developments had obtained substantially their full stature. Advances in sight were of degree only, and of small degree at that.

"Our work on synthetic rubber has changed all this. To use but one illustration, vulcanization, the key process of the rubber industry, was a unique phenomenon applying only to rubber and sulfur. A host of synthetic materials can now be vulcanized with a wide variety of reagents, and these new facts must lead to a better understanding of this particular process. In other sections parallel discoveries have been made."

GREY IRON

Has Outstanding Advantages in Many Applications

ONE PROPERTY in which grey cast iron has an inherent advtantage is torsional strength. In steels, the ultimate strength in torsion is lower than the ultimate tensile strength; but with cast iron, the situation is reversed, the torsional value being 25 percent to 40 percent higher than that in tension. Thus it is evident that our modern high-strength alloy irons will develop torsional strengths superior to those of the common structural steels, and are, therefore, highly suitable for applications in which the chief stresses encountered are in torsion, such as flanged couplings, pulleys, and so on.

This is true also of such parts as crankshafts, which are subjected, in addition, to periodic vibrational impulses. The ability of grey iron to dampen out vibrations has long been recognized, and is attributable to its discontinuity of structure, the graphite inclusions preventing such impulses from being built up to the danger point, which can easily occur with a more homogeneous material such as steel.

For some years prior to the war high strength grey irons, alloyed with nickel, chromium, and molybdenum, were coming into progressively broader use for crankshafts and camshafts in heavy Diesel engines, pumps, compressors, and certain types of small gasoline engines. The adoption of the high strength alloy irons for these purposes was due to their good torsional properties, combined with damping capacity, notchsensitivity, and high wear-resistance on the bearing surfaces. Moreover, the economic advantage of a cast material, in cases where the quantity to be produced is comparatively small and expensive forging dies can be eliminated, is obvious.

For these reasons, crankshafts of alloyed grey iron are in use to a considerable extent today in engines operating on war production and war transportation, and resumption of unrestricted civilian production in the post-war period should result in a tremendously increased adoption of this material for such applications.—*Nickel Cast Iron News.*

USKOL

Not for Tires, but for Many Other Rubber Applications

A NEW synthetic rubber, the sixth major type to be discovered through chemical research, has been developed by the General Laboratories of United States Rubber Company, according to Herbert E. Smith, president.

"Known as Uskol, this new synthetic will be used in both industrial and household products," Mr. Smith says. "As a result of its distinctive properties, it is expected to take its place alongside the present five commercial types of synthetic rubber—buna S, buna N, neoprene, butyl, and thiokol.

Compounding Uskol in the laboratory

"Offering a new high degree of resistance to solvents, this new synthetic will be used in the manufacture of commodities which come into contact with fuels, oils, gasoline, dry cleaning fluids, and other penetrating chemicals which are the enemies not only of natural rubber but of the other five synthetic types. It will also be used for specialties such as industrial molded items, tubing, gas and oil hoses, tank linings, and for application to paper and cardboard to render them resistant to grease, water, and chemicals.

"Household goods such as mats, dish drainers, sink strainers, aprons, gloves, and the like, may be made from the new rubber. It also may make possible for the first time the manufacture of raincoats that can be dry cleaned. It is not applicable to tires but it can replace in various items other synthetics which can be used in tires."

In addition to its superior resistance to solvents, Uskol is said to possess numerous other advantages, including the following: It can be vulcanized in several ways to acquire high physical properties; it has high tear resistance exceeding that of natural rubber; it can be used alone or as a blend with other synthetics; it is more resistant to the effects of sunlight, ozone, and oxygen than any other synthetic rubber; it has no odor either in the raw material state or in the finished product; it can be produced with present machinery and it is easy to handle during manufacture.

This new synthetic resulted from search for a rubber which would provide greater resistance to attack of high octane gasoline. Its use will be limited to war products for the duration.

PISTON MACHINING

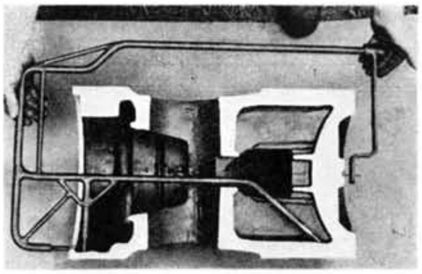
Simplified by Use of Ingenious Jig

A VALUABLE contribution to engine production at the Cooper-Bessemer plants consists of a simple jig devised to save time and to overcome the difficult problem of producing engine pistons with consistently uniform wall thicknesses.

Developed by John V. Shaffer, Cooper-Bessemer machinist, this tool was constructed of several pieces of tubing welded together in the form shown in the accompanying photograph.

The end of the jig is inserted through the narrow opening at the bottom of the piston core so that it contacts the wall inside the cored chamber. By revolving the jig around the outside circumference of the piston, and inscribing marks at intervals by means of a sharp pin in the outside end of the jig, the true center of the casting is designated at the point where the inscribed lines intersect.

The lathe operator is thus able to save a considerable amount of machining time and produce a piston with an outside diameter that is concentric with the inside core, resulting in absolutely uniform wall thicknesses so desirable in oil-cooled piston design.



