RUBBER FACTS THAT DON'T STRETCH . . . Page 276

SCIENTIFIC AMERICAN

JUNE • 1942

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An Industry That Started from Scratch . . . Page 278

We think this is what they meant

154 YEARS AGO, the men who drew up the Constitution of the United States wrote into it this phrase: "To provide for the common defense, to promote the general welfare."

Just what did they intend these words to mean—the men who helped guide the first faltering steps of a new nation?

We believe this is what they meant:

That in times of peace, it was the duty of all individuals and all industries continually to exercise their skill and ingenuity for the benefit of the "general welfare"—so that Americans everywhere could live healthier, happier, better lives.

We think they meant that, should American democracy ever be threatened, the defense of that democracy then became the responsibility of every man and woman in the United States.

Because we at Westinghouse believe this is the meaning of those words from the Constitution, we have lived and worked by them—and are living and working by them today.

Westinghouse contributions to the general welfare and the common defense are many and varied. The products of Westinghouse "know how" range all the way from tiny bulbs for medical instruments to thousand-ton generators for hydroelectric power plants. And now, devoting itself to wartime needs, that same "know how" provides tank and plane equipment, binoculars, bomb fuses, torpedo tubes, battleship turbines, electrical instruments, and weapons of many kinds.

From engineering and science comes our "know how"

What is this Westinghouse "know how"? It is the teamwork and experience of skilled workmen, blended with the knowledge and imagination of engineers. It is the ability to get things done in the best possible way. In war, as in peace, Westinghouse engineering and science are the guiding forces of our "know how."

Already these men have turned over many inventions and improvements to our armed forces. And this work will continue—day and night—until America writes the peace that ends the war.

Westinghouse

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURGH, PA.

PROGRESS in the chemical industry, dealt with in detail on page 278, is symbolized by our front cover photograph, taken in a plant of the Calco Chemical Division, American Cyanamid Company, of one part of a process of producing organic chemicals.

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SCIENTIFIC AMERICAN

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NINETY-EIGHTH YEAR — **ORSON D. MUNN, Editor**

JUNE • 1942

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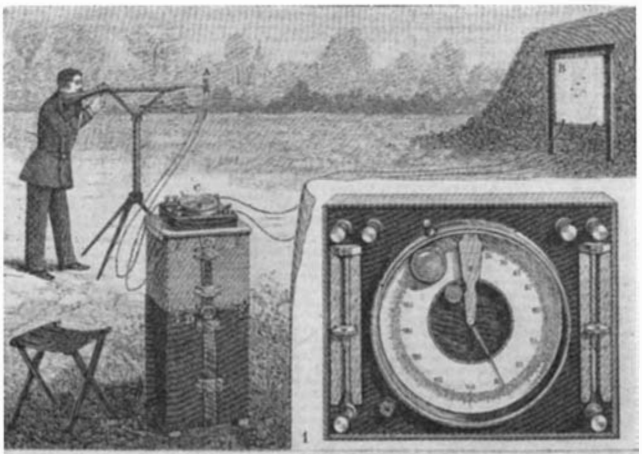
50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of June, 1892)

COLOR PHOTOGRAPHY—"The method adopted by Mr. Ives for photographing in colors is another instance of American ingenuity. Acting on Helmholtz's theory that the nerves of the eye respond to wave vibrations corresponding to light of red, green, and bluish violet, and that all tints are made up of combinations of these light waves, he takes three photographs of a scene or object, screening off from the first sensitized plate all but the red rays, from the second all but the green rays, and from the third all but the blue-violet rays. Then he places the photographs on celluloid in a three-lens lantern, and projects these so that they coincide in one picture, screening his lenses with glass of red, green, and blue-violet color. The result is a large photograph in all the actual colors of nature."

CHRONOGRAPH—"The chronograph of Mr. Schmidt, which is capable of measuring as minute a period of time as the ten-thousandth part of a second, is based on this principle: The regularity and rapidity of the movement of the balance wheel of the escapement enables measurement to be made of intervals of time much less than that of one oscillation. . . . These chronographs have been used principally for measuring the initial speed



APPARATUS FOR MEASURING THE VELOCITY OF PROJECTILES.

of projectiles. At the moment of discharge the projectile breaks the current by cutting a wire which is stretched in a primary frame attached to the end of the gun. The chronograph continues to operate until the projectile passes through a secondary frame located in front of the target. . . . It is possible, therefore, to read the exact interval that has elapsed while the projectile has passed between the two screens."

ENGINES—"A 60 horse power nominal Otto gas engine is one of the largest gas engines yet constructed. Even when the success of the Otto gas engine of sizes up to 20 indicated horse power had been insured a few years ago, the makers themselves would scarcely have ventured to predict that in the short time that has since elapsed engines indicating 85 horse power with a single cylinder would be commercially successful, and supplanting fairly good steam engines."

MOUNTAIN RAILWAY—"The most recently completed high mountain railway in Switzerland is that up the Rothhorn 7,240 feet high, from the lake and town of Brienz, not far from Interlaken. . . . The material through which the eleven tunnels of this line were excavated consisted of debris which had slipped down the mountain, and which seemed disposed to go on sliding when disturbed. Subterranean springs also made the work difficult, and in places new beds had to be made for mountain streams."

BANANAS—"While apples yield only 12 per cent, bananas with the skins removed yield 25 per cent of thoroughly dessicated fruit. The supply of bananas is practically unlimited. The fruit grows to maturity all the year round, and may be obtained every day throughout the year, so that the manufacture of dried bananas can be made continuous."

MOSQUITOES—"The beak of the mosquito is simply a tool box, wherein the mosquito keeps six miniature surgical instruments in perfect working order. Two of these instruments are exact counterparts of the surgeon's lance, one is a spear with a double-barbed head, the fourth is a needle of exquisite fineness, a saw and a pump going to make up the complement."

CANAL TRAFFIC—"Few persons who have not made a personal study of the matter realize the magnitude of the traffic of the Great Lakes. There were over 1,100 more vessels passing through the canal into Duluth, Minnesota, in 1891, than passed through the Suez Canal the year previous. Through the 'Soo' Canal at the outlet of Lake Superior there were more than three times as many vessels and nearly a million and three-quarters tons more freight in 1890 than through the Suez Canal during the same year."

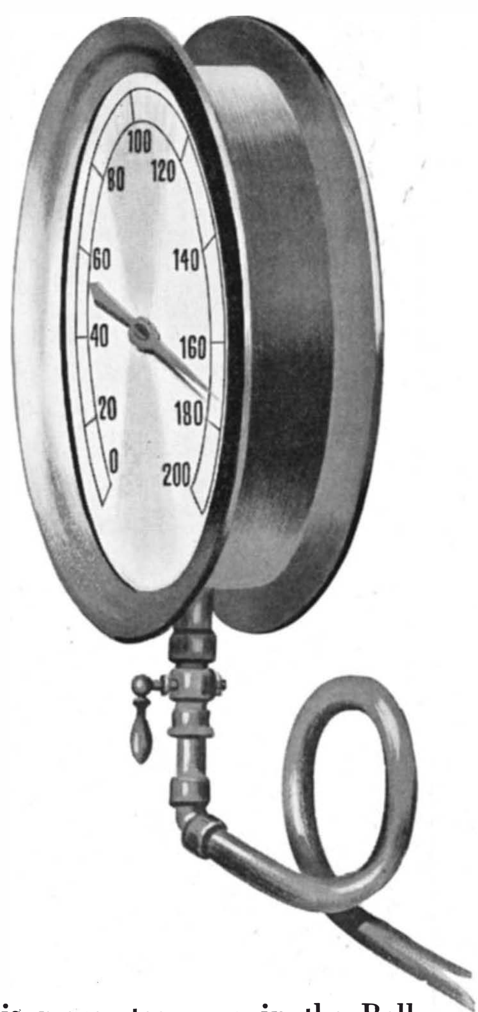
BOMBING—"Mr. Maxim, of gun fame, has for some years directed his attention to the problem of aerial navigation. Recently he said: 'If I can rise from the coast of France, sail through the air across the Channel, and drop half a ton of nitroglycerine upon an English city, I can revolutionize the world. I believe I can do it if I live long enough. If I die, some one will come after me who will be successful, if I fail. . . . It can be done as sure as fate.' "

FAMINE—"The attention of the whole world is directed to the terrible famine in Russia; consequently it is not generally known that a similar scourge is afflicting India. In this country all the horrors which follow in the wake of starvation occur with fearful regularity every fifteen years, or twice in every generation. The last great famine was in 1876."

SLUMBER—"It is said by scientists to be a fact that all our senses do not slumber simultaneously, but that they fall into a happy state of insensibility one after another. The eyelids take the lead and obscure sight, the sense of taste is the next to lose its susceptibility, then follow smelling, hearing, and touch; the last named being the lightest sleeper and most easily aroused."

PASTEURIZATION—"Machines are in use in Paris and some other cities which will heat great quantities of milk to a temperature of about 155°Fah. for a few minutes, and then cool it rapidly to a low temperature. The method has been called the pasteurization of milk. It does not kill all the bacteria, but it does destroy so many of them that it greatly increases the keeping properties of the milk. Moreover, it almost entirely destroys the danger from disease germs in milk, since nearly all forms likely to occur in milk are killed by this temperature."

"Carrying lots of pressure these days..."



"THERE is more steam up in the Bell System than I ever remember. The wires hum with war and wartime production. There's more telephoning than ever before.

"The pressure of war and war's work is on—especially on our toll lines. If you are going to use Long Distance you can help by —

> **Knowing the number you want to call.**
>
> **Calling in the less busy hours — before 10 A. M. and after 8 P. M., for example.**

"Let's give vital war calls the right of way and make equipment go as far as possible, saving copper and other materials for the war."

BELL TELEPHONE SYSTEM

"The Telephone Hour"— ***presenting great artists every Monday evening — N.B.C. Red Network***

X-RAY PHOTOGRAPHS IN A MILLIONTH OF A SECOND

HIGH-SPEED photography, by X-rays, of bullets passing through gun barrels or smashing their way through armor plate are possible with the new X-ray tube invented by Dr. C. M. Slack (left, above), of the Westinghouse Lamp Division laboratories. Dr. Slack is shown explaining a laboratory model of the tube to Dr. Herschel Smith, civilian aide at Frankford Arsenal. At right is L. F. Ehrke, who collaborated with Dr. Slack in the development of the tube. More details of the tube and its uses will be found on page 293.

'POP-GAS' AIDS WAR DRIVE

Harmless Vapor Balks Saboteurs, Saves War Plants

PAUL W. EBERHARDT

SOMEWHERE in New Jersey several hundred men are working day and night turning out steel cylinders, filling them with common ordinary "soda-pop" gas.

Somewhere in Connecticut an airplane engine is taking a final test. A defective fuel line spills raw gasoline on a red-hot steam pipe. Instantly the supply trench under the test cells is a river of flame, but the motor is delivered on schedule.

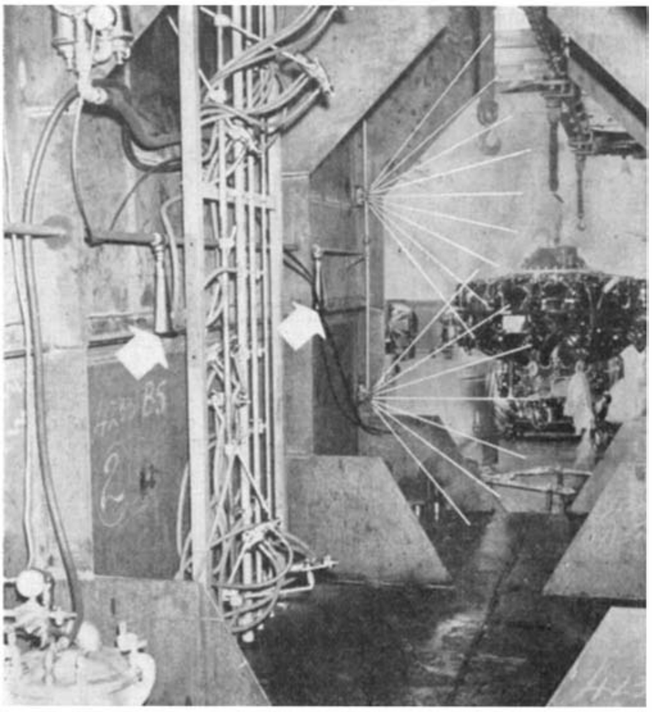
Somewhere in California a saboteur places an incendiary tube in a storeroom stacked with drums of flammable liquids, but the fire department isn't even called. Damage is negligible.

Somewhere in Tennessee a huge generator is supplying thousands of kilowatts of electricity for the manufacture of aluminum. A piece of insulation cracks and flame bursts out, but the faulty insulation is soon replaced and the generator is back on the job.

Somewhere in Alabama a plant is ginning cotton for Army duck. A piece of tramp iron causes a spark, ignites the lint in a flue, but 15 minutes later the gin is back in operation.

From all over the country come reports of fires that threaten great industrial plants, power companies, refineries, and warehouses, fires which threaten total destruction but which are miraculously snuffed out with little or no damage. How do these seeming miracles take place? The answer is in the cylinders being turned out by those men in New Jersey and the "soda-pop" gas with which they are filled. For it is this gas that snuffed the flames at their inception—turned a possible holocaust into just a minor accident.

Legend has it that carbon dioxide's peculiar ability to smother fire was discovered accidentally by a Swedish harbor-master who was using the compressed gas to make a light-buoy wink at regular intervals. One night his supposedly non-extinguishable flame went out, and investigation proved leaking carbon dioxide gas to be the cause. Be that as it may, American engineers get the bulk of the credit for harnessing the gas and teaching it new tricks, for a great many harnessing stunts began on drawing boards in the New Jersey laboratories of Walter Kidde and Company.



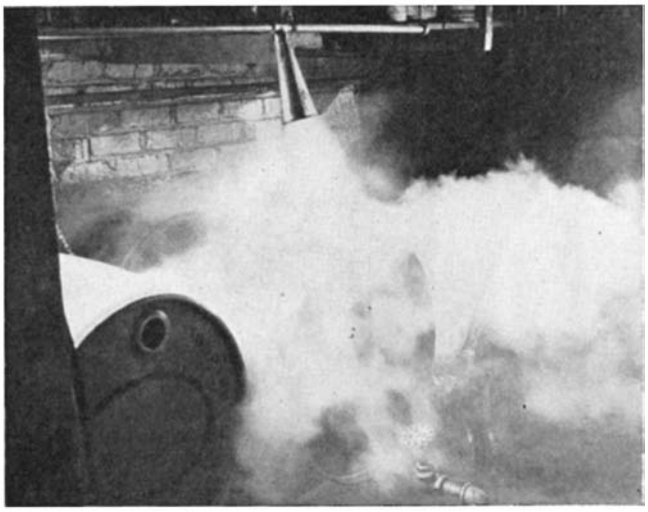
Carbon dioxide protects airplane engines under test. Arrows point to discharge nozzles; white lines at right indicate extra gas from special screening nozzles

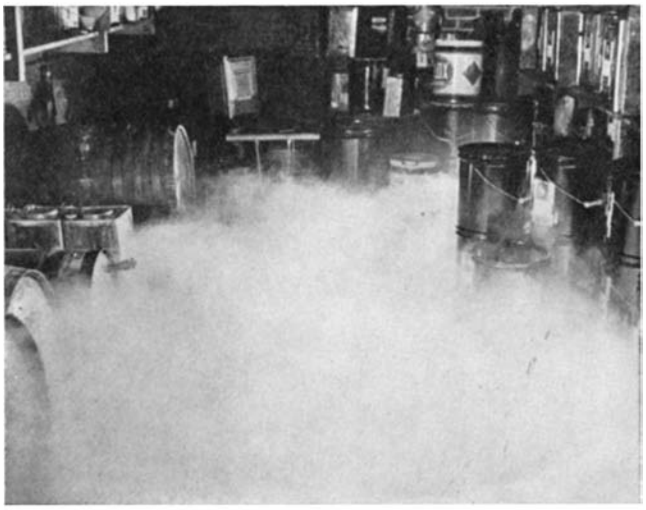
Carbon dioxide's debut as a fire-extinguisher took place soon after the World War I—on the high seas. The then-untried gas was introduced dramatically to London ship-owners by an engineer, who rented an old trawler, set a raging gasoline fire in its hold, and extinguished the blaze in a matter of seconds with clouds of the cold, white gas. Since that demonstration, carbon dioxide fire protection devices have become standard equipment on merchant vessels. It is even being used on the new Liberty ships which have been stripped of all non-essentials.

Just how does carbon dioxide work on a fire? As any physics student knows, air at sea-level contains 21 percent oxygen. If that oxygen content is substantially reduced, a fire cannot burn. So if enough carbon dioxide is discharged over the flames to cut the oxygen content to 14 or 15 percent, the fire goes out.

This same principle is applied in fighting sea fires. Stored carbon dioxide is discharged into burning cargo compartments, inaccessible to ordinary fire-fighting agents. The white gas penetrates into crevices and underneath bales where fire may be burning, instantly extinguishing all flame. There has been no change in this basic principle since the initial application of the gas to cargo fires. The major improvements have been made in the means of distributing and discharging the gas, and of detecting the fires to be extinguished.