Simple jig for checking pistons, shown in place in sectioned unit

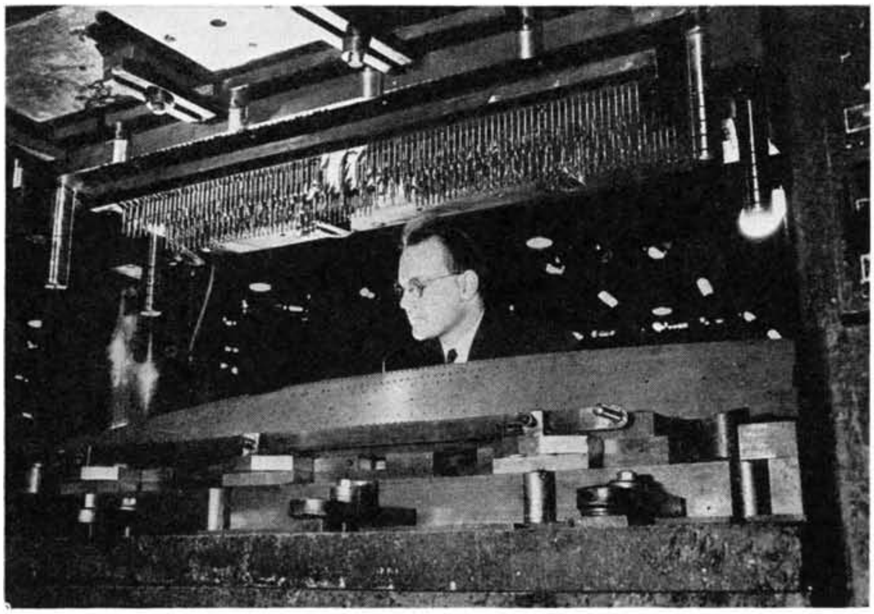
PORCUPINE DIE

Punches Hundreds of Holes In a Single Stroke

CAPABLE of punching 388 riveting holes in a single stroke of a giant hydraulic press, a new Boeing-developed die is turning out parts, ready for riveting, 30 times faster than the previous method of drilling. Parts manufactured by the new die are riveted together to form the bomb-bay catwalk of the Boeing Flying Fortress.

Tool engineers express the belief that this die contains the largest number of coördinated punches ever to be located in a single die. Affectionately named the "Porcupine" by Boeing employees, because of the similarity between the many punches and a porcupine's quills, the new die makes a total of 976 riveting holes in ten separate parts which comprise the walkway through the bomb bay of the big bomber. These are assembled, as a sub-assembly operation, with more than 400 rivets. Aside from the web, or flooring, which is aluminum .064 inches thick, four "T" sections as well as angles and reinforcements are pierced on the porcupine. The heaviest material is .150 inches thick—over an eighth of an inch.

The construction of the porcupine was



At Boeing's home of the Flying Fortress, this porcupine die accurately punches 388 holes in a single press operation. This is 30 times faster than by previous methods

held to an accuracy of 5/10000 inch. This insures alinement of holes from one part to another, making possible rapid assembly and greater production. A die of this type is expensive to manufacture. Its construction, however, typifies the quantity production tooling which is continuing to alleviate the manpower shortage.

DRUG SOURCES
Now Assured to the Untied States

AMERICA in peace or war has declared its independence of foreign sources for its vital drugs— from digitalis to quinine—"an investment which must never be forsaken," according to Dr. Ivor Griffith, president of the American Pharmaceutical Association.

"Consider how great was our need for quinine, a distinctly vegetable compound which over the decades has resisted all efforts dedicated to duplication," says Dr. Griffith. "Bataan and Corregidor might have had totally different implications had a supply of this vital botanical derivative been available at the critical time. And what a marvelous job has been done in this country even in the course of the last two or three years in making available natural plant drugs which in normal times had been imported in great amounts: Digitalis, the outstanding heart drug; belladonna, the source of the important atropine and other important principles; valerian, hyoscyamus, squill, aconite, and other drugs, once could be secured only from Europe or elsewhere on foreign soil.

"Indeed, in a land where cardiac diseases are high in the death-dealing scale, does it not seem strange that digitalis and strophanthus and squill and other heart-active drugs had to come from Europe or elsewhere? And every time Europe had a fuss of its own the great American heart went begging for its proper medicine."

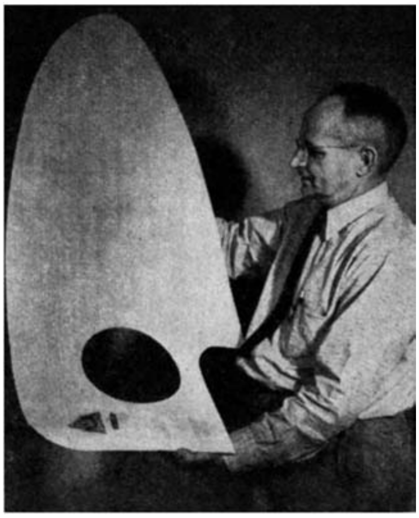
The declaration of independence from these sources just signed by America was "commonplace insurance," Dr. Griffith says, adding:

"The day may yet come when science, kept pure, will bring to the world the gift of permanent peace. Who wants Java except for her rubber and quinine? When rubber and quinine are made in the shop, then Java will not be such a bone of contention."

PLASTIC BOARD
Light in Weight, Easily Formed

ONE OF the uses of plastics with a future is the development of a plastic board that is already in wide war use and for which engineers are perfecting important peacetime uses that should greatly lighten the work of housewives and add beauty and color to the home.

The plastic board is very light—only half the weight of aluminum. Its tensile strength and its ability to withstand strains compare favorably with best metal alloys with relation to weight,



New light-weight, strong plastic board, described below, is used for forms that support bullet-sealing fuel cells in military airplanes

according to United States Rubber Company engineers. It is also a non-conductor of electricity, will stand excessive vibration and is not affected by gasoline, oils, aromatic blends of fuels, acids, most alkalis, alcohol, and other solvents. The fact that it retains its properties over a wide range of temperatures makes it highly useful for wartime needs.

The plastic board can be bent, cut, and formed into almost limitless shapes. These and other properties give it great promise for a wide variety of uses in the home, on the farm, and in industry after the war.

WHAT IS ELECTRICITY?
Adequate Answer Requires Volumes

OFTEN asked of the scientists in General Electric's Research Laboratory is the question "What is electricity?" L. A. Hawkins, executive engineer of the laboratory, has one answer, although he says that whether an answer is possible depends on the kind of definition desired.

"For instance, the question 'What is water?' may be answered in three different ways," explains Mr. Hawkins. "First, we may define water by its composition; second, by its source or occurrence, and third, by its properties—its boiling and freezing points, its density, its action as a solvent, its part in maintaining life, and so on.

"But when we come to electricity, we find only one kind of definition is possible, because electricity is the most fundamental thing in the universe and is the thing of which everything else is made. Electricity cannot be defined by its composition, for it is composed only of itself. Neither can it be defined by its source or occurrence, for it is everywhere, wherever there is matter or radiant energy.

"Therefore, electricity can be defined only in the third way, by its properties—and to describe these properties adequately requires a book or several books."

New Products

RESURFACING COMPOUND

To REPAIR or completely resurface broken or worn floors, driveways, ramps, and so on, a concrete-like compound is now available in ready-mixed form for quick and easy use. To resurface and level an entire floor or roof area overnight, or to transform an old wooden floor into a smooth but skid-proof, spark-proof, and fire-proof surface, Lev-L-Flor may be applied by unskilled labor. This product has greater compressive strength than concrete, though much lighter in weight. Because it is more resilient than concrete, it will not chip or crack under hard traffic and for the same reason is less tiring and easier on the feet.

Tests of this compound show that it does nine jobs in one application—repairs, resurfaces, water-proofs, dust-proofs, acid-proofs, damp-proofs, slip-proofs, decay-proofs, and weather-proofs.

NEW KELVIN BRIDGE

SEVERAL innovations are presented in a new model Kelvin bridge just announced by Industrial Instruments, Inc. First, the bridge source voltage is 60 cycle A.C. instead of the usual D.C. Second, an electron-ray null indicator has been substituted for the conventional galvanometer. Third, the instrument can be operated by unskilled personnel at high speeds—up to several hundred tests per hour with suitable test fixtures. Fourth, the entire equipment is completely self-contained in a single cabinet, requiring no outside accessories such as batteries or galvanometers. Fifth, operation is reduced to utmost simplicity and directness, since measurements are obtained by the rotation of a single dial directly calibrated in resistance, the dial readings being multiplied by a factor determined from the setting of the standard resistance switch.

Bridge for shop or laboratory

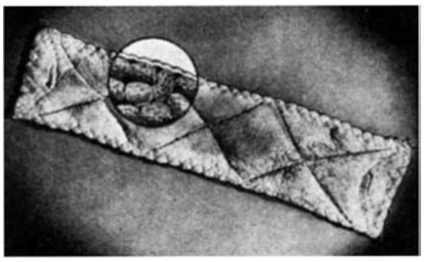
The new Model K-1 bridge is particularly useful for routine measurements in production, or in the laboratory, on low-resistance elements such as fuses, fuse clips, switch contacts, wire, bonds, and other similar items.

QUENCH TEMPERING

TOOL STEELS dipped for quenching into a new liquid material known as Steeltemp are simultaneously tempered, thus eliminating one operation. This material is applicable to chisels, taps, punches, star drills, and similar tools.

PROTECTION PADDING

LINING of a new type for goggles, chin straps, sweat bands, and other headgear has been developed which incorporates the use of sponge clippings and chamois skins. The soft texture of chamois skins and the natural resilient characteristic of sponge clippings combine to make an ideal protection padding.



Sponge clippings in chamois pad

Among the many uses for this new development is padding for head phones. Operators of listening posts have found that perspiration is a constant source of chafing to the head-phone wearer. But with this new sponge and chamois padding inserted in the inner section of the ear phone unit, all perspiration is absorbed and soreness due to chafing is eliminated.

In war plants, perspiration running down the faces of workmen can be a threat to war production. To eliminate this threat a sponge and chamois sweat band has been produced which eradicates the danger of sweat getting into the workman's eyes.

LOCK-TYPE PROTRACTOR

A NEW pocket-size, lock-type protractor is designed for accurately measuring angles of drill points, tool bits, machine ways, and depths of deep holes; for sketching and laying out tool and machine parts, dies, and jigs; and for inspection of manufactured parts.

Made of fine materials and vernier equipped, Xactor's adjustable lock-type sliding scale pivots 360 degrees, assuring measurement of any angle instantly to an accuracy of ½ of 1 degree. Deeply etched graduations afford easy readability.

Aside from its accuracy, this new protractor has the added advantage of

Versatile vernier-equipped protractor

a quick acting and compact locking feature on the vernier turret which rigidly secures any specific measurement or angle by locking both the vernier turret and the sliding scale. This enables accurate mass gaging necessary when many items of the same size or angle must be checked.

DIAMOND-BONDED WHEEL

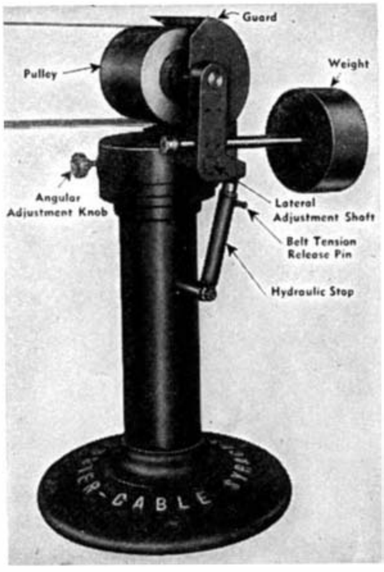
NEWCOMER in the field of diamond-bonded wheels is the Super-Cut, just announced by Industrial Abrasives, Inc. A secret bonding process reportedly gives to Super-Cut diamond wheels an unusually long life, as shown by numerous tests. The new bonding process sets each individual diamond solidly and uniformly in a special metal, thus giving both fast cutting and long life

Super-Cut wheels are made in a wide variety of types and sizes, making them adaptable to hundreds of tool and grinding operations.