Detecting the presence of cargo fires is as important as extinguishing them, and the old method of having the deck officer sniff at ventilation tubes was





A storage room packed with inflammable materials is protected against fire by a carbon dioxide system. At left, gas is being discharged to cover the whole room as at right. A few seconds later, room was flooded to ceiling

long ago found far too haphazard. The engineers solved this problem by developing an automatic sniffer which employed an electric eye to investigate air samples drawn automatically, every few seconds, day and night, from each cargo hold. These same "sniff pipes" are the pipes through which the blast of carbon dioxide is directed into the cargo hold, once a trace of fire is detected.

But the Kidde engineers did not stop with perfection of this gas for sea-going duties. While one group of engineers worked on the automatic sniffer and similar maritime devices, another group tackled the even larger problem of industrial fire protection. It is to the result of their labors that the airplane engine in Connecticut, the storeroom in California, the generator in Tennessee, and the cotton gin in Alabama all owe their escape from a flaming end.

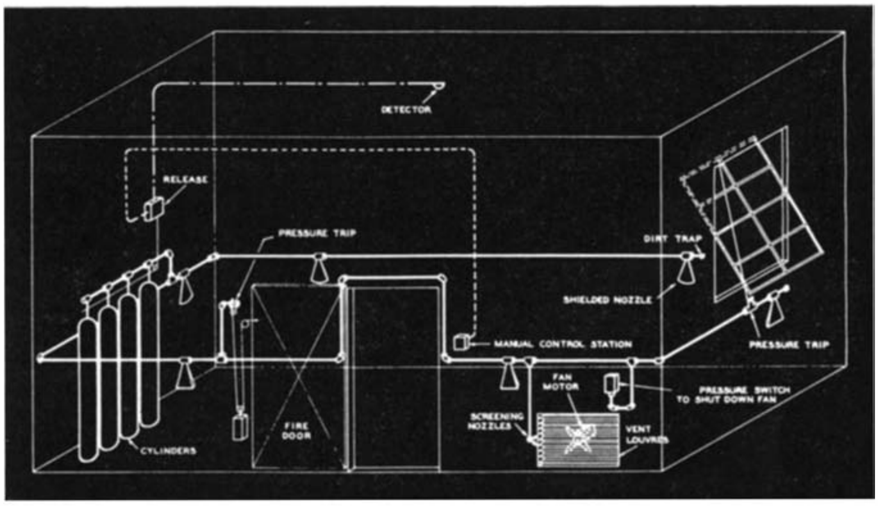
A small cylinder of carbon dioxide supplies buoyancy for life vest

The importance of carbon dioxide industrially comes from the fact that it is especially effective against two types of blaze—Class "B" (flammable liquids) and Class "C" (electrical equipment). For these two hazards account for a large percentage of today's factory fires. What's more, in many of these fires carbon dioxide is the only means of effective control.

For example, let's go back to that test cell in Connecticut and see exactly what happened. As soon as the gasoline ignited, the fire registered on a heat-sensitive detector in the fuel-supply trench. This detector opened the valves of a bank of steel cylinders located outside the threatened area. Carbon dioxide gas, stored in these cylinders at a pressure of 850 pounds per square inch, roared through pipes into the trench, expanding to 450 times its stored volume, and completely flooding the burning space. In a matter of seconds the flames were completely stifled. And after the fire was out, the extinguishing gas dissipated in a few minutes, leaving no residue.

In California, the saboteur had counted on three things—surprise, inaccessibility of the crowded storeroom, and a blaze of such intensity that no human would dare face it. But a carbon dioxide system cannot be taken by surprise. Its heat sensitive detectors were on guard every second of the day and night. Likewise, inaccessibility was no problem, as the system flooded every cubic inch, every niche and crevice of the room, with the heavy, white gas. And of course the human element was not involved, as the whole situation was handled by steel cylinders, steel pipes, and an inert gas which not only flooded the room and put out the fire but, in addition, released trips as it rushed through the pipes, automatically closing doors and windows through which the flames might have spread into other parts of the factory.

The equally important role of gas extinguishing in electrical fires is shown by the generator in Tennessee.



Diagrammatic layout for a typical industrial system for flooding a room with carbon dioxide gas. Pressure trips are used to close doors and windows

As in the previous cases the system was entirely automatic. At the first trace of smoke the generator housing was completely flooded with gas—an action which could be taken without the slightest worry of short circuits and other electrical damage because carbon dioxide is a non-conductor. At the same time, a second bank of cylinders was held in reserve to discharge its contents gradually into the housing and maintain the concentration of gas during the half hour needed to stop the huge rotors. This added precaution did away with any possibility of re-ignition and, since the gas could be dissipated with a few moments ventilation, there was no fear of damage from the extinguishing agent.

The story of the Alabama cotton gin is similar, but it is notable in this case that carbon dioxide does a two-fold job. It not only stifles the immediate blaze, but it is equally efficient in guarding against partially ignited fibers which, if not quenched in the flue, may find their way into the center of a bale and smoulder, later causing a disaster on a dock or aboard ship.

While the above examples are all concerned with automatic systems, some built-in carbon dioxide equipment is operated by manual control. In such cases, however, the control is located at a distance from the fire hazard so that there can be no question of the flames preventing workmen from reaching it.

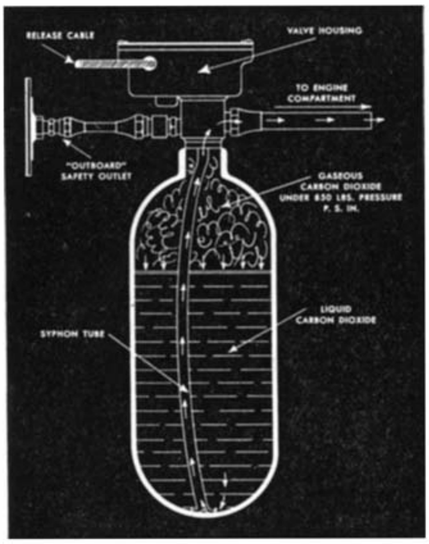


Diagram of extinguisher, hand controlled, for 'plane installation

Still another milestone in the saga of this modern fire-eater was the portable carbon dioxide extinguisher. The impetus to create such a device came first from the telephone companies, who yearned for a fast method of killing switchboard fires—a method which would not saturate or dissolve insulation. The pop-gas filled the bill, but the large steel cylinders then in use for carbon dioxide fixed installations were far too heavy for hand maneuvering. As a result, engineers developed a new light-weight cylinder, which now is not only the basis of the portable extinguishers found in homes and factories throughout the country but, in addition, protects military planes, tanks, and PT boats from fire during action.

But fire-fighting is not the only use to which Kidde engineers have harnessed soda-pop fizz. Among recent developments are collapsible life-belts and life-rafts that can be stored in a small place and given immediate buoyancy by releasing a shot of compressed carbon dioxide. Before the war they even had automatic waterwings for landplanes, which inflated as soon as the plane hit the water and kept it afloat. But these have been discontinued for the duration, lest forced-down ships, floating in war-zone waters, might fall into the hands of the enemy.

• • •

PLANE DETECTOR

Portable, for Use by Plane Spotters

An aural plane detector, easily carried and operated by one man, has been developed by The Zadig Patents, for use by individual spotters of the Aircraft Warning Service. The accessories for the device, including the power supply, are housed in a case smaller than the familiar gas mask container.

When the device is to be used, the spotter puts on a headpiece suggestive of the Buck Rogers fantasies, consisting of earphones topped by a parabolic "concentrator" of sound waves, from which wires are plugged into an amplifying apparatus in the case. When a low-pitched sound in the earphones heralds the approach of a plane, the spotter turns his body until the sound is at its loudest. He is then facing the oncoming plane and is able to turn his binoculars swiftly and accurately on the aircraft to be identified.

It is claimed that the device has been passed upon by technicians of the U. S. Army Signal Corps and by members of the Aircraft Warning Service, who find that it can be used effectively by technically untrained spotters.

The pick-up unit is of thermoplastic material molded to a parabolic curve with a microphone of special characteristics placed at the focal point. The

Microphone in headpiece, vacuum-tube amplifier in case at side

headband which carries the earphones also supports the concentrator.

The amplifier and its batteries are contained in a shielded drawer which slides into a compartment at the bottom of the carrying case. The amplifier uses three tubes of the miniature type which are connected in a high-gain circuit. Filters eliminate noises other than those emanating from the approaching plane. A volume control knob regulates the sound in the earphones to the watcher's comfort

BLACKOUT BULBS

Now Emit Deep Orange Light

Important changes in specifications for blackout bulbs recently described in these columns are announced by the Wabash Appliance Corporation, whose silver-lined bulb placed on the market in early January had been put through exhaustive blackout tests in actual city-wide blackouts in many states. Specification changes are based on the results of these tests, as well as on various official recommendations.

The most important specification change is in color of light from blue and red to the deep orange recommended by the office of Civilian Defense. Other changes are in size which is smaller, in reduced current consumption to 15 watts, in elimination of the former built-in reflector, and in an improved type of heavy black silicate coating to prevent light leakage.

The deep orange light that the new unit provides is said to be ample to permit room occupants to see each other plainly, as well as furniture, doors, and windows.

Cement Aids Oil Production

Deep Oil Wells are Controlled and Conserved by Application of High-Speed Cementing Process

ANDREW R. BOONE

THREE compound steam engines mounted on a large truck ceased their laboring. Standing alongside the outfit, Bert Fry wrung a muddy mixture of cement and perspiration from his shirt. A. W. Earl, who had been riding herd on the throbbing engines, closed a pair of control wheels, and Aaron Griffin, trailer tender, moved a horn-like chute to one side.

"Well, boys," Bert grinned, "that does it. Dust fills the hole."

It wasn't really dust, and the hole no longer was a hole. Fry and his crew in 45 minutes had forced 75 tons of fast-setting cement, a special oil-well formula they had mixed with 20,000 gallons of water, down a pipe 11,200 feet long, out the bottom, and up a distance of a mile between the pipe and the rocky wall.

Cement in an oil well performs several important jobs. It prevents water from trickling down into the oil sand from upper formations, protects the casing against collapse due to high pressures in the earth, halts corrosion caused by highly mineralized fluids seeping through the formation, keeps gas from blowing out, and conserves shallow oil formations for future use.

When a drilling crew is ready for cement, they must have it fast, for oil wells have a way of running wild, perhaps bringing in water which ruins their production. It was to meet this need of urgent haste that Earl Halliburton, Los Angeles oil man, devised a system of speedy transportation of large quantities of cement and delivering it in a steady stream to the bottom of the deepest holes in jig time.

Alongside Highway 99, seven miles north of Bakersfield, California, stands one of Halliburton's groups of silos, from which the writer recently accompanied the crew on a cementing job.

This structure, though complicated in appearance, is much like a single silo of the type found on farms. It contains six cement bins, their mouths standing 15 feet up from the ground. Loaded by means of screw conveyors, each contains 55 tons of cement. When a cementing job comes along, a Diesel-engine truck-trailer pulls under the bins, a workman trips a lever, and the stuff pours down through a cloth chute into the huge trailer. When full, a batcher scale automatically weighs the load, and the driver roars off toward the oil field at a 30-mile-an-hour clip.

On arriving at the well, the trailers are backed in a semi-circle against another truck equipped with the three steam-operated pumps. On signal from the tool pusher, four members of the cementing crew swing into action, timing their actions to a split second.

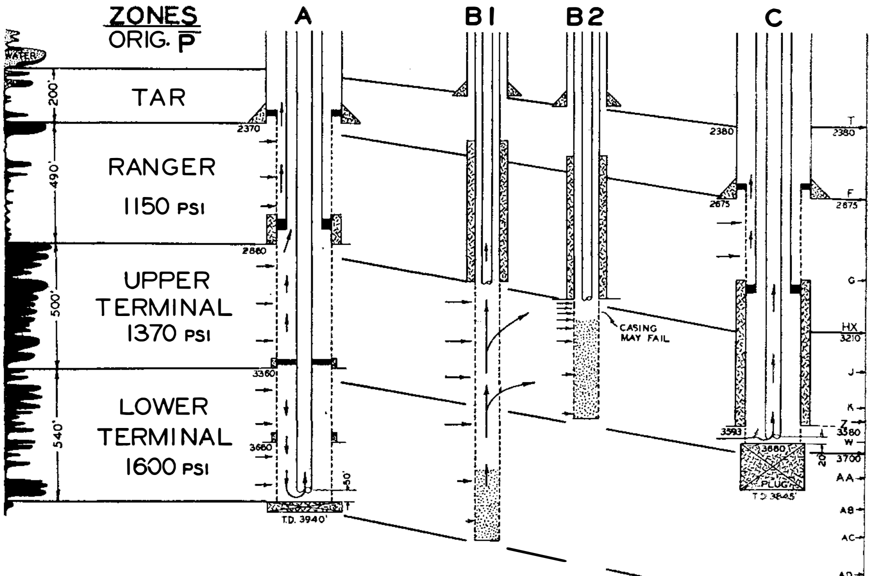
On the front of the first trailer to be unloaded, the driver starts a 16-horse power air-cooled gasoline engine. At the rear, another workman actuates a clutch, engaging the engine with a screw turning at the bottom of a double Vee running the length of the trailer. As the screw begins delivering cement into a cone leading through a small pipe to a slurry box alongside the pumper, still another workman turns on the water. And on the pumper, the fourth man opens a pair of valves, and the pumps start the thin mixture of finely-ground cement and water on its downward journey.

Until recently, a crew of 50 men was required to slit sacks and deliver cement into a mixer. Now four men do the job twice as fast. As the mixture leaves the pumps under pressure of 6500 pounds per square inch, it flows down inside the pipe, forcing ahead and out through the bottom, immediately above the oil sand soon to be brought into production, the mud used to lubricate the drill and pipe. Wood-and-rubber plugs and an expanding basket make it possible to keep mud and cement separated, and to place the cement exactly where it will do the most good. The basket, whose ribs are collapsed as it slides down the hole, lands on top of the oil-bearing sand. There the ribs expand, diverting the cement outward and upward.

MANY oil wells brought into production at great depths would not be flowing today, providing fuel necessary to keep the nation's war machine running, were it not for fast and accurate cementing. Unlike the cement that goes into concrete for pavements and sidewalks, this material is ground so fine that, at a depth of 2000 feet, it will set in an hour; in a 13,000-foot well, under great pressure and at temperatures high enough to produce steam, a hundred tons of the stuff, rising 6000 feet outside the pipe, will set in three hours.

When the heavy plug surrounding the bottom of the pipe hardens, and there is no longer danger of water seeping down from above, the drill is lowered to eat its way once more into the oil. Then, provided the cementers have done their job properly, another oil well is added to the production line.

Cementing also has found a valuable application in the so-called multiple-zone well. This is a well which does the job of two or more individual wells,



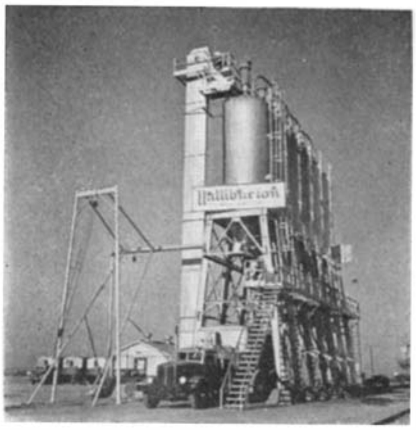
Schematic section of an oil field. See explanation in the text

each drawing from a single zone of oil. Multiple-zone wells have found widest application in the Wilmington, California, field. In this field, the multiple-zone well serves the purpose of permanently separating production of oil at several levels, and controlling each flow individually. Thus oils of various gravities are kept separated, formation pressures conserved, and the flow rates preserved within desired limits.

C. James Dean, field engineer for the General Petroleum Corporation of California, recently reported to a meeting of the American Institute of Mining and Metallurgical Engineers at Los Angeles upon the development of this practice. Accompanying this article is a schematic section, not to scale, of the Wilmington field. It indicates how cement units hold back undesired flows, how two or more zones may be caused to produce through a single well.

At *A* in the drawing is shown a multiple-zone well. Oil from the Ranger zone flows between the casing and a blank flow string; from the Upper Terminal zone between the casing and tubing; and from the Lower Terminal through the tubing. Packers inside the casing and cement outside separate the various zones.

"A multiple zone well," explains Mr. Dean, "when properly completed prevents the migration of oil and gas from high-pressure zones to zones of lower pressures. *B1* and *B2* in the drawing illustrate an example of migration believed to exist in wells with long un-



Cement in this battery of silos can be loaded in trailers at a rate of 100 tons in half an hour

broken producing intervals. A Full Terminal well producing at a curtailed flow rate is permitting gas and oil from the Lower Terminal Zone to repressure and resaturate a neighboring Upper Terminal well which is producing at the same daily rate from a thinner zone of lesser pressure. This involves not only the monetary value of the gas and oil lost, but, in addition, the limited gas energy is being used to actually drive oil away from the higher pressure well, leaving comparatively dead oil in the Lower Terminal Zone,

The fine cement is fed by screws to a cone, from which it is drawn to the slurry box for water mixing

to be recovered by less efficient mechanical methods. This migration could have been prevented by multiple-zone practice and probably still can be abated by producing the Full Terminal well through tubing hung near the bottom of the hole . . . . .

"It is significant, too, that the segregation of the zones permits taking the restricted allowable quantity from the zone producing the most desirable oil. The ability to regulate the pressure differentials which cause flow to the well is useful in the control of entrance velocity rates which determine the ability of the entering fluid to carry sand. This permits the production of the maximum sand-free rate from each zone."

Where may this technique be applied?