BACKSTAND IDLER

A NEW addition to a line of abrasive belt grinders is the Porter-Cable backstand idler shown in the accompanying illustration. This idler is used to adapt grinding and polishing lathes to abrasive belt grinding.

The backstand idler makes possible the use of an endless metal-cutting abrasive belt, which is faster cutting than coated polishing or solid "stone" wheels. Then, too, heat is reduced be-



Adapter for abrasive-belt grinding

cause of the long abrasive belt used This lower temperature operation greatly decreases such hazards as heat discoloration, warping, fracturing, and so on.

Where it has been customary to grind, rough polish, and finish on regular wheels, the same results are obtained by the abrasive belt method, but the rough polishing operation can be eliminated.

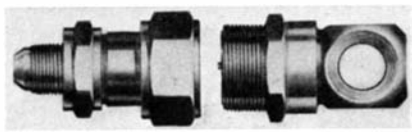
PORCELAIN-CLAD CAPACITORS

FOR HIGH-VOLTAGE D C. applications where space is limited, new porcelain-clad capacitors are hermetically sealed in a tubular, wet-process porcelain body with solder sealed end closures. The end closures act as the capacitor terminals by connecting the element leads at opposite ends, utilizing the porcelain tube as insulation.

By eliminating the large metal case and bushings required by metal-case capacitors, the new Westinghouse porcelain-clad capacitors help maintain minimum over-all dimensions. Larger types are furnished with or without cast mounting flanges. Where castings are used, the capacitors are solder-sealed, then castings are cemented on with a mineral-lead compound.

SELF-SEALING COUPLING

A DISCONNECTING self-sealing coupling, said to withstand a pressure of 2500 pounds per square inch after just ordinary finger-tightening, is a development of American Screw Products. Tests show that the heavy construction of the aluminum alloy body prevents



Leak-proof self-sealing coupling

distortion, and that jamming of the spring-loaded shut-off valve is prevented. One sample coupling was purposely crush-tightened with a long-handled wrench yet is reported to show no leakage upon disconnection and reassembly.

Springs are of heat-treated steel. Lightweight cast phenolic poppets are positive-sealing in action. The synthetic gasket provides leakproof connection when coupled for service.

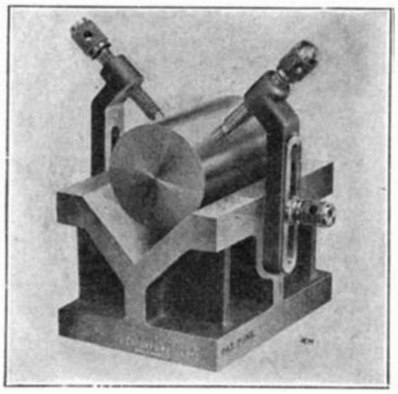
WALL PROTECTION

MASONRY walls are subjected to disintegration due to low and high temperatures and high and low moisture content. The usual method of protection has been a paint coating made up of oils or resin emulsions, casein, or cement, mechanically bonded to the surface.

A new product from the A. C. Horn Laboratories, called Waterfoil, has now been developed using an entirely different principle. Waterfoil is made of irreversible inorganic gels. The lime hydrate of the masonry reacts with the inorganic gels to form an "irreversible" protective coating of microscopic "spongelike" character. When applied to masonry, such as brick, concrete, or stucco, Waterfoil welds itself to the surface not only mechanically but chemically as well. Water vapor finds exit, but actual water penetration is impeded, thus helping to prevent reinforcing bar rust and concrete spalling.

IMPROVED "V" BLOCK

WITH A ribbed base of cast iron, to which are fastened forged steel facings to form the "V", the device illustrated in this column is known as the Hercules



"V"-block facings can be refinished

Heavy Duty "V" Drill Block. The facings of the block, as well as the clamp bars, are accurately machined and heat treated. When the facings wear, they may be readily removed for re-finishing, thus prolonging their useful life.

BIN-LEVEL INDICATOR

OPERATING by electronic principles, a dry materials bin-level indicator is wholly foolproof because there are no moving parts to wear or get out of order. For the same reason, danger of clogging, arcing, and mechanical breakdown is eliminated and the device is effective in measuring all types of material, whether fine or coarse.

Use of the bin-level indicator, made by Mosher Electronic Control Systems, gives a positive check on shipping and storage operations and thereby prevents possible loss of valuable material through spillovers, underfills, or other miscalculations.

The device consists of two parts. The first is a detector box, which is attached to a probe extending into the bin. In the box are a series of vacuum tubes. A second box is the signal control which is attached to a series of colored lights that show conditions in the bin. Hookup with valve cut-offs, sound makers, or remote signal devices can readily be arranged through appropriate relays.

BORING TOOL

A RADICALLY different type of boring tool that is reported to get diamond boring machine results from an ordinary lathe is called the Shearcutter Boring Bit. This new tool has a circular cutting edge that lasts 10 to 30 times as long as a straight-edge cutting tool before resharpening is necessary. According to the manufacturer, the Shearcut Tool Company, the grinding time saved pays for the cost of the tool before resharpening is necessary.

The shearing (instead of conventional prying) action of the new boring bit leaves a curled chip and allows huge cuts to be taken without chatter. Chips sliding back over the cutting edge have a resharpening action. When an edge becomes dull, a new one is provided by simply turning the bit in its holder. No new set-up is required.

Circular cutting edge is the secret

With cutting speeds up to 1000 feet per minute, the new boring bit requires less power and generates less heat because of the shear cutting action. The mirror finish which this tool produces in one operation meets Navy specifications and usually eliminates any necessity for grinding, filing, reaming, or polishing to remove tool marks. The bit works well with either a positive or negative rake and permits working to closer limits than normally possible.

BAROMETER, ALTIMETER

High sensitivity and precision are combined in two new instruments, suited for use in meteorology and surveying, for airport service, for research work, and as standards for calibrating other instruments.

The instruments have a sensitivity of one part in 8000, and an accuracy of ±0.1 percent. A pointer, moving over a mirrored five-inch dial, makes practically two revolutions in traversing the full scale-range. This is equivalent to a linear scale of approximately 29 inches, and permits scale-readings to one-foot altitude or 0.05 millibars pressure. Inherent temperature compensation of the instruments is extremely high, so that no special compensating elements are necessary.

New altimeter, provided with a pointer that moves over a five-inch dial

Unique simplicity of design, developed by Wallace and Tiernan Products, Inc., helps the instruments to hold their accuracy under severe usage conditions. For portable service, they are available in shock-proof protective cases. They can also be furnished for wall or panel mounting.

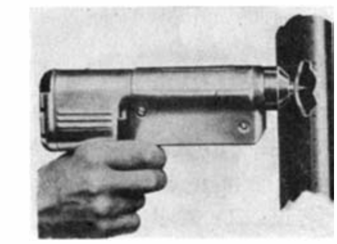
HEIGHT GAGE ADAPTER

Recently announced is a simple height gage adapter which not only enables one machinist's height gage to do the same amount of work formerly done by two units, but also permits a zero reading, a feature which has heretofore been impossible with standard equipment.

The adapter, made by Barentzen Products, consists essentially of a small machined unit which is clamped to the arm of the height gage. The scriber is then placed on the adapter and clamped in place. The result is an adjustable joint which replaces the clamp that formerly held the scriber stationary to the arm of the height gage. With this adjustable joint it is possible to do the things mentioned above, and to get positive dimensions without any pencil-and-paper figuring.

RIVET DRIVER

A new device that will drive four "blind" rivets a minute in aircraft production is pneumatically operated and will drive and buck, in one speedy operation, the "blind" rivets on finished plane sections to which are connected de-icers, instrument panels, and other light assemblies.



Blind rivets may be driven rapidly with this light-weight pneumatic tool

The tool operates in a fast four-step cycle and features a light at the top of the handle which flashes "OK" to indicate to the operator when the rivet has been accurately upset on the "blind" side. The first step in the cycle screws a mandrel into the rivet; the second step pulls back the mandrel, upsetting the rivet and flashing on the "OK" light; the third step unscrews the mandrel; the fourth shuts off the tool, completing the cycle and making the tool ready for the next operation.

Weighing only four and a quarter pounds, the machine measures nine and one half inches in length and has a spindle offset of seven eighths of an inch. Known as the Thor "RIV-Driver" the new instrument makes practical for production use a wider application of "blind" rivets, not only on aircraft but also on scores of other assembly operations.

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.)

GETTING DOWN TO EARTH ON POST-WAR WORK is a 30-page booklet prepared by a practical business man who surveys first the whole problem to be considered and then breaks down the overall problem into reasonable components. This is no long-haired theorist's approach, but one that deserves the serious attention of hardheaded business men. *Corrigan, Osburne and Wells, Inc., Lincoln Building, New York, New York.—Gratis.*

PIPER CUB . . . IN WAR AND IN PEACE is a 32-page, full-color aviation booklet which presents the illustrated history of the light airplane from its beginning up to the present day. This is a booklet of interest to aviation enthusiasts both young and old. *Piper Aircraft Corporation, Lock Haven, Pennsylvania.—10 cents.*

ALL-ELECTRIC FLOATLESS LIQUID LEVEL CONTROL is a 28-page illustrated catalog which describes the primary equipment required for the installation of such controls, as well as special equipment, waterproof enclosures, and so on. Request Catalog No. 943. *B/W Controller Corporation, Birmingham, Michigan.—Gratis.*

PLASTICIZERS AND SOFTENERS CHART lists a group of these new products for use in coatings, adhesives, plastics, synthetic resins, and synthetic rubbers, giving data on specific gravity, color, solidification point, acid value, solubility, boiling point, compatibility, and odor. *Glyco Products Company, Incorporated, 26 Court Street, Brooklyn, New York.—Gratis.*

HYDRAULIC PORTABLE ELEVATING TABLE is a four-page bulletin describing and illustrating a well-designed table applicable to a large number of jobs in any shop. The table top cannot only be elevated but also rotated, under full control of the operator. *Lyon-Raymond Corporation, Greene, New York.—Gratis.*

LIFE TESTS OF ELECTRIC DISCHARGE LAMPS, by M. K. Laufer and H. S. Bernstein, is a 19-page mimeographed pamphlet giving the results of a study of cold-cathode electric discharge lamps. Technical development note No. 29. *U. S. Department of Commerce, Civil Aeronautics Administration, Washington, D. C.—Gratis.*

THE ROSAN LOCKING SYSTEM is a four-page bulletin which explains this system for installing threaded inserts and locked-in studs. The system has potential applications in all industries where screw fasteners are used. *Bardwell and McAlister, Incorporated, 7636 Santa Monica Blvd., Hollywood 28, California.—Gratis.*

SALVAGE MANUAL FOR INDUSTRY is a 245-page paper-bound book, edited by seven engineers, which presents systematically organized and classified information and data on industrial salvage practice in all its ramifications. This well-illustrated volume deals with planning for salvage, methods of handling metal scrap and non-metallic waste, and so on. *Superintendent of Documents, Government Printing Office, Washington 25, D. C.—50 cents in coin.*

PRODUCTION TODAY WITH DoALL PRODUCTS is a 36-page booklet illustrating and describing a complete line of new tools for industrial production. These include high-speed sawing and filing machines, surface grinders, gage blocks, variable speed pulleys, hydraulic presses for powder metallurgy, and so on. *DoALL Service Company, 1201 Thacker Street, Des Plaines, Illinois.—Gratis.*

ACME PROCESS NEWS NO. 14, a house publication, is devoted to the dissemination of information of value to shippers of war products. The material is particularly concerned with the applications of steel strapping for protecting war shipments. *Acme Steel Company, 103 Park Avenue, New York 17, New York.—Gratis.*