"The drilling of multiple zone wells," says Mr. Dean, "is in general a satisfactory practice on leases with insufficient drilling sites for the individual exploitation of several zones, and as a counter measure to offset wells which are either multiple zone or very densely spaced. Another accepted application would be for the development of sands or zones which in themselves do not justify the drilling of individual wells.

"The principal problem in the casing and cementing of a multiple zone well lies in the proper placement of a sufficient quantity of uncontaminated cement behind sometimes very short intervals of blank pipe. Oil zones at locations which offer no intermediate water problems are not difficult to separate with very small quantities of cement. Annular spaces requiring as little as 15 sacks have been filled effectively to separate zones. The necessity for simultaneously effecting a zonal separation and water shut-offs at the top and bottom of the blank interval is a more difficult problem. To do this the pumping of an excess of cement is desirable, which in turn involves the problem of the removal of the excess without cementing off perforations."

How may this feat be accomplished? Mr. Dean continues, describing one successful method:

"The casing is run with properly spaced sections of perforated and blank pipe. At the bases of the blank sections are placed upright cement baskets with the usual cementing parts. At the top of the blank sections are inverted baskets with open ports to receive the excess cement. The inverted baskets are wired to prevent expansion until in place. At the basket for the lowest cement job there is a duplex cementing collar which consists of a solid bottom baffle below the ports and a back-pressure valve above the ports. Tubing is then screwed into, or is sealed off on, the duplex collar and the cement is pumped into place. After displacing the

From the slurry box, where the cement-water combination is shown being checked, the mixture is forced into the well by pumps

cement, the tubing is raised to the top of the blank section and the excess cement in the casing is circulated out. The procedure at any of the cement points above the lowest is as follows: a cement retainer is set as a bridging plug below the ports, tubing is run and packed off above the ports with a second cement retainer; the cement is then pumped into place and the excess removed as described before.

"This method provides a positive means of placing the cement and prevents any movement after placement due to unequalized columns or circulating pressures. The drilling up of several retainers in the casing is troublesome, but not hazardous."

Rotating Galaxies

That the Spiral Nebulae Rotate is Now Beyond a Doubt. Our Own is Not Much Larger than Others

HENRY NORRIS RUSSELL, Ph.D.

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THE great spiral nebulae are flat, thin disks—as is proved by the fact that we see some of them edgewise. There is no reasonable explanation for such a shape unless they are rotating. We now know that they are so far away that even very rapid motions would not shift the finest details on our photographs by a perceptible amount except after many centuries. The spectroscope, which measures velocities of approach or recession independent of distance, is our only hope; but observations are difficult, for the surface brightness of these objects is very low, and spectrographs of special design are necessary to concentrate enough light onto the plate to produce an image. Nevertheless, Slipher, in 1914, proved that the great Andromeda nebula was rotating, and Pease, in 1917 (with an exposure of 79 hours!), followed the motion through a region five minutes in apparent, and 1000 light-years in actual, diameter. Within this region the velocity increases steadily with the distance from the center, attaining about 75 kilometers per second at 500 light-years from the center, so that this part of the nebula is rotating almost uniformly at the rate of one revolution in 11,000,000 years.

This is, however, only 5 percent of the distance to the outer portions of the spiral arms, which were then too faint to observe. Twenty years' improvement in spectroscopic design made it possible for Horace Babcock (son of the well-known solar observer), working at Lick in 1938, to carry his measures more than ten times as far—to a distance of 30 minutes, or nearly 6000 light-years, from the center, with exposures running up to 21 hours.

Beyond this the star-clouds are too faint to be observed. But there are several small patches of emission nebulosity—gaseous nebulae belonging to the Andromeda system, as the Orion nebula belongs to the Galaxy—which have bright-line spectra and can be more easily observed. One of these, nearly on the long axis of the nebula, is 96 minutes from the center, corresponding to the enormous distance of 18,000 light-years.

The velocities measured from these spectra showed that, at a distance of about 800 light-years from the center, the rotational velocity reached a maximum, dropped to small values at 1600 light-years, and then increased again, until for the most distant emission patch it rose to 370 kilometers per second, giving a rotation period of 100,000,000 years.

Photo Mt. Wilson Observatory

The magnificent spiral nebula M 33

The only other nebula large enough to be available for a similar detailed study is the magnificent resolved spiral Messier 33 (No. 33 in Messier's Catalogue). This is so faint that the motion of the star-clouds can be studied only close to the nucleus; but there are many patches of emission nebulosity, and no less than 20 of these have been observed by Mayall and Aller at the Lick Observatory. Their results, just published, show that all these objects on the south-west side of the nucleus (as seen in the sky) are receding from us, compared with the nucleus, while all but one on the north-east side are approaching, and place the rotation beyond doubt.

The general form of the nebula indicates that its plane is inclined 33 degrees to our line of sight. Allowing for this (as was, of course, also done for the inclination of 15 degrees for the Andromeda nebula) and adopting Hubble's distance of 700,000 light-years, it is found that the rotational velocities of the condensations increase to a maximum of 120 kilometers per second at 3500 light-years distance from the center, and fall off gradually to 60 kilometers at 600 light-years. The corresponding periods of revolution are about 50,000,000 years at the smaller distance, and 190,000,000 at the larger.

Hubble, reporting briefly on work by Humason and himself, records periods ranging from 3,000,000 years for an elliptical nebula, without spiral arms, to 200,000,000 for the outer parts of fully resolved spirals.

Both in the Andromeda nebula and in Messier 33, the regions along the apparent minor axis of the general elliptical outline show substantially the same motion as the central nucleus. This completes the evidence that the motion is really rotatory, for, at such point, rotation would carry the material of the nebula at right angles to our line of vision, without change of distance. In both cases the nebulae as a whole are approaching us—or, more reasonably put, the Sun is approaching them. This motion, shared by the stars in general in the Sun's vicinity, is itself due to the rotation of the Galaxy, which carries part of it where we happen to be toward these nebulae.

THESE vast motions of rotations demand explanation—not the mere fact of rapid motion, which is no more remarkable than what we call rest (relative to ourselves!), but the fact that the motion is curved, in paths which, on the average, are evidently nearly circular about the nucleus of each nebula. To draw any moving body into a curved path demands attraction—in this case an attraction directed toward the center. The only known force capable of producing such an influence on such a scale is gravitation. The combined attraction of the countless millions of stars which compose the nebula will average out to draw bodies in the direction of the center. The dark matter, which reveals its presence in the form of obscuring clouds, will add to the effect, if there is enough of it.

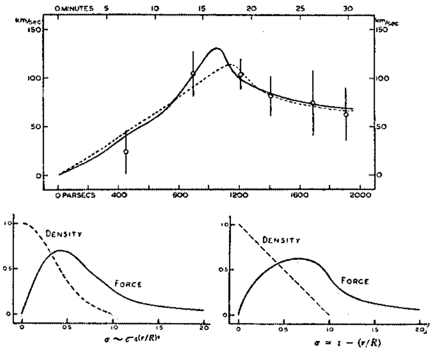
Knowing the radius of the circle described by any point, and the period, the inward force can very easily be calculated. For both nebulae, in the inner region where the rotation period is nearly constant, this force *increases* with distance from the center. If the whole mass, or at least most of it, were concentrated in the nucleus, this would not happen, but, as in the solar system, the orbital velocity would decrease at greater distances. The larger velocity there shows that the attraction of a greater quantity of matter is effective. This would happen inside a uniform spherical cluster of stars. It was shown by Newton that the combined attraction of all the stars nearer the center than the attracted body is the same as if they were lumped at the center, while the stars farther out than this point attract in all directions, in such a way that the net forces in all directions balance, and no effect is produced. As one goes farther from the center, a greater part of the whole mass becomes effective, and the attraction increases.

The nebulae, however, are anything but spherical and it is certainly a much better approximation to regard them as thin disks. In this case the effect is exaggerated. The parts of the disk nearer the center attract with their full force (though not exactly as if concentrated at the center); but the near side of the outer ring now has a greater attraction than the far side, so that its net attraction is outward, diminishing the total force. Outside the boundary of the disk the attraction falls off rapidly.

The expression for the attraction of such a disk is complicated, especially if it is assumed (as is reasonable) that its density is different at different distances from the center. Wyse and Mayall have just published a paper (with nine or ten pages of formulas full of elliptic integrals), have computed tables which can be used for calculation, and have applied these to the two nebulae whose rotations have been observed.

For Messier 33, the situation is fairly simple. Two assumptions regarding the density give a good representation of the facts. In the first, the disk is supposed to get thinner (or less dense) toward the edge, like a very greatly flattened ellipsoid of rotation. The outer radius is 3900 light-years. The second gives a nearly constant density up to 3000 light-years, dropping rapidly to zero at 3500. The observed and calculated rotational velocities are shown in the upper part of the drawing. Both curves fit the observations satisfactorily—the solid representing nearly constant density, the other varying density.

For the Andromeda nebula, where the velocity falls off and increases again, a more complicated model was required, consisting of a small and relatively dense disk of radius 850 light-years, at the center of one of lower density, at first increasing outward, and of radius 19,500 light-years. This curious distribution of density (shown at lower left in drawing) accounts for the still stranger distribution of velocity—according to Babcock's observations—shown at lower right. The very small force, indicated by the slow rotation at 1600 light-years (500 parsecs), arises



Courtesy *The Astrophysical Journal*

Calculated rotational velocity-curves for M 33. Solid line: nearly constant density. Dashed line: density varying according to thickness of an oblate spheroid. The circles and vertical lines represent observations with their probable errors. Lower curves are examples illustrating the relation between density distribution and central gravitational force. Abscissae (horizontal) are distances from the center with the radius of the disk as a unit. Ordinates (vertical) are arbitrary units, which are mutually consistent for the density and the force. From the published paper by Wyse and Mayall

because this region is well outside the inner disk, so that its inward attraction is much diminished, and inside the region of greatest density of the outer disk, so that its net attraction is outward, and decreases the total force.

Even this remarkable distribution of velocities may therefore be explained by the gravitational attraction of a quite reasonable distribution of matter.

The masses of the nebulae, resulting from these calculations, are very great. For Messier 33 the two solutions give masses 1,600,000,000 and 1,800,000,000 times the Sun's mass. For the Andromeda nebula, the mass of the small central disk comes out equal to 560,000,000 Suns, while the huge outer region totals 95,000,000,000 times the Sun's mass.

The two systems appear, therefore, to be very different; but it has long been recognized that Messier 33 is not far from being an average spiral nebula, while the Andromeda nebula is in all respects a giant. Our Galaxy is probably even bigger—the Sun is some 30,000 light-years from the center—and there are plenty of stars still visible on the opposite side of the Milky Way, farther out. Calculation of the galactic rotation makes the period at the Sun's distance about 200,000,000 years, and the total mass between 100,000,000,000 and 200,000,000,000 Suns. No system greater than the Galaxy has yet been discovered; yet it does not appear to differ very much from the largest of the others. Shapley's suggestion—well expressing the uncertainty of a dozen years ago—"Perhaps the nebulae are island universes, but the Galaxy is a continent"—would hardly be made now.

The new measures emphasize one strange property of these nebulae, already indicated by earlier observations. A large part of the light of both systems is concentrated into small regions close to the nucleus; but nothing of the sort happens with the mass. The faint outer parts of the Andromeda nebula, which are invisible to the eye, and are revealed only by long-exposure photographs, contain an amount of mass, per square light-year of cross-section, about one tenth that of the central region, but, for equal areas, they send us less than a thousandth part as much light. If both were composed of stars of the same kind—or the same mixture of stars of different kinds—and differed only in the number of stars per thousand cubic light-years, the ratio of mass to light would obviously be the same. There must therefore be an enormous difference in the distribution of the various forms of matter in the two regions. If the central regions were composed mainly of stars of large mass, and high luminosity, and the outer parts of faint dwarf stars, some such difference might occur. But the outer regions are resolvable into stars, which must be very bright to be observable individually even with the greatest telescopes, and such objects are not found near the nucleus, though they should still be observable there. It is hard to escape the conclusion that, in the outer regions, there are great quantities of dark matter, of aggregate mass much exceeding that of the visible stars.

This ties in well with Whipple's conclusion—which we reported last month—that it is in just such regions that giant stars may still be born. We must wait, however, for further data before these questions can be settled, and observation of even the nearest nebulae beside the two already studied will be "an observational problem of the first magnitude"—so Mayall and Aller say—and they know about it from experience. — *Mount Wilson Observatory, March 24, 1942.*

Rubber Facts That Don't Stretch

A Systematic Survey of Minor Emergency Sources of Natural Rubber in the United States

● An outstanding American trait is a penchant for self-deception through wishful-thinking—often rationalized as optimism. Such optimism can, however, be a vice. For example, readers will recall numerous glowing articles in magazines and newspapers during the past decade in which the great expectations from some newly-found and marvelous wild rubber-giving plant or weed were extolled. Yet, somehow, nothing came of these hopes. Now that we need rubber, where are these wonderful weeds? Some of us, it appears, still hope they will jump into the breech and save us. Guayule, of course, is satisfactory, but never was one of the wonderful weeds; it long ago proved up well. But what of goldenrod, rabbit brush, Russian dandelion, and others? Aren't at least some of these *it?* Believing our readers would prefer the truth to optimistic observations, we asked the United States Department of Agriculture for a canvas of the emergency sources of natural rubber in the United States, free from wishful thinking. The accompanying data are what we received. — The Editor ●

There are thousands of species of trees, shrubs, vines, and smaller herbaceous plants that contain rubber, many of which are native to the United States or are known to grow under our conditions, though only a small proportion of the eligible species has been tested. Some are tropical or subtropical plants that probably would have to be confined to southern Florida, while others are native to or could be grown in dry regions like the southwestern states.

Cryptostegia: Two species of Madagascar rubber vines, *Cryptostegia grandiflora* and *Cryptostegia Madagascariensis,* have been planted in many localities in Florida as ornamentals because of their handsome foliage and flowers. The first species is a large climber, while the second takes the form of a broad, rounded bush five or six feet high. A hybrid of the species also has been propagated and studied in Florida. Rubber obtained from *Cryptostegia* has been tested and found to be of good quality but the present supplies of these plants are limited. The percentage of rubber in the roots, stems, and leaves is very low, running only two to three percent, and the cost of extraction of the rubber is high.

Ornamental plants in Florida might yield small quantities of rubber but, for immediate emergency use, propagation or reproduction would be slow and no appreciable tonnage could be expected from this source within the next several years. This is a plant that could be handled by machinery equipped for extracting rubber from guayule but, because of the low rubber content, the extraction is inefficient and costly. Considering the low yield, the time required for production in volume, the difficulties of extracting, and the low percentage of rubber, *Cryptostegia* is not regarded as a practicable source of rubber in this emergency.

Milkweeds: Experiments also have been made with native rubber-bearing plants of the hot desert districts of southern California and Arizona. A promising species is one of the desert milkweeds *(Asclepias subulata),* with tapering, slender stems growing in clumps like a large bunch grass. A second desert milkweed, *A. erosa,* also has been tested and found to contain even higher amounts of rubber than *A. subulata.* Methods of cultivating these plants have been worked out, and they could be grown in large quantities in the desert districts. In cultivation tests, the yields of rubber have been so low that it has never been possible to demonstrate more than 80 to 90 pounds of rubber per acre per year from either of these species. Processes of extracting the rubber and utilizing it commercially have not been developed.

In addition to these two species of milkweed, attention has been given to the common broadleaf milkweed, *A. aspira,* common to the eastern states, but it has proved less promising than either of the two desert milkweeds. Another plant, commonly known as California milkweed but belonging to the composite family rather than to the true milkweed family, is *Stephanomeria virgata.* In spite of publicity recently given this plant, it has been impossible to demonstrate that it contains an appreciable amount of rubber. At the present time, no member of the milkweed group could be considered promising in comparison with the tested quality of guayule rubber.

Euphorbias: This group contains innumerable species of latex-bearing plants closely related to the true Para rubber tree. However, only one of these has ever been an important source of crude rubber. This is *Euphorbia intisy,* native to Madagascar, which was introduced into the United States in 1928. Cultivation experiments with this plant in the United States have been disappointing. It has been impossible to obtain seeds, and reproduction by cuttings has been very slow. It takes a period of many years to grow the plant and the plant must be destroyed to obtain rubber. The common Christmas plant, *Poinsettia,* also is a member of this group and has been promoted and tested for rubber production. Reliable tests have demonstrated that the rubber content of this plant

Rabbit brush, New Mexico. Enormous labor for only 40,000 tons

is too low for serious consideration.

Russian Rubber Plants of Anterior and Middle Asia: A number of plants have been discovered and tested in Russia for rubber production. Reports are that several of these have been cultivated on a fairly large scale. Of late, publicity has been devoted largely to the *kok-sagyz,* which is a species of *Taraxacum,* or dandelion.