LIGHTING HANDBOOK is a 175-page manual designed as a practical guide and working reference book for lighting engineers, architects, and builders. It will, however, be of interest to anyone concerned with lighting problems. *Westinghouse Lamp Division, Bloomfield, New Jersey.—$1.00.*

PORCELAIN ENAMEL is a 24-page lavishly illustrated pamphlet presenting useful data for product engineers, designers, architects, and others interested in the use of porcelain enameled iron. Engineering information is given on the physical characteristics of this material and drawings are used to illustrate several specific points to be considered when designing products which are to be porcelain enameled. A brief explanation is presented of the methods of making porcelain enamel and of applying it. *The American Rolling Mill Company, Middletown, Ohio.—Gratis.*

SYNTHETIC DRYING OILS, by A. G. H. Reimold, is a reprint of a four-page article from *American Ink Maker.* It outlines the characteristics and applications of synthetic quick-drying oils which are of such vast importance to American oil and fat chemistry today. *Woburn Degreasing Company, Harrison, New Jersey.—Gratis.*

PREVENTING WELDING AND CUTTING FIRES is a 16-page illustrated booklet which instructs users of welding and cutting equipment in methods of reducing potential fire losses. *International Acetylene Association, 30 East 42nd Street, New York 17, New York.—Gratis.*

Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

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

Ingenious and controllable way to rig the base of a fairly large telescope which nevertheless must be made portable is shown in Figure 1. Two of the legs have large casters and the third has a loose lift-up lever for towing purposes. This is an 8" telescope and therefore not light. A. J. Walrath, 14024 Archdale Ave., Detroit, Mich., is the maker. It is his first telescope. He writes, "The mirror is larger than recommended for a beginner but no serious difficulty was encountered. With a ½" eyepiece, giving a magnification of 144, the rings of Saturn are clear and beautiful. Jupiter, too, with its moons, can be seen in good detail."

Several readers have inquired within recent months about a mirror grinding problem. Here is a typical question: "I have passed the roughing-out stage with coarsest abrasive and am now trying to obtain contact with abrasive No. 120. However, the mirror, no matter how much grinding I do, or how short the strokes I use, persists in touching the tool at the edge zone alone."

Remembering a battle with one mirror which persistently acted in the same manner, your scribe dug up a log book for 1930 and from it has worked out the data which follow. It is not, however, claimed that these methods will always work.

Use full-diameter—that is, very long—hogging-out strokes on only the first two sizes of abrasive grains. Thereafter, use regular one third strokes. That is, do not change to short strokes.

Grind with No. 220 abrasive a long time, not alone for pit insurance but also to reduce the gap between mirror and tool to about 1/2000". This can be measured with "feelers."

Let the first feeler be a tiny piece of ordinary paper—say a corner torn from a book page. Lay this on the center of the tool and place the mirror on it. Will the mirror now spin, as on a turntable? Seize the mirror and tool simultaneously between the thumbs and fingers of both hands, on either side, and develop any hidden slight rocking by alternate squeezing. Note an inch of similar book pages, dividing by 2. This gives the feeler's thickness—generally around 1/250" or 1/500". Now you have at least an approximate idea of the space you are dealing with.

To reduce the gap, try painting a ring of wet abrasive in the edge zone.

A method which gave still better results was to invert the tool and mirror and work the tool on the mirror in a series of epicycles limited in width to the center on one side and the intermediate zone on the other (farther might turn the edge).

Another method, which worked up to the hilt on one occasion, was to carry the wet far toward bone dry—10 minutes instead of half that time. This requires muscle and there is risk of a sticking mirror, so don't stop or lose full control. This method brought a persistent central gap into central contact very rapidly.

As finer and finer grades are used in grinding, the gap can be narrowed (this probably cannot be done on the coarser sizes) and the space measured with tissue paper feelers, which are generally about 1/800" thick. One can "guesstimate" the rest, up to about 1/2000", by noting the amount of teeter on such a feeler.

Reduce the gap to about 1/2000" on No. 220 before proceeding to finer sizes of abrasive. The same methods should then further reduce it on the finer sizes.

Figure 1: The telewheelbarrow

Since short strokes alone did not solve the problem, while fearless one third strokes with the above methods did, timid fussing with short strokes was thereafter abandoned. (Such timid fussing often leads to other troubles, and grows by what it feeds on. Your scribe recalls futile hours with feeble quarter-inch strokes and no results.)

The carrying-out-to-dryness-and-with-muscle method, described above, was hit on as a result of getting mad at the mirror, one bad day, and not caring what happened to it. On another occasion, this time during polishing, the same method brought about sphericity when short-stroke fussing had failed; vigorous strokes that were longer than orthodox one third strokes (due again to being mad at an evil mirror) brought it to reason in short order. (Or was it the accompanying imprecations?)

The moral seems to be, don't let a mirror bluff you—but at times get tough and give it the works.

Is the gap between mirror and tool, dealt with above, on the mirror or is it on the tool? No answer seems available, nor was one necessary since the empirical method got results. But if any amateur scientist wishes to be a martyr and give such a mirror a polish, just to measure its zones in order to find out, he will be awarded a medal.

The above matter was shown to Cyril G. Wates, Edmonton, Alberta, since it is unsafe to hand out advice on a basis of a single experience, because too often some hidden personal factor is involved. Wates commented: "My experience has been that a one third stroke applied with vim, vigor, and vitality is a cure for many mirror evils—almost a panacea. I have had mirrors with zones that looked like the Rocky Mountains clear up perfectly after a 15-minute session of 'the works.' I use a machine.

"Yes," he continues, "it is hardly possible to obtain contact with coarse abrasive—I too find it a matter of approach only as finer and finer sizes are used. For, even if you got perfect contact with No. 80 or 120, you couldn't keep it."

One reader to whom the above methods were explained in a letter reported, "I tried the 'spit-on-your-mitts-and-punish-it' method but it wasn't very effective. I then tried inverting the tool and mirror, with elliptical strokes, as suggested, and one wet took the mirror down to almost perfect contact. It solved my problem."

Trees make a wonderful support for a mid-summer hammock but often they have virtually prohibited amateur telescope makers from having an observatory dome. Your scribe, for example, lives in a deep "hole" between 90' oaks on neighbors' lands and cannot even mount a telescope. How, then, about a dome atop a tower?

Figure 2 shows how Earl Manbeck, Jr., 3920 Cottage Grove Avenue, Des Moines, Iowa, got above the trees; he built a 23' tower, 10' square, and put the observatory on it.

"The tower," he writes, "is made of wood bolted together, and my neighbor, E. H. Ruby, helped me a great deal. The deck is made of 2" lumber. A 12" reflector, which I purchased second hand, is mounted on it. The dome is 14'6" in diameter and made of iron ribs and sheet metal."

Asked whether this arrangement was steady, Manbeck at first replied that it was, but after 12 days of observing with the telescope he reported that "I have found that when other persons are present it is necessary for everyone to stand still, otherwise the telescope picks up a lot of vibration. So we are going to put in the suggested central pier, separate from and at no place touching the tower."

This note is published to forewarn readers against towers in which the telescope is an integral part of the tower. Possibly such a tower could be made steady enough, at great expense, but the separate pier is probably cheaper.

When your visitor prances around or even scratches his ear, your physical senses will hardly detect the vibrations in the tall tower structure—direct. But your eye, at the eyepiece where the vibrations are many times magnified, probably will and all too well—for a telescope is a magnifying seismoscope. An amateur in Washington, D. C., once related how his telescope on the roof of an old, lightly built, wooden-framed four-story apartment house always told him when the ladies were beating eggs far below in the kitchen. Not, however, that a telescope atop a whole house will necessarily be unsteady—it has been done and has proved good. Much, however, depends on the house. But a tall tower usually lacks the mass of a whole house.

Five years is a long time to hide one's light under a modest bushel. Frank A. Jasset, Newton, Mass., assisted by Frederick Richards, Newton, Mass., and Guy E. Gordon, Natick, Mass., five years ago finished a Cassegrainian reflector (Figure 3) of 20″ aperture and then failed to write it up for publication.

Learning recently about this telescope we invited Jasset to give us the pertinent data, and these now are published—perhaps more briefly than would otherwise have been the case. We wonder how many other larger-than-average telescopes lurk elsewhere, similarly unheralded and unsung.

The observatory is wooden and is 10′ x 10′, with a square pyramidal roof revolving on a "round-square" track.

Concrete pier separate from floor.
Springfield-type mounting.
Electric drive.
Tube, 21″ x 61″.
Primary, 1½″ x 20″, 47″ f.l.
Secondary, 4″ diameter.

There is a 2″ right-angle prism at the elbow near the eyepiece.

At first the primary was silvered and coated with amyl acetate, which worked very well, but when no amyl acetate was applied to a later coating the

Figure 2: The teletower

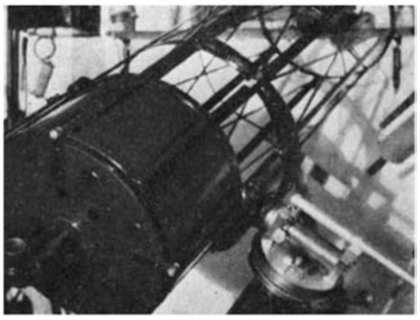


Figure 3: The bashful 20″

silver soon tarnished rather badly.

Asked about the unconventional thinness of the mirror, about 1:13, Jasset replied: "Definition very good, no distortion. The mirror rests on a flotation system resting in turn on felt blocks on a disk of 1½″ laminated wood sealed with wax and painted. This has proved very satisfactory.

Jasset and Richards, also Gordon, were members of the recent "Roof Prism Gang." Because working only in spare time, of which there was not enough, they were unable to go into actual production but together produced 36 acceptable roof prisms and thus demonstrated that in more favorable circumstances they could have produced many. The initial belief on the part of your scribe, that the amateurs could make these prisms in spare hours, was mainly erroneous. The work proved to be too exacting for tired men who already had done one day's work. With one exception those who produced large numbers—thousands—were those who could arrange to quit their regular vocations and go into prism production whole time (actually, in fact, for most, about double time, with sleep taken mainly after the emergency). The exception was the team of Ralph Franklin of Patchogue, N. Y. and Frank Cameron, Inwood, N. Y., who, together, produced 1700 roof prisms in spare hours—and felt about 100 years old during the long period of the doing. Today, all the roof prism work is completed.

Last month's Telescoptics department dealt with the effects of temperature in different types of telescope tubes. In addition to the effects described there and previously in astronomical literature, a reader contributes a new one so far as this department knows—the huddle, or "crowd poison" effect. Too many people crowding around a telescope together give off about as big a volume of heat as a small bonfire; one human being alone sheds heat at a rate of about 400 B.t.u., about enough to light a lamp bulb. That's why the poor telescope aches to yell "Spread out—crowd poison. And quit breathing on my eyepiece or I'll get hot and put on some temperamental aberrations or go into a coma if you persist in ganging up on me this way." A crowd indoors will warm a room; even outdoors it will suffocate a telescope.

Copy of first edition of "A.T.M.," good condition, now rare, has turned up in the hands of a telescope maker's widow. To highest bidder.