The current favorable reports on performance of these plants do not appear to be verified by records of actual field performance in Russia received from reliable sources. In contrast to the reported rubber content in the roots of 10 to 27 percent, recent information from Russia indicates that when grown on a large scale by collective farms, the maximum percent rubber is 3 to 5 percent, and the average 1 to 1.5 percent. From the same source, it also appears that the average yield of the *kok-sagyz* root per acre is about one-half ton. On the basis of the maximum rubber content, that would be only 50 pounds of rubber per acre, which is pitifully small. Other plants tested by the Russians are the so-called *tau-sagyz,* which is a species of *Scorzonera,* related to black salsify, and the *krim-sagyz,* also related to the dandelion. Results in Russia are less favorable than those from *kok-sagyz.*

Goldenrod. Much talk, but its use is out of the question

Goldenrod: The late Thomas A. Edison discovered that of some thousands of species native to the United States, which he tested for rubber, the goldenrod showed the most promise in so far as rubber content was concerned. Cultivation experiments were initiated by Mr. Edison and later continued by the Department of Agriculture. Selections with improved yield of rubber were obtained but, up to the present, it has not been possible to produce the rubber in a quality acceptable on the American market. The rubber heretofore produced, on being tested at the National Bureau of Standards, showed a tensile strength of approximately 50 percent of that of comparable compounds using Para rubber and a resistance to abrasion of only 35 percent of that of Para rubber.

In addition, satisfactory methods of extracting the rubber have not been devised, so that the cost of the present method of extraction by chemical solvents is very high and inefficient. For certain uses, rubber from goldenrod is acceptable despite the impurities, but it does not lend itself to large-scale substitution for Hevea rubber. Only a small amount of propagated material of improved strains of goldenrod is available at the present time and a maximum planting of 60 acres in 1942 would be possible, followed by a 20-fold increase in 1943. The use of unselected goldenrod is quite out of the question because of low percentage of rubber and small leaf yield.

Rabbit brush: Many portions of the states of California, Arizona, Nevada, New Mexico, and Utah grow a species of *Chrysothamnus,* known commonly as rabbit brush. This plant contains appreciable amounts of rubber, running up as high as 6 percent of the dry plant content. Results in survey publications of 1919 indicate that appreciable quantities of rubber could be obtained from these wild plants. In many places, the rabbit brush occurs in almost pure stands but such stands are limited to local areas, widely scattered over these six states. The work of collecting and transporting is possible, but would be very arduous and would make large demands upon man-hours of labor.

The rubber has been extracted from rabbit brush by the method used for extracting rubber from guayule, and the rubber has been tested and found to be of good quality. The rubber extraction plant in existence at Salinas, California, could be utilized without modification for extracting rubber from rabbit brush, particularly from areas in the Mojave Desert and contiguous portions of California where some of the best stands have been located. It is estimated that as much as 30,000 to 40,000 tons of rubber may be obtained from plants of this species actually growing, but at enormous labor cost.

Osage Orange: Because of its milky juice, osage orange or hedge apple, botanically known as *Maclura pomifera,* has attracted attention as a possible source of rubber. Interest in this plant dates back to before 1910 and studies have been conducted by many investigators. Tests conducted in the laboratories of the Department of Agriculture have failed to show even 1 percent rubber in the fruits of osage orange and analyses of other parts of the plant have been equally disappointing.

Microörganisms: Synthesis of rubber by the use of bacteria or other microörganisms has been suggested as a possibility. The idea is to inoculate expressed juice of rubber-bearing plants and increase the amount of rubber yield from a given weight of the plants. As the rubber-bearing plant, itself, synthesizes rubber, there is no reason to doubt the possibility, providing the necessary elements or materials are in the expressed juice, or in the air and available to the microörganisms, but successful use of such methods to produce rubber have not been demonstrated.

From The Ground Up

Our Chemical Industry Had the War-Time Advantage of Starting Practically from Scratch

DOUGLAS M. CONSIDINE
Chemical Engineer

THE production of explosives and munitions constitutes a very minor part of the great American chemical industry in peacetime. Even in times of war, munitions production does not completely overshadow production of other chemicals and chemical commodities commonly identified with peacetime usage. Thus the chemical industry, today, is playing a most important and dual role in our war preparations; namely, by producing explosives and materials commonly identified with war, and by expanding production of such essential peacetime commodities as petroleum, rubber, and plastics. Of great significance is the fact that petroleum refining and rubber and plastics production are as dependent upon chemical technology as is the actual production of explosives.

In the fall of 1940, when an initial sum of $75,000,000 was made available to the War Department for construction of munitions plants, the stage was set for possibly the greatest task ever to be undertaken by the chemical industry of any nation. That long list of military ingredients, which has since become so trite, was placed on order for delivery as soon as possible. But nearly all the plants for this production were still on paper, or yet to be designed. We did not have any Krupps or Schneiders; we had neither a Skoda Works, nor a Vickers Armstrong, Limited. In a European sense, we had no munitions industry! Our peacetime facilities could supply no more than 10 percent of requirements and these plants were already on a 24-hour basis making munitions for Britain.

America's disadvantage in having to start from the ground up was not without assets, the greatest of which proved to be our ability to locate these plants according to all the best lessons of economic geography. Several factors were considered before the plant sites were selected. Despite the huge sizes and great capacities involved, expansion for the future had to be considered. Incidentally, this early foresight has proved a boon to expediently carrying out America's second great munitions program. As remote as an air attack on American soil seemed in 1940, the possibility of long-range bombing operations had to be considered. A strip 200 to 250 miles deep from the geographical boundaries of the United States was ruled out. New munitions plant construction was to be reduced to a minimum in this limited zone. World War I munitions production was confined chiefly to a geographical triangle, of which Boston, Pittsburgh, and Wilmington were the vertices. This resulted in critical power and transportation problems. Our great World War II industrial load had to be distributed as evenly as possible throughout the nation. In addition, availability of labor and raw materials, usually the primary guides in peacetime plant location, had to be weighed on the plant location balance. Good transportation facilities and power in large quantities had to be available to this great new industry. Coal and water had to exist nearby in great abundance.

SELECTION of sites in Illinois, Indiana, Virginia, and Iowa seemed a bit surprising until the War Department's fundamental policy became more evident. These plants were being located where there were vast undeveloped reserves of labor and natural resources. A new geographical network was being laid. As a result, the new munitions plants are drawing most of their workmen and supplies from neighboring vicinities, tending to eliminate the sacrifice and strife involved when labor migrates to cities and industrial centers already overcrowded. The difficulties which some communities have suffered to date from this cause are insignificant, as compared with the situations which would have been precipitated had this factor not been in the foreground when plans were being made.

This forethought will greatly aid the industrial situation when the present emergency has passed and these plants are put on bank. In the meantime, we may expect these plants to grow into centers for important peacetime industries. Munitions plants are chemical plants and the chemical industry is turning more and more to farm products as a source of raw material. With the equipment on hand to conduct the unit operations of chemical engineering, so-called "Chemurgy" may find a boon in these newly created industrial areas, tending to unite the chemical industry and agriculture into one great beneficial combine. When one realizes that all these factors and many more had to be seriously considered, the War Department may not only be excused, but lauded for using good farmland for the location of plants devoted to the manufacture of munitions and to other wartime activities.

One of the nation's largest combined shell loading and TNT plants rapidly took form in a mid-western state. Over 280 farms, comprising 38,000 acres of fertile farmland were converted into a great arsenal occupying some 35 square miles. Adjoining this Ordnance Works is a great shell loading works with an area of 22 square miles. Cost of the Ordnance Works was approximately $48,760,000 as compared with a cost of $22,000,000 for the shell loading plant. An expansion of these plants at an expansion of these plants at an expenditure of $9,400,000 has already begun. The Ordnance Works includes some 450 buildings and is surrounded by over 40 miles of unsurmountable fence. The shell loading plant includes some 500 buildings, several of which are powder and ammunition magazines.

THE principal raw materials for the preparation of TNT are toluol, sulfuric acid, and anhydrous ammonia. Toluol will be shipped to the Ordnance Works from a plant in Texas and from by-product coke ovens in the Chicago area; sulfuric acid will come from Chicago plants; ammonia will be shipped in tank cars from plants in West Virginia and Kentucky.

Loading and assembling shells will be the primary function of the shell loading plant. Empty shells and cartridges will come to the loading plant from scattered midwestern factories. High explosives for shells will come primarily from the neighboring Ordnance Works, while smokeless powder will come in bags from an Ordnance Works nearby. Facilities at the shell loading plant for loading airplane bombs, artillery shells, and fixed round ammunition will center about three loading or manufacturing lines. Of industrial interest is a conveyor line costing approximately $500,000 which carries shells through the long loading lines.

A small village in a nearby state

has been transformed into a thriving community and the site of America's largest smokeless powder plant. Over 20,000 people were engaged in $75,000,000 worth of construction to erect this plant. The plant site covers an area of thousands of acres; over 50 miles of standard gage railway track and 25 miles of narrow-gage track are required to serve some 650 buildings. Over 20 miles of water main are required to carry water to satisfy this plant's enormous requirements.

This plant exemplifies the great care exercised by the War Department in locating munitions plants. Located inland, it is practically immune from all but longest range aerial bombers. This plant is able to draw on the large industrial populations of nearby cities. A river provides an unlimited supply of water and a convenient means for diluting waste products. Transportation facilities, both rail and highway, are excellent.

The story of this plant is an epic in the history of great American chemical and powder plants, but only typical of the great series of similar plants now completed or under way. Construction of the plant started on Sept. 3, 1940, and proceeded with great rapidity. Soon after that date, modern ditching machines were digging foundations. A concrete plant, with a 2000 cubic-yard-per-day capacity was installed. Roads and railroad trackage suitable to construction purposes were rushed to completion. Steam required at the various parts of the huge plant site could not be purchased locally. This problem was expediently solved by renting four large railroad locomotives which served as mobile units, supplying steam requirements wherever needed. Twenty thousand board feet of lumber required were supplied by a saw mill built right on the grounds. Notwithstanding the immensity of this undertaking and the role that time played, confusion was reduced to a minimum and an All-American construction safety record of 4,000,000 man-hours without a single lost-time accident was established.

Ammonia, cotton linters, sulfuric acid, and alcohol are included in the list of important raw materials required for smokeless powder production. Ammonia will come to the Ordnance Works from a plant in Kentucky; cotton linters will be brought up the river from the south; great sulfuric acid plants in Tennessee will supply this vital ingredient; alcohol will come from nearby midwestern plants.

The first of Uncle Sam's new ordnance plants to begin production was in Virginia. Construction of this $40,000,000 plant was started late in 1940 and required the employment of some 22,000 workers. Production of smokeless powder began just five months later. A few miles away was constructed another Ordnance Works, a $10,000,000 plant which will load part of the smokeless powder produced at the first plant into bags for use in large caliber guns. The third of three smokeless powder plants scheduled on the War Department's first program is under construction at a cost of $48,000,000. The second program calls for a $60,000,000 smokeless powder plant.

Other arms, ammunition, and explosive plants on the first program, now under construction or in operation, include a shell loading plant—cost $17,000,000; a TNT-DNT plant—cost $11,000,000; a TNT-DNT plant — cost $9,388,000; and small-arms munition plants at costs of up to $30,419,000. The first program also called for two $1,000,000 plants for the production of activated carbon.

Expansion of the first program calls for additions to practically all of these plants at costs, in most cases, in excess of the original investments. Included in the outstanding new plants of the second program are a $26,000,000 TNT-DNT-Tetryl plant and a $33,500,000 ammunition loading plant. Even this by no means completes the lists of plants now proposed or under construction.

Despite the fact that we had practically no munitions industry in 1940, our chemical preparedness was considerably better than the period of World War I. In many cases, our 1940 peacetime production of strategic raw materials used in munitions manufacture was considerably greater than the peak of World War I production in 1918. For example, in 1918, we were producing 75,000 tons of ammonia per year. Today, our synthetic ammonia production alone totals several times this figure. But even with this great production, plus ammonia obtained from other sources, our present ammonia production, which momentarily appeared bright, is, in reality, only about one half of estimated requirements; chlorine production is in somewhat the same status.

As stated previously, our production of munitions in 1940 was sorely lacking, from a war-time viewpoint. In 1918, we were producing 192,000,000 tons of TNT per year, while in 1940 production was only 10,000,000 tons; early defense needs for this high explosive were estimated at 600,000,000 tons. In 1940, we had practically no commercial production of picric acid, as compared with the 1918 production of 140,000,000 tons. Smokeless powder production in 1918 amounted to 513,000,000 tons, as compared with our 1940 production of 30,000,000 tons and a total estimated requirement of 900,000,000 tons.

The comparative abundance of some war-time raw materials and lack of others may be explained primarily by the fact that many materials, essentially concerned with war-time usage in 1918, now have found their peacetime counterparts. Many others have not. Thus, we find ammonia used in hundreds of chemical processes for the manufacture of peacetime goods, while a peacetime place for picric acid has not been found.

Toluol is the basic raw material for TNT. Large amounts of TNT are used in airplane bombs which carry up to 60 percent of their weight in TNT. This is a lot of TNT in bombs weighing a ton or more each! Artillery projectiles carry 15 to 20 percent of their weight in TNT. Before World War I, our primary source of toluol was the by-product coke oven, with a capacity of about 100,000 gallons per month. This production was stepped up to 800,000 gallons by April 1917. An expenditure of $30,000,000 provided additional coke oven capacity in plants of eight large steel companies and new ovens at five other mills had been contracted for at the time of the Armistice. But toluol from coke ovens was not enough! In November 1917, construction was started on plants for stripping toluol from domestic heating and illuminating gas. The first plant of this type, a $7,500,000 project, went into production in April 1918 and, throughout the duration of the war, 13 large cities used gas with 6 percent less heating value.

Finally, a third source of toluol—petroleum—was tapped. Toluol was produced at a monthly rate of 400,000 gallons in several California refineries and all doubts of adequate toluol supplies were erased. This represents the mad scramble for toluol during World War I and it must be remembered that toluol is only *one* raw material used in munitions production. This scramble proved successful. Our Army's requirements were filled, 11,000,000 pounds were shipped to the Allies, and 17,000,000 pounds were left over at the time of the Armistice.

Today, our toluol problem is large, but vastly different from that of World War I. The solutions are more obvious and easier. The important questions, today, are those relating to minimum costs and maximum industrial convenience. Great strides in research and experience in the present conflict have placed the petroleum industry in an effective position to fill the gap in toluol production. The coke oven remains our primary source of this strategic raw material, however. Better equipment and methods now make it possible to obtain from 20 to 25 percent more toluol per ton of coal coked than was obtainable by the methods of 1917.

Our nitrogen needs are being bolstered by the construction of several new ammonia plants. Nitrogen is an important ingredient of nearly all explosives. It is estimated that ammonia production from privately-owned plants will reach over 1000 tons per day. One government-financed plant of 450 tons per day capacity is being constructed in West Virginia; several government-financed plants of 250 tons per day capacity each are scheduled for construction in Kentucky, Alabama, Louisiana, Missouri, Kansas, Arkansas, and Ohio. We must be concerned with one fact; from 18 months to two years are required to construct a synthetic ammonia plant, as compared with other munitions plants which can be built in eight or nine months.

Sulfuric acid is vital to munitions production and, today, is made principally from raw elementary sulfur, or brimstone. Today, our sulfur resources and facilities for producing sulfuric acid are among the brighter spots in the War program. This is due to the great quantities of sulfuric acid consumed by peacetime industries. Our sulfur problem during the early stages of World War I was a sorry one, however. Prior to that time, most of our sulfuric acid was prepared from Spanish pyrites, a sulfur ore. Prior to 1917, we were able to obtain all our requirements of pyrites, but soon after the initiation of unrestricted submarine warfare, shipments from Spain became increasingly difficult. We turned more and more to our domestic pyrites, but, in 1918, we found our sulfuric acid requirements for the next 12 months at approximately 8,000,000 tons, with sufficient raw material on hand for only 5,000,000 tons.

Perhaps the situation was fortunate —it resulted in the birth of a new American industry. In 1916, drilling near Martagorda, Texas, indicated the presence of large amounts of brimstone underground. Early in 1918, the government pushed exploitation of these resources without further delay. Since that time, there has been a marked development of our brimstone sulfur resources. Today, this greatly overshadows all other sources of raw material for sulfuric acid production. At present we have over 4,000,000 tons of brimstone on hand, representing over one and one-half times the highest annual consumption of American sulfur during any one period up to the present time.

Other strategic war materials in the realm of chemistry include petroleum, rubber, synthetic fabrics, plastics, activated carbon, drugs, pharmaceuticals, and the like. It is interesting to note that we now have from two to three years supplies of such important drugs as quinine, iodine, and opium on hand.

Just as the American chemical industry is better prepared now than in 1914-18, so is the American chemical profession. During World War I, plants established by the government, such as the chlorine and phosgene plants in Maryland, the Lewisite plant in Ohio, and the cyanide plant in Virginia, availed themselves of nearly every chemist who could be found. Today, most of this type of material is being produced by government-financed or subsidized plants and operated by private corporations. In contrast with World War I days, we have the world's most highly developed and efficiently operated chemical industry, an industry which literally produces dozens of new products daily. Our chemical industry is no longer an infant, but holds a high position in America's list of great industries. We have thousands of chemists and chemical engineers educated and experienced in this highly specialized work.

Research, especially chemical research, always will be our first line of defense and offense. We must remember that despite the vast magnitude of the present emergency program, it is of a comparatively rapid, short-range nature. As Sidney D. Kirkpatrick, President of the American Institute of Chemical Engineers, states: "We should not entirely overlook the fact that some time in the indefinite future we are coming to D-Day. Industry is going to have to be De-mobilized (or perhaps Re-mobilized) for Peace." With this thought in mind, company executives and research directors of far reaching vision and imagination are beginning to plan their remedies for reducing the great post-emergency headache to the smallest possible pain.

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TO REPLACE COPPER

Thermoplastic Tubing is Chemically Resistant

A FLEXIBLE, semi-transparent tubing of thermoplastic Saran is now available to the chemical industry as an alternative for copper and other metal tubings, according to The Dow Chemical Company.

Developed through years of research, this tough, chemically resistant tubing may be used in many applications previously demanding copper except where high temperatures and very high pressures are encountered. Also, Saran tubing has been tested and proved suitable to replace such strategic materials as nickel, stainless steel, copper, and ceramics in several fields where its properties are advantageous.

Saran is characterized by toughness and resistance to moisture, brines, solvents, acids, and alkalies. Another feature of this plastic material is that it may be used for short periods of time at temperatures of 250 to 275 degrees, Fahrenheit, although its strength and resistance are somewhat reduced at these elevated temperatures.

Available in sizes one-eighth inch to five-sixteenths inch outside diameter with wall thicknesses varying from .030 inches to .062 inches, this tubing may be joined by Parker standard tube couplings and S.A.E. or other flare type fittings. Already the Mueller Brass Company is developing fittings for Saran tubing which permit the construction of a tubing system in which contact between such fittings and the material conveyed is entirely eliminated.

EYES OF DEFENSE

Instruments Made on Production Basis

MECHANIZATION, the basis of modern warfare as contrasted even to World War I, depends for its every movement, as well as for many actual combat actions, on information supplied by instruments. Anti-aircraft guns get their range by instruments. On an airplane cowl is a bewildering array of dials. Even the tank must have its two-way radio or its range finders. Almost any implement of warfare, beyond the rifle, has its operator watching the movement of a slender dial needle.

The production of the millions of instruments needed for defense has imposed on the instrument maker the greatest burden he has ever known. How well he does his job will affect the outcome of the world struggle. A look at the results to date are reassuring. For example, Uncle Sam urgently needed 5000 D.C. switchboard ammeters in a variety of ranges as part of a mine-sweeper modernization program. Although this represents a normal year's production of this type instrument for Westinghouse, the 5000 were built and delivered to a half dozen navy yards in 28 calendar days. This is one concrete refutation of the often-heard charges of lagging production. Unseen behind this achievement lies progressive engineering that has created the relatively few but interchangeable parts needed, and coordination of products and methods that has nullified the disturbing effect of a wide variety of sizes and types. It is, in short, a tribute to the production-line, interchangeable-part idea that, fortunately for our defense program, has been so successfully incorporated into instrument manufacture just in time for the present emergency. It shows one thing more—the remarkable elasticity of the production-line system —the weapon with which the democracies will outfight totalitarianism.

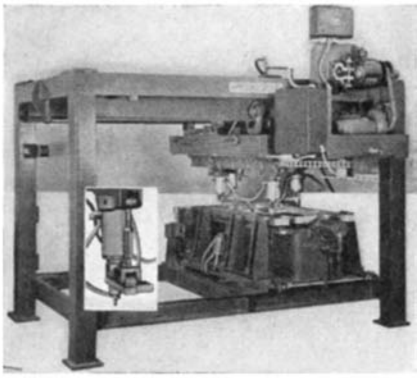
In addition to the thousands of standard instruments, there are many new types that have called for the utmost in engineering ingenuity, but which for military expedience must now be secret. In this group are those for aircraft blind landings, for protection of vessels against magnetic mines, and scores of new aircraft radio instruments.

WALKING WELDERS

Make 80 Spot Welds in 12 Seconds

KNEE-ACTION walking welding guns are the latest innovation in the resistance welding field. Developed by Progressive Welder Company, they permit performing of multiple welds in sequence in an automatic machine, where it is preferable to hold the work stationary in large fixtures. The manner in which this is done is illustrated in a machine developed for welding the back panel into a refrigerator shell.

The machine is designed to handle two sizes of such shells, and welds one assembly while another is being loaded and unloaded. Shell and back panel are dropped over the locating fixture, which incorporates the lower electrode. Clamping is by air pressure. (One fixture has been removed, in the photograph, to show the clamping mechanism at the side of the fixture.) When a button is pressed, the entire operating head of the machine moves to a position above the loaded fixture. Pushing another button starts the automatic welding operation. The four gun points come down and make four welds. At the same time the chain has started to move. The motion of this chain is continuous, carrying the heads of the welding guns along. Weld time is controlled by an electronic timer. When the weld is completed, the pressure is off the gun points, and these points swing—under spring pressure—to a new position farther along (depending on the amount the chain has moved). Another weld is made automatically, and the guns take another step.



Push-button operated

To complete one assembly, each gun takes 19 steps and makes 20 welds, 1½ inches apart. While the shell is being welded, the other fixture is being unloaded and re-loaded. The machine operating head now moves above over the second fixture and repeats the cycle, except that the movement of the guns is now in the opposite direction, the chain reversing its travel at the end of each complete cycle of welds. Off-time, between welds, to permit the guns to move on to the next spot before welding current comes on, is controlled automatically by a notched timing disk.

Time for the complete welding cycle is approximately 12 seconds, during which time 80 spot welds are made.

SCRAP NICKEL

Recovery Possibilities Up To 1,000,000 Pounds a Month

FROM 20 to 40 percent of the total tonnage of alloy steels delivered by mills to manufacturers are lost in machining and other processes of fabrication. Sometimes net losses may run to 70 percent, and—in complicated operations—up to 80 percent. Nickel content in the case of automotive and similar type low-alloy steels runs from slightly over 1 percent to over 5 percent. In stainless steels the figure often may rise above 10 percent.

The alloying elements in these materials are largely reclaimable, but in the past most of them have been lost—though the stainless steels, to an extent, have been an exception. They have been lost by a general practice of mixing the alloy-steel scrap with carbon-steel scrap and disposing of it as carbon steel. The extent of this practice is indicated by the fact that in the past year the residual nickel content in miscellaneous scrap as revealed by periodic examinations was approximately 0.05 percent.

This residual nickel enters carbon steel through alloy steel mixed with ordinary carbon-steel scrap charged into the furnaces with pig iron. An average of 50 percent scrap is used in the usual furnace charge. In other words, this nickel enters by mistake or failure to segregate alloy from carbon-steel scrap. It is too low in content to add appreciably to the qualities of the steel. It remains buried but under proper conditions could have been saved.

During the past year approximately 70,000,000 tons of steel were produced. At the average figure of 0.05 percent residual nickel this tonnage would account for 70,000,000 pounds of nickel. This nickel might well have been salvaged had scrap segregation been systematically carried out over the years in which, through cumulative effect, this quantity of residual nickel was being built up.

Steel production is mounting rapidly. During the first eight months of 1941, for instance, more scrap was used than in any other year of the steel industry's history. Hence the concern of both government and industrial leaders for an intensified nation-wide salvage campaign.

As indicated, segregation is the springboard for recovery of essential alloying elements. It means far more, of course, than segregation of alloy-steel scrap from carbon-steel scrap. No general specifications for such segregation according to percentage of nickel content have yet been completely outlined, though numerous divisions along these lines not only have suggested themselves, but also are being carried out in a number of cases.

While all scrap containing nickel is valuable and should be segregated so that the nickel content can be salvaged, it should be obvious that scrap containing 2½ per cent nickel or higher is far more valuable to the producing mills than scrap which, through dilution, runs 1½ per cent nickel or under. On the basis of present nickel-steel consumption it is estimated that up to 1,000,000 pounds of nickel a month may be saved for producers and users of these nickel-steels by careful scrap segregation.—*Inco.*

INDUSTRIAL TRENDS

DOWN TO THE SEA FOR METAL

If ever a search were conducted for the most versatile metal in commercial production, magnesium would probably finish at the head of the list. One third lighter than aluminum, it can readily be used in alloys of light weight and outstanding strength. Such alloys, usually involving aluminum, zinc, and manganese, are easy to machine. An example of the resulting light weight of these alloys is found in magnesium alloy wheels for large bombers, which, substituted for aluminum wheels, show a weight saving of some 100 pounds.

But weight and strength alone would not be sufficient to place magnesium at the top in versatility. It has other qualities that are of particular interest in wartime, yet are not unusable in times of peace. Thus, the metal can be ignited to burn at the intense heat of 1300 degrees, Centigrade, giving off at the same time a brilliant light. If water is poured on the burning metal a violent explosion takes place. Direct a stream from a carbon tetrachloride fire extinguisher on such a fire and the deadly gas phosgene is evolved. Ignite a quantity of the metal in powdered form and an explosion will occur. These oxygen-hungry properties of magnesium make it ideal for use in incendiary bombs, tracer bullets, flares, and other wartime applications.

It is not to be wondered at, then, that production of magnesium is being stepped up many times in an endeavor to make full use of its qualities for the diversity of purposes of war into which it fits. Yet, strangely enough, there was no commercial production of this metal in the United States until 1915, when supplies from Germany were cut off by World War I. During that year only about 87,000 pounds were produced in the United States; scheduled production for 1942 is several hundred thousand pounds.

Like aluminum, magnesium does not occur as a free metal in nature. There are large quantities of magnesium-bearing ores in existence in some of the western states, but the principal source of the metal is brine from the ocean or from salt wells in the middle west. From these brines is extracted magnesium chloride which, in turn, is subjected to an electrolysis process to obtain the pure metal. Another method involves the reduction of magnesium oxide through the use of carbon and electricity, hydrogen being used in one of the steps to obtain the free metal. Still a third process has been developed, known as the ferro-silicon process, which, it is claimed, uses less electricity than other methods, and is less expensive in other phases.

Be that as it may, the one company in the United States that has pioneered in magnesium production, and which undoubtedly can most definitely be depended upon to indicate the present and future trends in the industry, is the Dow Chemical Company. With extraction plants at various ocean fronts and with brine wells in the middle west, this company is not only a metal producer but a fabricator as well. In such a position, and with huge expansion plans for war purposes well underway, this company, together with ten others now in the field, may seem to be in the position of war babies that will some day find themselves so overexpanded as to face possible industrial disaster.

Such disaster might indeed be a possibility if it were not for two important factors. First, potential uses of magnesium in industry are just beginning to be explored. Second, Dow's operations in the extraction of magnesium from brine are only a part of a chemical business using the same basic material. From the same source are being obtained such varied finished products as bromine, iodine, alkalies, chlorine, and so on—all chemicals with huge present and potential demands.

But to stick to magnesium for a moment: Increased production and improved methods have already resulted in decreased costs which may be expected to decrease still further as production is stepped up. This factor alone has made it possible to invade many fields hitherto closed to the metal. Aviation is, of course, the most obvious and the one that is receiving the greatest attention at the moment. It naturally follows, then, that the lessons being learned in building military aircraft are going to be applied to the aircraft industry of peacetime, and that magnesium alloys are going to loom large in plans of the industry after the war. Then there are the fields of the automobile, the railroads, the electrical industry, all of which will welcome the advantages to be had from magnesium alloys made available through low cost of the pure metal. Household appliances such as washing machines, vacuum cleaners, fans, and so on, when once more put into production, will find wide use for the light, strong, inexpensive alloys.

With these facts alone in mind, the trend of the magnesium industry is a healthy one for the war of the present and the peace of the future. Couple it with the extraction of other raw materials from brine, mentioned above, and salt water, in the hands of the chemist, promises to loom large in the industrial picture.

GLUE RELEASES STEEL

That this is an age of metals, and that this war is a war of metals, is one of those obvious truisms that upon investigation discloses other factors which render the truism only partly correct. While the demands of armaments have thrust metals to the fore, these same demands have created vastly increased uses for man's oldest constructional material—wood. And these increased uses are not only in civilian fields where wood is employed as an alternate for steel, but for military purposes as well, where strength is needed but where the other qualities of metals are unnecessary.

One of the factors that have contributed largely to satisfactory applications of wood in a diversity of uses has been the development of glues which are strong, weather resistant, easily applied, and not attacked by the fungus growths that can render some glues unsatisfactory for use over extended periods of time.

Indicative of the trend in the glue industry is the fact that many government projects are using laminated arches made up of layers of wood securely bonded with glue. These arches are going into the construction of airplane hangars, armories, ship-building sheds, and factories. In addition, thousands of government workers as well as service men are being housed in dwellings of glued construction. In California alone, it is reported, there are some 5000 living units of this type.

Aside from the savings that can be realized in structural steel through such wood and glue construction, there is the saving in nails which, at first glance, might seem unimportant. But, it is estimated, 100 pounds of nails are saved in every FWA home now being put together with glue. Multiply this by many thousand units and the sum total certainly indicates a trend in future building construction.

—The Editors

OUR *Point* OF VIEW

THE LONE INVENTOR

Edison, Howe, Whitney, and a host of others are names that conjure up visions of the lone inventor. Working long, weary hours, often under circumstances of dire need, even hunger, these men struggled on, reached the pinnacle of success through sheer inventive genius. That they often worked alone may have been a fortunate circumstance rather than a serious handicap. Coming before the era of inventors backed by the almost unlimited resources of the modern industrial research laboratories, these men have become symbolic of a period in the development of our country which often but erroneously is thought to be gone forever.

True enough, inventing has today been brought to such a point of perfection by industry that casual consideration of the subject might easily lead to the conclusion that the day of the lone inventor is past. How far from actuality would be such a conclusion may be found by skimming the weekly list of United States patents issued, as published in the Official Gazette of the United States Patent Office. Here will be found recorded official recognition of hundreds upon hundreds of the brain children of individual inventors who have labored as faithfully, suffered as keenly, struggled as heroically as any of the honored inventors of the past three generations whose names are now part of our nation's industrial and scientific history. And—what is even more important to many—these brain children frequently form the foundation of fortunes for the men who gave them birth.

No, indeed, the day of the lone inventor has not vanished. Today the opportunity for individual effort is as great as, if not greater than, ever before. Thousands of keen minds, rendered even keener by the pressure of industrial production necessitated by the exigencies of war, are at work throughout the country on new, often strange jobs, turning out the materiel demanded by our armed forces. As these minds are applied to the problems at hand, they are absorbing new knowledge, finding new ways of doing things better, faster, more easily. And, relaxing during hours off the job, these minds often and naturally dwell on the work of the day and of days to come.

What is more to be expected, then, than to find the possessors of these minds turning to home workshops and laboratories to try out new ideas, to experiment with some new twist that flashed out of a seeming nowhere into a receptive medium?

Those whose intellectual curiosity or mechanical talent constantly urges them onward into fields of exploration have a bright and fruitful future ahead. They must not let the war ruin their perspective but, rather, should take every advantage of the opportunities being offered by the demands of the moment. There is great need of inventions for furthering our war efforts to a successful conclusion; there is likewise great need for inventions in civilian lines, particularly for use after the war.

If, then, the individual inventor, as he develops his ideas, finds that some of them have no apparent applications today, he should not too quickly abandon them. Careful scrutiny may indicate future possibilities. Such inventions should be just as thoroughly protected as if they were going into production tomorrow; lack of foresight in this respect may lead to bitter disappointment and financial loss in the future. The effort and investment needed to obtain such protection is relatively small when compared with the losses that may be sustained when the need for the invention is discovered and it is found that protection is lacking.—*A. P. P.*

FOR BETTER SHOOTING

In the April and May issues of *Field & Stream,* Arms and Ammunition Editor Bob Nichols describes a new type of gun-mount, adaptable to .50-caliber machine guns and 37-mm anti-tank guns. The compelling feature of this mount is its maneuverability which, while revolutionary compared to existing military usage for this class of fire power, is an old story to the American bird hunter. Like the shotgun at the hunter's shoulder, the machine gun or anti-tank gun, through application of this mount, may be rotarily swung through 360 degrees. Coincidentally with the rotary movement it can be elevated or depressed 90 degrees. In a quoted letter appearing in one of the *Field & Stream* articles, the gun-mount inventor states the Army and Navy are "trying to hit dive-bombers and low-strafing planes with slow, fixed gun-mounts—too heavy and too slow to swing on the target . . . using three men to aim, sight, and fire one gun—an attempted co-ordination that is impossible to achieve in the split-second time allowed on fast-moving, twisting, and diving targets." Although presentation of the mount was made last January before all branches of the service and, writes the inventor: "all tests were completed successfully—and the test operator ended up by shooting a buzzard out of the air at least 500 yards out," there has, at this writing, been no official adoption of the mount. While we are not in a position to substantiate the inventor's claims for the physical perfection of his mount, we heartily subscribe to the theory of maneuverability involved—as old, as tried, and as true as the technique of shooting game birds on the wing, or jackrabbits on the hop. In either offensive or defensive warfare the adoption of the theory of properly leading a speeding target—a theory proved sound by generations of American hunters—would, we believe, make it possible to knock more enemy planes and tanks out of action.—*A. D. R., IV.*

NAVAL ARTICLES

In our issue for May we presented an analytical article on the battleships of the United States Navy, the article to be the first of a series. The present number does not carry the second article because of the war-time censorship to which Scientific American has voluntarily submitted. The manuscript of the second article was submitted to the Navy Department for approval, but such approval was not granted. As soon as we can obtain clearance, in a form satisfactory to the Navy Department and to the Office of Censorship, these articles will be published.—*O. D. M.*

Harnessing the Sun

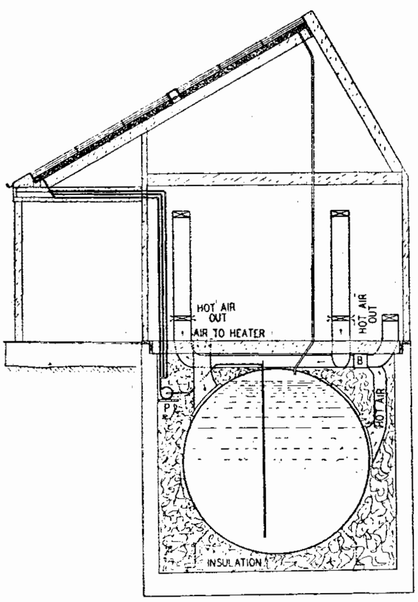
Research on the Practical Problem of Power and Heat from the Sun: A Progress Report from M. I. T.