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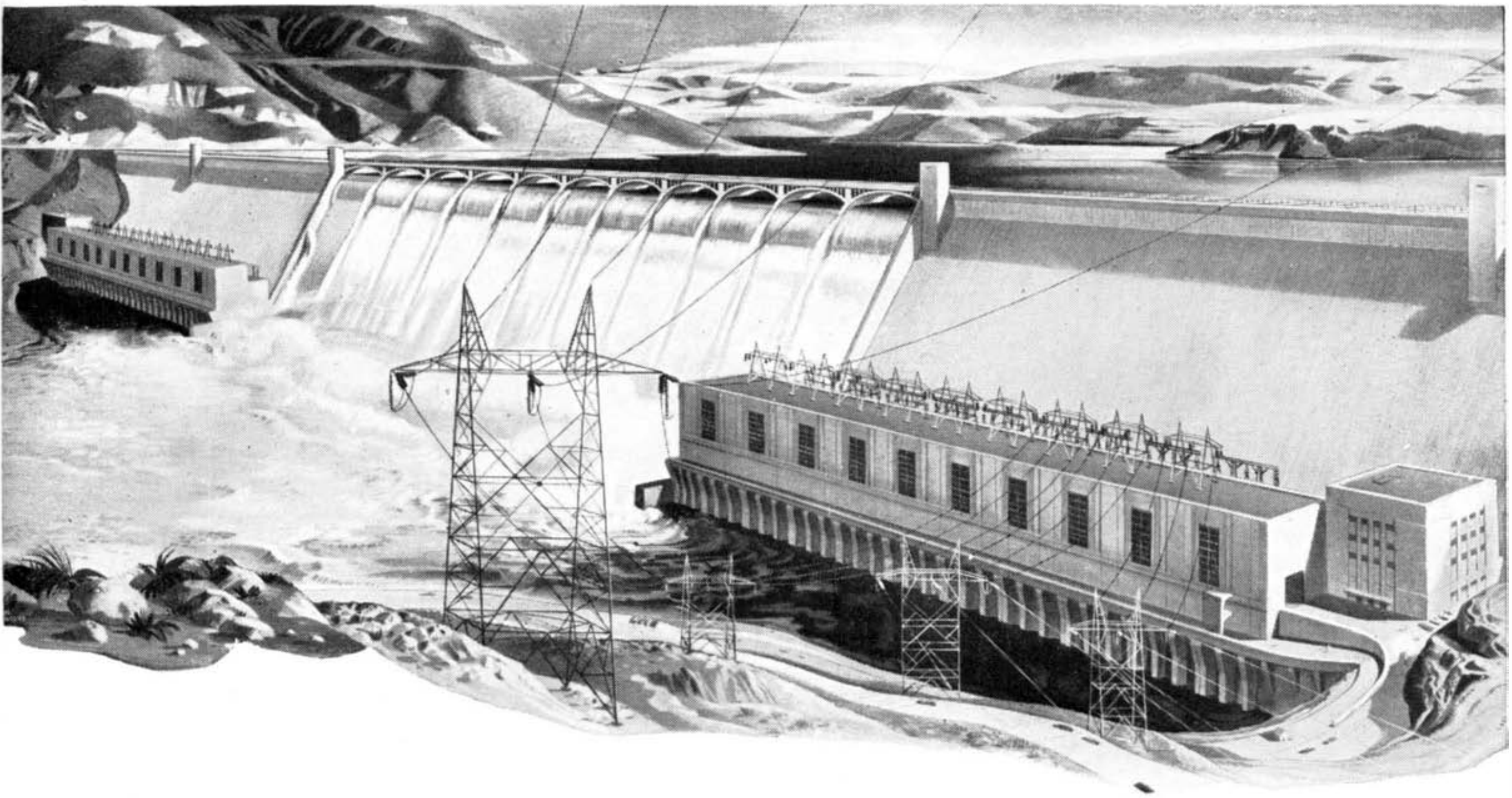

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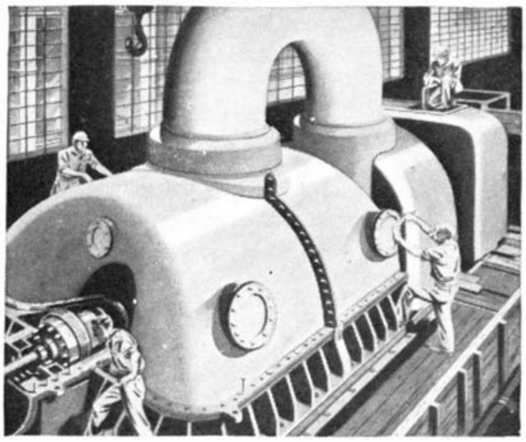

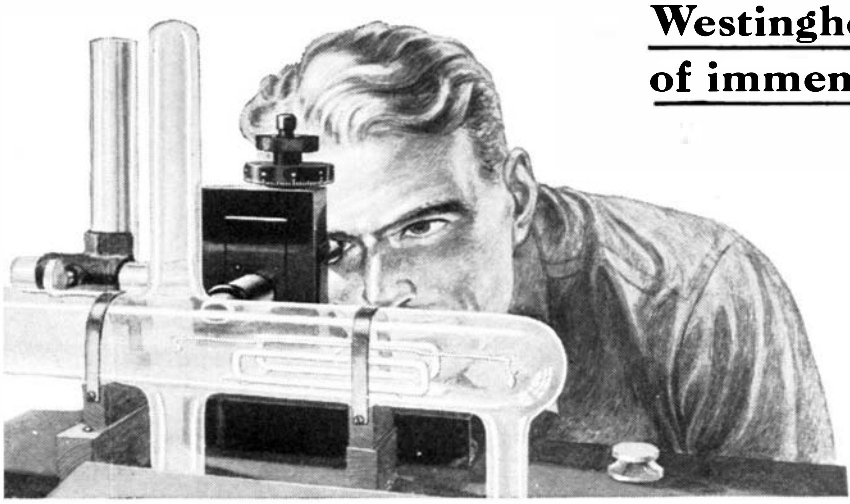

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