JOHN A. SIBLEY

As man's society becomes more and more complex, his energy requirements increase at an immense rate. The cave man, whose only need was about 2000 calories of food a day, used the equivalent of about one half pound of good-grade bituminous coal per day, or about 200 pounds per year. Yet a modern man, living in the midst of thousands of mechanical devices which require energy both in their manufacture and use, consumes over ten tons of equivalent coal a year, or over a hundred times the energy actually needed by the body. This rate is constantly increasing; the last 60 years, during which America has changed from a young agricultural nation to the most highly industrialized nation in the world, have seen this country's fuel requirements increase six-fold. As technological advances are being made every day, there is little doubt that an even greater supply of energy will be needed in the future.

The sources of energy have likewise changed. During this same 60-year period, wood has declined in importance from 60 percent of the total to only 6 percent. Coal rose to a peak of about 80 percent in 1918 and then decreased due to the development of the oil industry. At the present time anthracite and bituminous coal supply about 45 percent of the total; petroleum and natural gas supply about 36 percent; water power supplies about 10 percent; and the small remainder is furnished by wood, food, and wind. With the exception of wind and water, the supplies of these materials are being rapidly depleted, and, although the problem at present is far from urgent, they may eventually be entirely used up.

For many years scientists have realized the need of developing a new source of fuel and have been considering the possibility of employing the vast amount of energy which is constantly being received from the sun. The earth and its atmosphere intercept the equivalent of 21 billion tons of good coal per hour, which means that in three minutes enough energy is received to equal America's consumption for one year. In the past, many devices have been built in an attempt to tap this immense flow of power, yet the results of these early experiments have been unrelated and undecisive. These inventions worked with varying degrees of success, but, until two years ago, when Dr. Godfrey Cabot's gifts to Harvard and the Massachusetts Institute of Technology made possible the establishment of research programs at the two schools, no scientific inquiry into the basic problems of solar energy conservation had been made. The Harvard group is primarily concerned with an investigation of the chemistry of photosynthesis, while a committee of the Institute is studying the physical problems of energy collection and utilization.



Sectional view of solar energy building described in the text

Before proceeding further with a discussion of solar power perhaps it would be well to destroy the optimistic picture which is given by the above figures of the amount of solar energy available. They are based on the amount received per acre of surface at a point outside the earth's atmosphere and normal to the sun's rays, which energy at noon reaches a total of about 7500 horsepower. Of this power only about 5000 horsepower reaches the surface of the earth. If this energy is used to operate a heat engine, allowance must be made for the efficiency of collection as heat in a fluid, and the energy rate drops to 3300 horsepower. Taking the highest attained value for the efficiency of converting such heat to useful power, the horsepower becomes only 490.

Thus far the calculations have been based upon sunlight normal to the surface of the collector. If the collecting system is mounted to follow the sun, in order to fulfill this condition, the different units of the system must be separated so that they do not shade each other during part of the day. Allowing a ground coverage factor of one third, the horsepower is cut to 163. Converting this figure to power over a 24-hour period in summer in Arizona, the output becomes 83, or in winter 68, horsepower. Finally, considering the average number of clear days in New York the actual horsepower per acre is 50, only one 150th of the initial figure.

One may evaluate this answer in terms of dollars and cents and hence roughly determine the economic feasibility of employing solar power. Assuming that electrical power can be produced in a large modern plant at .6 cents per kilowatt hour, or $53 per kilowatt year, the output of a one-acre plant is worth $1900 a year. Figures on labor costs and maintenance are lacking, but optimistically assuming a high capitalization of 15 percent, there is $13,000 to spend on the entire plant, or $2.60 per square yard. As ground coverage was only one third, $8.00 is available to construct each square yard of reflectors, mountings, and accessories. This value is quite low and shows how slim the margin of profit is at present on a solar energy plant. It is evident that the degree to which solar power is to be utilized in the future depends upon the increase of these efficiencies, and it is toward this end that the research is being devoted.

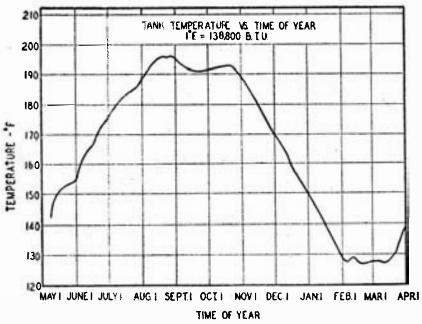
The first project in the solar research program at Massachusetts Institute of Technology is the study of different types of collectors and the development of one with the highest possible efficiency. The type of collector which has been perfected to the greatest degree is the simple, flat-plate type. It consists of a sheet of metal, or a body of some other material such as water, sulfur dioxide, or even sand which is heated by the sunlight. The bottom side of the plate is insulated and the top side is covered by a sheet of glass parallel to it with about an inch of air space between. When thus covered,

Courtesy *The Tech Engineering News*

the plate receives practically as much sunlight as before, the glass transmitting about 90 percent, but the losses from the plate to the atmosphere are greatly reduced, the convection losses being eliminated due to forced stagnation of the air, and the radiation losses being eliminated because the glass, although transparent to the sun's rays, is opaque to the long-wave infra-red radiation emitted by the hot plate. Variations in this design include the provision of vacuum spaces instead of dead air spaces, and employing several glass plates instead of one.

As each additional layer of glass cuts down the losses, one would suspect that with sufficient layers a perfect collector could be built, yet this is not the case. It is true that if the right glass is chosen there will be little absorption of the sunlight, but there is a reflection loss of about 4 percent at each surface. Consequently, as one adds more plates, one ultimately reaches a point where the reduction in heat loss from the metal plate is more than offset by the reduction in intensity of incident radiation due to reflection losses. This optimum number of plates varies, being less the greater the heat from sun and more the colder the weather or the hotter the collecting plate.

It was in order to decrease these losses through reflection that the process of coating glass was developed by



Yearly chart of tank temperature

Dr. Turner and Dr. Cartwright whereby the glass has a permanent surface of reflectivity approaching zero at one point of the spectrum. This important discovery has already proved valuable in many other fields, ranging from spectacle lenses to bomb sights. As yet the special glass has not been used in an experimental solar energy collector, but calculations indicate that its use should make possible the attainment of 800 degrees, Fahrenheit, without the use of mirrors, lenses, or other concentrating devices.

A second problem in designing flat-plate collectors is that of optimum tilt. Because of the simplicity of the design, it is more economical to have the collectors mounted at a permanent tilt than to have them follow the sun. The angle of tilt depends very definitely on the use to which the collected heat is to be put. If the purpose is the maximum collection of heat during the entire year, tilting should favor the summer months. If, however, the object is to supply heat for a load which varies during the year, the tilt should favor the part of the year during which the load is the greatest.

Sun laboratory where the plan to heat a building by solar energy is tested

Of the many uses to which such collectors may be put, perhaps the simplest is the heating of a house in a relatively cold but sunny climate. The system would consist of a well insulated tank from which water can be pumped to the collector and back whenever the collector is hotter than the tank, and a set of radiators through which the hot water could be circulated to heat the building. It was for research into this type of heating that a testing cottage was built on the Massachusetts Institute of Technology grounds. For many months the plan has been put to a practical test, and valuable data are being obtained on the optimum number of glass plates, the best tilt, the ratio of roof to tank area, and the advisability of employing special types of glass.

Another obvious use is the employment of the sun's heat to run a steam engine, a hot-air engine, or similar device which requires a heat reservoir. The cost of power production in a conventional plant depends enormously upon the size of the plant, and, therefore, although the efficiency of solar power plants is small compared to large conventional plants, it nearly equals the efficiency of very small plants. It is not unreasonable to hope that future large solar energy converters will make power as cheaply as a fuel-fed plant.

In order to obtain efficiency in small solar plants, another type of heat engine is being developed—the thermopile. When two dissimilar, conducting materials are joined to form a loop and the junctions kept at different temperatures, heat flows into the loop at the hot junction, a portion of its energy is converted into electrical energy, and the rest flows out as heat at the cold junction. This principal of thermoelectricity has long been known, and the possibility of electrical power production on a large scale by this method has often been considered and always dismissed because the effect is very small. As the result of recent research, the overall efficiency of the best thermopile is about 4 percent, but it is possible that intensive research will increase this value several fold. As the efficiency of the best steam power plants is only 25 percent, a small converter with an efficiency of 5 percent would be of great value. It is toward the development of more effective thermopiles that the second branch of the research program is directed.

In order to form an effective couple, the two metals must have, in addition to high thermo-electric power, a low thermal conductivity in order to minimize the loss of heat flowing from the hot to the cold junction, and a high electrical conductivity so that there will be low resistance losses. The ratio of thermal to electrical conductivity is known as the Weidemann-Franz ratio, and it is desirous to have this value as low as possible. Experiments have shown that alloys of zinc and antimony have a surprisingly low Weidemann-Franz ratio while retaining a high thermo-electric power. By using an alloy of 43 percent zinc in antimony against a Copel alloy with a temperature difference of 400°, Centigrade, a moderately effective engine is formed.

Thus far, only the so-called heat engines have been discussed. Both steam engines and thermocouples are devices which receive energy at a certain temperature, convert part of this energy to useful power, and throw away the rest to a so-called heat sink at a lower temperature, and, therefore, their efficiency is limited by the Second Law of Thermodynamics. It is this law which states that the efficiency of a heat engine cannot be greater than the difference of the initial and final temperatures divided by the initial temperature; that was the reason for the sudden reduction of the value of solar power from 3300 to only 490 horsepower. As high efficiencies are thus impossible if only the heat from the sun's rays is employed, scientists have been examining other properties of this radiation in the hope of finding other more profitable methods of power conversion.

It has been found that the light quanta are able to knock electrons out of atoms or atomic lattices in crystals and produce an electric current, a phenomenon known as photo-electricity. This property of light is employed in camera exposure meters in which the current generated moves a galvanometer needle, and thus measures intensity of illumination, and it is the project of the third branch of solar research at Massachusetts Institute of Technology to see whether this same method is applicable to large scale current generation.

The light-sensitive unit of such a device is known as a blocking layer photo cell, of which the copper oxide cell is typical. It consists of a massive plate of copper which has been oxidized on one side and then etched, thus producing a layer grading from cuprous oxide through all proportions of oxygen down to pure copper. The cuprous oxide surface is coated with a very thin layer of some other metal, so thin that it is transparent to light quanta. A light quantum, on hitting the cell, passes through the metal cover and the cuprous oxide into the layer of composition varying between copper and cuprous oxide, the so-called blocking layer. Here it succeeds in breaking an electron away from the crystal lattice, and this electron finds it easier to migrate toward the copper than through the copper oxide to the metal film. This unidirectional motion of the electrons constitutes an electric current.

How important is this phenomenon in generating power from sunlight? Quantitative experiments have shown that of the visible light quanta falling on a cell only 5 percent succeed in freeing an electron, and that the voltage efficiency is about 10 percent. The overall efficiency is, therefore, only .5 percent, but, as in the thermocouple, it is possible that this efficiency may be increased as much as tenfold. Such an accomplishment will not be easy, however, for physicists actually know very little about what goes on in the blocking layer of a photo cell. In order to supply these data, a research project is being initiated in the Electrical Engineering Department in connection with a broad program of study of insulators and semi-conductors, from the viewpoint of atomic physics.

The last of the Massachusetts Institute of Technology solar energy projects, like the one just discussed, depends upon the special properties of sunlight rather than on its overall energy content. Everyone is familiar with the basic action in plant leaves whereby carbon dioxide and water are converted into carbohydrates and oxygen by means of sunlight in the presence of the catalyst chlorophyll. If man were able to copy nature and utilize light to produce substances of high energy content, a vast supply of power would become available. This does not mean that research should necessarily be directed toward reproducing photosynthesis in the test tube, but rather it should search for the necessary catalysts and conditions which would allow one to carry out some simple energy-storing reaction like the decomposition of water. A major problem would be to devise a reaction with suitable intermediate steps, in order that the small energy quanta of which light is composed could be employed one step at a time, just as nature undoubtedly does in the leaf of green plants.

Research at Massachusetts Institute of Technology, however, is approaching this problem somewhat differently. Rather than attempt to produce a stable product of great energy content, such as fuel or explosive, one may attempt to capture the energy of the intermediate products and convert it into electricity. It is necessary to find a photo-chemical reaction in which the passage from an unstable to stable state can be made to proceed as the electrode reaction in a cell. Such an oxidation-reduction reaction which is now being carefully studied consists of an organic dye, thionine, and ferrous iron in the form of a ferrous sulfate solution. The reaction can be represented in the following reversible equation.

$$\text{dye} + Fe^{++} = \text{leukodye (colorless)} + Fe^{+++}$$

Ferric iron is a much stronger oxidizing agent than thionine; therefore, in the dark, all the thionine is in the form of the dye, and the iron in the reduced state. If the mixture is exposed to light in the range absorbed by thionine—visible light from 5000 to 7000 angstroms—the thionine molecules become capable of oxidizing ferrous iron. As the leuko compound is colorless, the reaction can be followed by watching the decolorization of the solution. This is the most light-sensitive reaction which has yet been discovered. As the composition of the solution changes by illumination, its electrode potential also changes. If two platinum electrodes are placed in the solution and one is illuminated and the other kept dark, a potential difference is established and a current flows from the dark to the illuminated electrode.

There are two qualities of such a cell which must be determined if its industrial importance is to be ascertained: first the electromotive force produced by a given light intensity, and second the current which may be drawn from the cell. The variations in potential with intensity of light, with different concentrations of thionine and iron, and with solutions of different *pH* have been studied and optimum values determined. In order to produce power efficiently, the cell must be able to give a strong, steady current, but whether or not such efficiency can be hoped for it is too early to say.

Thus research on converting the sun's rays to useful power has only begun. Latest advances indicate that the likely fuel supply of the future is sun.

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FUNNELS

Stainless Steel Saves Over Four Tons Per Stack

Destroyers—often referred to as the "greyhounds" of the battle fleet—are required to operate on a comparatively low displacement, so that they can readily attain the high speeds essential to their effective use. Every ton of material that goes into the structure of a vessel of this class of warship, consequently, is given careful consideration.

Just recently, for example, it was announced that the United States Navy's newest destroyers will carry stainless-steel funnels. These funnels are said to be 4½ tons lighter than the type used on destroyers built in previous years. This means that additional armor, guns, and torpedoes can be carried.

Even though the sections of metal used in these funnels are relatively thin, the resulting structures are remarkably sturdy because of the high strength of the stainless steel, their welded construction, and the fact that adequate reinforcement is provided by corrugated stiffeners. The metal's resistance to the corrosive action of salt air and exhaust fumes, and its resistance to shock, should also provide added safely under stresses to which they will be subjected when placed in naval service.

REFRIGERATED

Containers for Express Shipments

A MARKED increase in variety of perishable commodities moving in its "refriger-ex" service has been noted recently by the Railway Express Agency; the system involves the use of refrigerated containers especially designed for less-than-carload-lot movement in express service.

The boxes, which are mounted on casters for easy handling, permit inside temperatures from below zero to levels above the freezing point and upwards. Dry ice is employed as refrigerant for extremely low temperatures and regular ice for those of more moderate ranges. Quick-frozen foods and some serums, vaccines, and medical supplies usually require below-zero facilities of the container.

The greatest traffic increases in the field, however, have been for products calling for water ice refrigeration. A number of containers, for example, are assigned to the movement of blood donations, in hermetically sealed bottles, from Red Cross stations in large cities to the processing plant in each area, for the production of dry plasma transfusion units.

In transit

The Church container is also being used on an expanding scale by large oyster shippers at Chesapeake Bay points, in getting the shucked product to dealers over a wider area. Fifty two-gallon cans can be placed in a container, making a shipment load of 418 pounds.

With portable display top

The containers have likewise been found advantageous for LCL express movement of ice cream, dressed poultry, frozen foods, fruits, vegetables and seafood, meat, hatching eggs, and a miscellany of other perishable products including serums, laboratory specimens, and unexposed motion picture film stock. When they arrive at their destination they may be equipped with a portable glass top, enabling consignees to use them as refrigerated display cases, paying only a nominal fee for retaining the boxes as long as needed.

TRUCKS

Urged to Replace Railway Mail Service

ESTABLISHMENT of additional highway post office routes as substitutes for abandoned railway service is recommended by Smith W. Purdum, second assistant postmaster general. Efficiency of such routes is evidenced by the fact that three highway mail routes, using specially built trucks, were established about a year ago by congressional authority to substitute for abandoned railway mail service between Washington, D. C., and Harrisonburg, Virginia; South Bend and Indianapolis, Indiana; and San Francisco and Pacific Grove, California.

LIGHTNING

Continuing Studies Trap Biggest Bolt

BOLTS of lightning hurtling down twin copper cables on a smelter stack 30 feet taller than the 555-foot Washington Monument, have been studied for science by engineer-detectives in Anaconda, Montana. One bolt was the most powerful direct stroke of lightning ever recorded. Its current totaled more than 160,000 amperes.

This investigation is part of a nation-wide effort to learn more about lightning, hence more about how to protect power lines and electrical apparatus from damage and resulting inconvenience or loss to power users.

Sponsor of the study is the Westinghouse Electric & Manufacturing Company, whose research engineers developed the "fulchronograph," a device which enables accurate measurement of the intensity and duration of lightning strokes. Co-operating in the work are engineers for the Anaconda Copper Mining Company and The Montana Power Company.

"Current in the most powerful bolt recorded probably totaled about 200,000 amperes," W. E. Lee, Westinghouse representative, said. "Unfortunately, range of the measuring device was only 160,000 amperes. Needless to say, capacity of the instrument was increased to 200,000 amperes immediately."

Although voltage of the stroke was not measured, it is estimated that approximately 15,000,000 volts would be required at the top of the stack, to cause the fulchronograph to register 160,000 amperes at the bottom. Momentary energy of the stroke probably totaled nearly two and one-half billion killowatts.

If such an immense amount of energy could be produced steadily at some gargantuan power plant, output of that plant would be approximately 57 times greater than the total installed capacity of all the nation's generating stations. Total installed generating capacity of U. S. power plants was 42,435,863 kilowatts as of June 1, 1941.

"Bait" in the lightning "trap" at Anaconda comprises 20 vertical one-inch copper rods, five feet long. Mounted in a copper ring 60 feet in diameter which encircles the top of the stack, these rods extend skyward like spikes on a coronet. Each spike is coated with lead to protect it from hot flue gases, and tipped with hard metal alloy to enable it to resist destruction as a bolt strikes. Two copper cables connect the ring atop the stack to the fulchronograph, which is installed in a small building at the base of the stack. Essentially, the fulchronograph comprises an electric motor and a slotted aluminum wheel, the rim of which is filled with small strips of magnet steel projecting like fins and rotating through two coils. The coils carry current from the lightning stroke being measured.

Current in the coils produces a magnetic field which is proportional to the surges of lightning current. The steel fin on the recording wheel which happens to be passing the coils at a given instant is magnetized in proportion to the amount of current carried by the stroke, in time divisions as brief as 40 millionths of a second. Characteristics of the stroke may be determined by the number of fins magnetized, and the degree of magnetization.

COIL TESTING

Quickly Done With New Machine

Coil testing machines, for quickly determining all of the electrical properties of a coil in one handling, are now available for checking the limits of insulation resistance, coil resistance,

Eleven tests, quickly

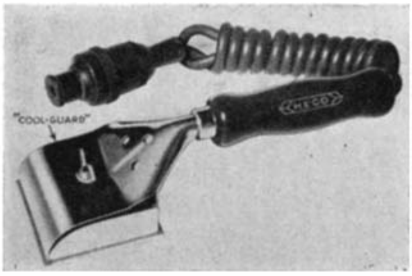
effective A.C. resistance, inductance, and shorted turns, as well as for checking effective turns, direction of windings, and other important properties. There are two types of machines: automatic and semi-automatic, each having holders adapted to the special shapes of coils to be tested.

One of our photographs shows a machine of the semi-automatic type, capable of making eleven tests in quick succession on each coil, and checking up to 250 coils per hour. In using this machine the operator attaches the coil to holder at center of panel, pushes terminal wires into spring clips, and turns the large knob one step at a time. The design is such that at each step the pointer of the illuminated galvanometer must cross the center of its dial by moving from left to right, or from right to left. The operator watches for this movement; if it occurs, he knows that the coil has passed that test. If the pointer does not cross the center of the dial for some one test, then the nature of the defect in that coil is shown by lettering on the knob.

PAINT STRIPPER

Heats and Scrapes With Same Unit

An electrically heated tool which heats painted surfaces and wet wallpaper surfaces, and then permits the operator to scrape the surface with the



Pull . . . push, to remove paint

same unit, can be operated on any conventional 110 volt A.C. or D.C. circuit. This new device, manufactured by the Heating Equipment Company and illustrated in one of our photographs, has a flat heating surface. When used for removing old paint or wallpaper which has been wetted, the heating surface is applied and drawn over the paint or paper. A prompt forward thrust of the scraping edge cleans the surface of paint or paper, stripping it off without burning.

The square scraping plate is regrindable or replaceable and has four interchangeable sharp edges. It is claimed that the heat from the unit keeps the scraper plate clean.

WAR GASOLINE

Sold to Public Contributes to Aviation Fuel

Automobile owners are contributing to the huge stock of high-test aviation gasoline with which the United States proposes to win the war. This contribution is being made in a new war-time motor gasoline, now being sold at most gasoline stations, according to Robert H. Colley, president of The Atlantic Refining Company.

"The new war-time gasoline starts just as easily on a cold morning, and in most automobiles will give just as good performance and yield just as much mileage. For that reason 95 percent of the automobile owners will not notice that there is a difference between it and the gasoline they used to buy at the service station on the corner," Mr. Colley explained.

"All gasoline blends are a complex mixture of petroleum compounds. Part are found naturally in crude oil. Others are products of the 'cracking' process. Some have a fairly high octane rating. But usually other substances have to be added to give the blend a sufficiently high anti-knock value. In most cases tetraethyl lead is the substance used. In others additional high-octane petroleum products are added.

"Both these added substances are needed by the government to assure adequate reserves of aviation gasoline to meet any possible emergency, and to obtain the amounts required, the precious tetraethyl lead supplies have been rationed and the high-octane petroleum products requisitioned.

"In order to produce a gallon of high-test aviation gasoline it is necessary to strip 16 gallons of motor gasoline of these high-octane components. To this is added a petroleum hydrocarbon of very high octane value, manufactured from one of the choice components stripped from motor gasoline. Then a final small dose of tetraethyl lead is used to bring the fuel up to the 100-octane mark.

"That explains the difference between the motor gasoline now being sold and that sold a few weeks ago. That difference represents the motorists' contribution to keep American planes flying and help win the war."

BOMBER-FIGHTER

New Dual-Purpose Plane Used by British

A new airplane with a dual personality—fighter as well as bomber—has enabled the British to develop a technique of bombing entirely new even among the novelties of modern aerial warfare. In a day when new planes are being equipped with superchargers to cruise in the heights of the substratosphere, this latest air weapon hugs the ground and even dips into hollows or ravines to hide from enemy fire.

While most bombers are heavy, lumbering craft requiring for protection convoys of fast fighters or the shelter of high altitudes and masking clouds or darkness, these new ships need no escort and make no attempt at high-altitude flying. With military experts pinning their faith on intricate bomb-sights, these pilots use no aiming devices at all, according to *Science Service.*

Machine-gun "strafing" from low altitudes is something European fighters have been familiar with since the days of World War I. Dive bombers are by now taken for granted. But this new sort of "horizontal bombing" from planes grazing the tops of the hedges, and whizzing by at 340-mile-an-hour speed, has provided the Germans with a complete surprise.

The British journal *Flight* reports it as fact that the Germans are building 30-foot anti-aircraft towers in order to be able to shoot down on these new bombers.

The new technique has produced its own problems in ballistics. When a bomb hits the ground from such a low height, it ricochets along the ground horizontally and hits the target from the side instead of from above. This is all right for a huge target. But one pilot who watched a companion attack a railway station reports that the bombs went clean through both walls of the station and exploded harmlessly some 300 yards away.

The airplane is in some danger from its own bombs at such low altitudes. In order to be reasonably safe from the explosion of a 250-pound bomb such as those carried by the new Hurricane, an airplane must be at a greater height than 1500 feet—2000 feet would be better. To get around this, delayed-action bombs that do not explode on impact are being used, and formations have abandoned their sentimental attachment for the V symbol in favor of flight abreast. If one plane flew behind the others, the last man would be blown up by the bombs dropped by the leader.

The regular procedure has been this. The planes cross the channel flying in formation at economical cruising speed. As soon as the coast of France is reached, they throw the throttles wide open and zip across country at full speed. some 500 feet per second. At this speed anti-aircraft fire finds them a very difficult target, and they have approached, passed, and gone before interceptor planes can leave the ground.

The two bombs carried by each plane are both dropped at one time, some distance from the target to allow for the tendency to ricochet along the ground in the direction of the plane's flight. Before their bombs explode, the bombers are already away—and no longer bombers. With their loads discharged, these dual-personality aircraft become fighters with all the speed and maneuverability for which the Hurricane is famous, capable of dealing with any interceptor planes.

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TRACTORS—Not more than 22 percent of all farms in the United States have tractors, but about 66 percent of all farms of more than 100 acres have them.

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PARTS CONTAINER

Plastic Unit Holds Parts Visibly in Compartments

ORIGINALLY designed for holding fishermen's flies and bugs, small transparent boxes have found an even wider application in industrial and other uses where they are employed for holding small parts. Made of plastic, they are

Small parts can't hide

available with a variety of compartment shapes so as to be applicable to various types of parts.

These transparent plastic boxes, made by the Shoe Form Company, make it easy to check stocks of parts without opening the box and, since the partitions also are transparent, there are no dark corners where small screws and parts can get lost.

FLUORESCENT LAMPS

Now Available in Small Sizes

TWO new sizes recently added to Hygrade Sylvania Corporation's fluorescent lamp line are the six-watt and eight-watt lamps. These small members of the fluorescent family are designed

Six watts, eight watts

for supplementary lighting purposes; for example, for instrument panels, in counter lighting, and over machinery. They are also suited for use in bed lamps, pin-up lamps, desk lamps, and for artistic direct or indirect illumination of mirrors, pictures, walls, and so on. The six-watt lamp is nine inches long and the eight-watt lamp is twelve inches long. Both are ⅝ of an inch in diameter. They are made in two colors —3500° white, and daylight—and have an average rated life of 750 hours.

CELLOPHANE BAGS

Find Uses in Varied Industries

THE famous Warner & Swasey lathes, now in great demand for armament work, come down the assembly line just a little smoother and faster because of Cellophane bags. All smaller parts are tagged with a part number in the stock room, then loaded into Dobeckmun Cellophane bags. This keeps them intact, yet fully visible to the operator, who does not have to open several containers before he locates the right one.

Since there are between 5000 and 9000 individual parts in a turret lathe, a good job of housekeeping and of control is needed to assure delivery to the assembly floor of all the parts when called for. The transparent bag system has been in effect nearly a year and, according to Warner & Swasey officials, is working out very satisfactorily.

Another use for similar bags, this time with printed panels on the bag faces, has been found by the Leece-Neville Company for the packaging of repair parts. Some fifty different automotive parts are packed in these bags. The white panel on the face of the bag is printed with a special ink which permits easy marking with pencil, crayon, or rubber stamp.

When a bag is packed, the count, part number, and customer's order number is written on the bag. This,

Transparent bags, easily labeled

plus the transparency of the Cellophane simplifies "checking in" the order when delivered to the customer. It also simplifies inventory and reordering as the contents of each bag can be checked without opening the bags or removing the parts.

STEELS

Developed in Peace, Used in War

MANY special steels originally produced by the steel industry for everyday, peace-time uses such as automobile bumpers, carpenters' hammers, and piano strings, are now being used in large tonnages in the manufacture of machine guns, tanks, armor-piercing bullets, other implements of defense.

Because the steel industry long ago learned how to make those steels well and in large quantities, it was able immediately to adapt its experience to the urgent needs of the national defense program.

Among the many commercial steels now serving for defense is an alloy steel containing about 1.5 percent nickel and somewhat less than 1 percent chromium. Developed originally as a steel for axle shafts of heavy-duty trucks, today it is used in the tread mechanisms of tanks where service conditions are even more rigorous than in trucks.

Another alloy steel with about 1 percent chromium and 0.1 percent vanadium, is found in almost every home workshop in the country in the form of a hammer or some other hand tool. It is also to be found today as the steel from which the cocking lever pin of a machine gun is made.

A plain carbon steel containing about 0.8 percent carbon, has long been used by automobile manufacturers for the manufacture of bumpers. A springy steel, it can stand a lot of punishment before crumpling up or breaking. Those same qualities are useful today in the locking mechanism of machine guns. Another important part of machine guns is the firing mechanism which is actuated by a steel spring made from exactly the same kind of wire that is used to make piano strings.

In adapting these and other steels from commercial to defense applications, steel metallurgists frequently prescribe changes in heat treatment and fabrication procedures. These changes are ordinarily made to produce physical properties different from those usually found in the steels.

Basically, however, a large number of the steels which today are building defense material are the same as those from which are made automobiles, pianos, bridges, washing machines, and the multitude of other peace-time products of American industry. — *Steel Facts.*

NITROGEN WELL

Discovered While Drilling for Water

PURE nitrogen gas flows from a recently drilled shallow well on a western ranch, Harold Cook, consulting geologist of Agate, Nebraska, reports in *Science*. This is believed to be the first nitrogen well ever struck. The well was being drilled for water, Mr. Cook says, when it began to yield gas at a considerable pressure at a depth of only 156 feet. A sample sent to the laboratory of the United States Geological Survey for analysis was found to be composed of 100 percent nitrogen.

Since an apparently large supply of pure nitrogen, all ready to use, may have value in the present war emergency, the new-found well has been shut down to conserve the gas until the best possible uses are developed.

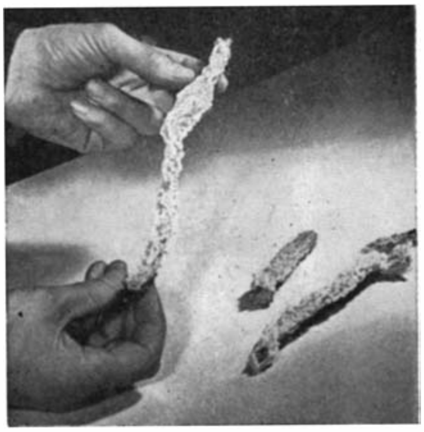
FULGURITES

Made Artificially, Using "Hot" Lightning

ENGINEERS at the Westinghouse high-voltage laboratory recently caught man-made lightning in a bucket of sand to produce replicas of the glass-like fulgurites formed by natural lightning strokes. "Since a temperature of about 3000 degrees is required to melt sand into fulgurites, these experiments give us definite knowledge of the tremendous heat which lightning can produce," Dr. P. L. Bellaschi, directing the experiments, reported.

"Fulgurites might be called petrified lightning," the investigator explained, "since they have the same crooked shape as the bolts that formed them. Natural specimens occasionally are found buried in the ground, particularly in dry desert sands. They are glass-like tubes of solidified sand, formed when lightning surges through dry earth in search of moist ground to neutralize its charge."

Because of the scarcity of natural fulgurites, the Westinghouse lightning engineers have shipped their first col-



Man imitates nature

lection of artificial specimens to the Chicago Museum of Science and Industry and are now preparing a second collection for the Franklin Institute in Philadelphia.

"Natural fulgurites are discovered rarely, because conditions must be just right for their formation," continued Dr. Bellaschi. "The sand must be of the proper composition to melt into the glass-like formation. And it must be struck with 'hot' lightning—a type that lasts longer than average strokes. Only a small percentage of the strokes is of this hot variety. Also, since fulgurites are concealed in the ground, they are discovered only by accident."

In the manufacture of artificial fulgurites Dr. Bellaschi used pure quartz sand, plus a small amount of feldspar sand to make the quartz melt more easily. The sand was packed firmly into a container about two feet tall and the end of an electric conductor from the "lightning maker" was stuck into the sand.

Then the generator was set to deliver a hot lightning discharge of 1000 amperes. In a hundredth of a second the artificial stroke bored its own path through the sand and heated the walls of this hole white hot, forming the fulgurite.

"A hundredth of a second is a long time for a lightning stroke to last," the investigator commented. "Some of nature's bolts, as well as those produced in our laboratory, last only a few millionths of a second. Such short strokes are known as 'cold' lightning, since they do not last long enough to create great heat in the substances through which they pass. However, they do ex-

How A Big Business Man Appears To His Wife

"LOOK at him over there, grinning to himself! Strange how little a man can change in fifteen years! The big boss one minute—and like a little boy the next!

"He was mostly 'little boy' before we were married. He'd been coming around for a couple of years, and I'd just about given him up. Then, suddenly, he was very much a *man*, rushed me off my feet and almost before I knew it, we were married.

"When we were newlyweds he was only a bookkeeper, and he'd come home in the evening all tired and discouraged. Other fellows at the office had been promoted, and he didn't know what to do about it. One night I forgot myself and said, 'If *you* don't do anything about it, Mr. Stick-in-the-Mud, no one else ever will!' Then I was sorry, when I saw how I'd hurt him.

"But it must have made him think hard, because one evening the following week he came home looking as though he'd just robbed the piggy bank. He told me he'd enrolled for a course of executive training. He thought I'd be angry, because we were still paying for the furniture. The 'little boy' and the man, all mixed up!

"After that, his whole point of view toward business seemed to change. One promotion followed another, until a few years later he became Treasurer of the company. Now he's beginning to surprise me. Says he expects to be Vice President soon!

"Of course, he's just as modest as he ever was. He'll tell you he got the breaks, but I know better. He *got* the breaks because he'd learned how to grasp them when they came. He's really smart—and so was I when I said 'I do' to a little boy turned man!"

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What does the lady in *your* life think of *your* success? Get more of the Alexander Hamilton Institute's story in the famous little book, "Forging Ahead in Business." Tells how the Institute's timely training is helping thousands of men to do a better business job in these wartime days. Just clip and mail the coupon—today!

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Name...

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ert explosive forces, shattering telephone poles and trees, blowing earth into the air, and causing thunder.

"Since it lacks the explosive force of cold lightning, hot lightning does not cause thunder. It destroys quietly. Strokes of hot lightning sometimes last as long as a tenth of a second—long enough to set fire to wooden structures or melt sand, rock or power wires. Many natural lightning bolts have both hot and cold elements, and therefore can start fires as well as cause thunder."

PROTECTION

Liquid Coating For Brickwork, Metals

DESIGNED for use on exposed surfaces in furnaces, kilns, incinerators, cupolas, and so on, a new liquid material available under the name of Helfyre can be painted over the surfaces of refractories as well as metals. The resulting coating protects against attack by slag, acids, and corroding elements at temperatures up to 3200 degrees, Fahrenheit.

SAWDUST

Serves as Fuel in Home Furnace

WITH new installations of gas-heating equipment prohibited, possible priorities on additional equipment for the use of fuel oil, and transportation facilities needed for the moving of war materials proper, it may be that Eastern and Southern house-holders, as well as those in the West, will soon be looking to America's abundant forests as a source of residential heat.

This would be no news to thousands of western home owners who live in the vicinity of the forest products mills.

Hopper-fed sawdust burner

For years chipped wood, mixed with sawdust, has been an important source of home heat in Tacoma, Seattle, Portland, and many other cities of Washington, California, Oregon, and Idaho. In fact, 25 percent of Seattle homes use such heating systems. The idea is applicable to other parts of the country because America's vast forest resources are scattered throughout the nation, and, for fuel, as well as in countless other categories, these resources can pinch-hit for war-scarce commodities.

Chipped wood and sawdust have proved to be a practical source of home heat, an economical fuel, and one which presents no fire hazard since sawdust is naturally damp. In the type of burner shown in one of our illustrations, the sawdust and chips drop from the bottom of a cone-shaped hopper into a burning grate designed for installation in an ordinary furnace. A hopper of sawdust will burn about 12 hours under normal conditions and provide plenty of heat with practically no ash.

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FINE YARN—A type of yarn produced on ordinary textile machinery for making typewriter ribbons, airplane fabrics, and fine dress goods, is so fine that it takes 50 miles of it to make one pound.

• • •

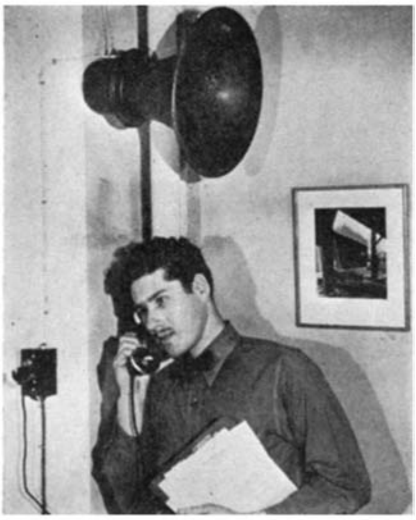
PAGING SYSTEM

Can Also be Used for Private Conversations

PRIVATE two-way conversations between any two or more points, conventional paging through loud speakers, or telephonic conferences can be had by the use of a new paging system recently placed on the market by Executone, Inc.

Each station of the system comprises a hand-set telephone and a loud speaker; any number of assemblies between two and 70 can be installed in any one system. The stations are connected through a branch to a six-conductor cable leading to an amplifier connected to any 110-volt A.C. source.

In operation, a call is made from any station, the caller merely talking into the mouth piece of the hand-set while holding the paging button depressed. The name of the party being called thus issues from the loud speakers at all stations, and in addition, a signal light shows at each hand-set box. To answer, the person called lifts the hand-set at the nearest station and private two-way conversation is established.



Answering a call on paging system

All loudspeakers are then automatically silenced.

For conference work, the person calling a conference pages the names of all men with whom he wishes to confer. These men then go to the nearest station, remove their respective hand-sets, and all stations are interconnected for conference work.

In addition to these uses, this system is being applied to broadcasting general messages to all departments.

ARMOR-CRASHING

Bullets X-Rayed by High-Speed Tubes

First X-ray pictures of bullets as they crash through steel armor-plate are being taken by Army laboratory technicians at Frankford Arsenal. Twin X-ray units, each capable of delivering a charge of 300,000 volts in a microsecond (a millionth of a second) will be used for a series of Army studies of the action of bullets in flight within gun barrels and when they hit targets of armor plate or other materials. This research will be directed by Lt. Col. L. S. Fletcher, officer in charge of Frankford Arsenal Laboratory.

Although a bullet travels at 2½ times the speed of sound, the new X-ray photographic technique, developed in Westinghouse research laboratories, permits making two separate exposures during the flight of a single bullet. The two X-ray machines stand side by side, and the elapsed time between the two exposures can be varied from a five hundredth of a second to a millionth of a second. Two exposures can also be made simultaneously.

In the new ultra high-speed X-ray machine a series of six condensers and a power transformer are used. Drawing power from an ordinary 220-volt line, the condensers act as reservoirs, storing up electricity for nearly a minute. When the condensers are charged to a limit set by central controls, they send a jolt of 2000 amperes at approximately 300,000 volts to the X-ray tube. In the tube this energy is converted first into electrons and then a fraction of it to a tremendous surge of X-radiation which does its work in one-millionth of a second—almost as long as it takes a car, traveling at 60 miles an hour, to move a distance equal to a quarter of the thickness of a sheet of writing paper. An intricate timing device enables operators to fire the two machines quickly enough to get two exposures of a bullet before it has moved more than a few feet.

The first experimental tube which made possible ultra high-speed X-rays was developed in the Westinghouse Lamp Laboratories at Bloomfield, New Jersey, by Dr. Charles M. Slack and his associates. This tube generated the X-ray-producing electrons successfully for the first time without the aid of the usual heated filament. In tubes whose elements heat to produce electrons, speed of an exposure is limited to about one-hundredth of a second because the

power required to make any faster pictures would burn out the inner mechanism. The "cold cathode" principle removes the limit on the amperage that can be applied and hence can produce an enormously greater amount of X-rays.

STRESSED SHEETS

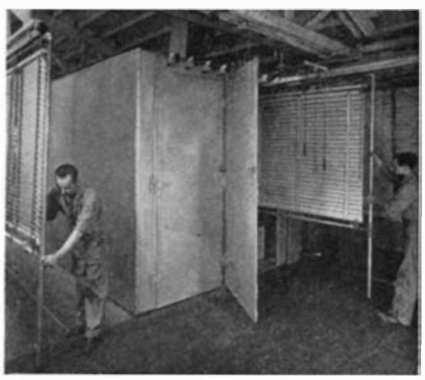
Of Steel Used in New Structural Units

By pulling steel sheets into tension between framing members and fastening them together without riveting or welding, a new method of structural construction has been achieved. This type of assembly, known as Lindsay Structure, is claimed to possess tremendous strength and to abolish needless weight. It is a definite breakaway from the traditional methods of steel construction and promises an annual saving of more than 100,000 tons of steel by using light sheet for many types of construction ordinarily requiring much heavier metal.

Sheet metal has been used for years on light structures—but simply as a covering material. Ordinarily, all initial racking stresses to which a structure is subjected are borne by the framing, which must be crossbraced to withstand them. If the framing begins to "wear," these stresses are concentrated at the weakest point of the sheets—the rivet, the bolt, the screw holes, or the tightest point of the weld.

In Lindsay Structure the sheets are pulled into tension between the framing members. These "pre-tensed" sheets instantly resist any movement of the framing, and the load is distributed over the entire area. With this construction, therefore, it is possible to use lighter-gage sheets and lighter framing, usually with a marked increase in strength.

This method of construction eliminates crossbraces, gussets, and struts by placing the sheets under tension between the framing members; it creates a union between sheets and framing



Stressed steel structure—strong

that approximates the full strength of the sheet; and it provides ease in assembly and disassembly from the outside, equivalent to the simplest bolted construction.

Many types of mobile structures have been fabricated with this new method. Motor truck bodies, bus bodies, railroad cars, and marine superstructures are some of the applications where light weight, tremendous strength, and rigidity are of primary importance. The system has also been used successfully in the construction of machine housings, industrial buildings, refrigerator lockers, farm buildings, portable shacks, garages, and other structures of diverse uses.

GOLF BALLS

To Be Recovered for Further Use

A METHOD for re-processing used golf balls, developed to meet the war-time emergency, was announced recently by United States Rubber Company. Golfers are therefore urged to save their used balls.

It is claimed that the re-processed balls will look like new, except that they will be branded to indicate that they have been re-processed. They will have good playing qualities and will give service almost equal to new balls. The re-processing will be accomplished without using any materials on the restricted list.

When balls are received for re-processing, they will be inspected and those balls which are out of shape, too old or too badly cut, will be discarded. The balls will be classified according to construction, the old covers removed, and new covers will be molded on the balls.

The cover will be of Tjipetir, a special form of Balata, and the new cover will be identical to the covers of new balls. The re-processed ball will then be finished, painted, and marked with its proper brand name, depending on its construction.

Only the company's own brands will be re-processed by this method. Individuals are asked not to send balls to the company direct, because no provision will be made for this service direct to consumer. When the plan is put into effect, players will be asked to turn in their used balls to their golf professionals. They will receive a merchandise credit which they may apply either to the purchase of new balls, as long as new balls are available, or the purchase of "Re-Processed" balls. The pros will return the used balls to the company as sizeable lots are accumulated.

SUGAR

Shortage Has Its Good Health Points

MOST Americans have too sharp a sweet tooth, and a little sugar rationing will do them more good than harm, according to diet authorities. M. L. Wilson, assistant director of nutrition, of the health and welfare defense program at Washington, for example, declares: "Sugar rationing certainly will harm no one. People will meet the restriction on sugar by adding calories from other sources—sources which contain vitamins and minerals lacking in our refined sugar."

Dr. L. H. Newburgh, University of Michigan authority on diet, advises: "Don't complain about sugar rationing; it will be good for you. As a matter of fact, it would be a Godsend if there were no sugar at all. For, if there weren't we would be forced to eat more grains, meats, milk, green vegetables, and other foods which give us everything that sugar does, plus much-needed B vitamins and minerals."

Dr. Newburgh points out that sugar's only importance to our diets is its fuel value, and this may be readily replaced by a host of other foods which provide more than mere fuel. Milk is the best fuel substitute for sugar, since it also provides proteins, vitamins, salts, and fats. One glass of milk, he says, is equal in fuel content to four teaspoonfuls of sugar.

Whole cereals are a much more wholesome food than sugar, since they provide, in addition to fuel, vitamins of the important B group and 10 percent of protein. An ordinary portion of oatmeal, for example, is equal in fuel value to four teaspoonfuls of sugar. Perhaps those who "have always intended to cut out sweets" will find the push from Uncle Sam helpful—*Science Service*.

BEWARE OF CADMIUM

Not Safe for Use in Food Containers

EVIDENCE of a public-health hazard in the use of cadmium for plating food containers and food processing equipment, says the United States Department of Agriculture, adds interest to results of tests made some time ago by scientists of the Bureau of Agricultural Chemistry and Engineering and Stanford University.

Any cadmium-plated article coming in contact with food, particularly food with an acid reaction, reported the investigators—Wilson, DeEds and Cox—is likely to contaminate the food and to cause acute illness. Small quantities of cadmium taken in daily, the investigators reported, can produce anemia, enlargement of the heart, and bleaching of tooth enamel—a bleaching similar to the effect of fluorides.

Since efforts are being made to meet shortages of various materials, research of this kind is of high importance in insuring the public safe and sound substitutes. Cadmium is already branded as unsuitable as a plating substitute for containers or for food handling equipment.

ARTHRITIS

Linked to Childhood Rheumatic Fever

EVIDENCE that chronic infectious arthritis in adults may have resulted from rheumatic fever in childhood is given by Dr. Archie H. Baggenstoss and Dr. Edward F. Rosenberg of the Mayo Clinic, according to *Science Service*.

The two Mayo physicians feel that arthritis involves more than disease of the joints; that it involves the vital organs, the crippled joints being merely one expression of this malady.

They examined the organs of 30 patients who had had chronic infectious arthritis and found evidence of disease in the heart, kidneys, liver, and other organs. There was damage to the heart in 24 cases and in 16 of these the injury was indistinguishable from that caused by rheumatic fever. Also significant was the pathologic condition discovered in the kidneys. It was felt that heart and kidney damage was due to the same underlying set of causes.

Drs. Baggenstoss and Rosenberg concluded there may be a relationship between chronic infectious arthritis and rheumatic fever, typically a disease of childhood.

SAFE PORK

Insured By Storage At Low Temperatures

TRICHINAE which cause the serious disease trichinosis, will not survive in pork treated by adequate freezing, according to the United States Department of Agriculture. The thickness of the cuts of pork or the inside dimension of the container determines the length of time the meat must be subjected to a given temperature to destroy any trichinae that may be present.

Pieces of pork or pork products not exceeding six inches in thickness must be stored for a continuous period of not less than 20 days at a temperature not higher than 5 degrees, Fahrenheit, or not less than 10 days at —10 degrees, Fahrenheit, or not less than six days at —20 degrees, Fahrenheit, to assure complete protection. For larger pieces or packages up to 27 inches in thickness, the storage period is doubled, except in the case of 5 degrees when the period is increased to 30 days.

The Bureau warns that in many food locker plants, temperatures are not kept low enough to insure a complete kill in stored pork.

GERM-KILLING

By Ultra-Violet Light Has Great Possibilities

Rapid increase of air sterilization by ultra-violet light to include apartments, offices, private homes, military mess halls, barracks, and hospitals was predicted recently by Dr. Theodore S. Wilder. He pointed out that "curtains" of the invisible artificial sun rays have successfully lessened the occurrence of measles in selected Philadelphia schools, and infections following surgery in hospital operating rooms, reports *Science Service.*

Ultra-violet light, the part of the sun's rays which causes sunburn, is fatal to bacteria and apparently to the viruses, germs so small they cannot be seen under a microscope.

In apartments with air conditioning the ultra-violet light would be especially valuable, Dr. Wilder said, since "recirculated air has been proved to be a carrier of contagion. It may not be far fetched to hear a Mr. A complain that his invaluable secretary is laid up with grippe which he is sure she caught from his friend Mr. B 10 floors above him."

Private homes might provide ultra-violet sterilization for the nursery, particularly where the infant has just come from a sterile hospital nursery. Further, ultra-violet light might take the place of the sheet, soaked in antiseptic, which used to be hung across the door of the sick room.

Military hospitals, dispensaries, barracks, lavatories, mess halls, and recreation rooms might find ultra-violet protection especially valuable during winter and early spring in cold climates. Dr. Wilder warned, however, that "the mere presence of an ultra-violet source in a given room is no guarantee that it is accomplishing anything. Varying air currents and reflecting surfaces greatly alter the efficiency of the light," and he added that the need of a particular situation for ultra-violet light should be determined by physicians, and its installation made by experts.

Industrial Growth

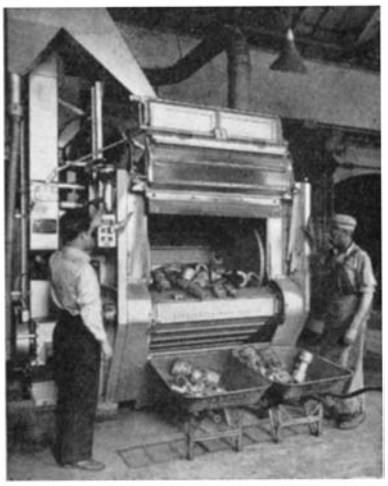
New Products and Processes That Reflect Applications of Research to Industrial Production

CLEAN?

Simple Test for Metal Parts

FOR blemish-free metal finishing—enameling, plating, galvanizing, tinning, and so on—it is imperative that the product be chemically clean—free of *all* foreign material.

Although these parts may look clean as they come from the cleaning room, it is entirely possible that traces of sand, scale, or other extraneous material may still be adhering. When that happens rejects in the finishing room become a certainty, with a consequent waste and loss of production.



Cleanliness test via open door

The simplest of all tests on iron castings, forgings, sheet steel (except stainless), and so on, is to make a saturated solution of copper sulfate (blue vitriol) to which a slight amount of sulfuric acid (2 percent) has been added. The use of this solution serves to detect the presence of iron in any form, including its alloys, by forming a bright yellow copper coating on the surface of the article tested.

Where sand, iron oxide, or foreign material is present, the surface will remain in its original color or may be blackened.

The material suspected of being chemically unclean can be tested either by immersion in the solution or by rubbing the solution on the work with a swab, such as the type used for throat painting. Special emphasis should be given to the fillets and cavities in the piece, if enameling or plating is to follow. It is a good idea to renew the solution or redip swab for each test.

For abrasive blast cleaning, it is a simple matter to determine when all pieces of a load in a Wheelabrator Tumblast are evenly cleaned, because all the operator has to do is stop the abrasive blast, open the machine door and conduct the test on a few selected pieces. Should additional cleaning then be necessary, the door can be quickly closed and the blasting resumed for as long as is required to remove whatever objectionable material may be present.

SAND BLASTING

Equipment For Design Cutting, Paint Removal

A LIGHT-WEIGHT sand blasting gun, equipped with a gravity-fed reservoir with a capacity of ½ pint, is now available for cutting designs in plastics, stone, glass, and so on. The same unit is also suitable for cleaning paint from small areas and for sand blasting small castings.

One of our photographs shows the complete sand blasting outfit including a portable compressor with a driving motor; the gun itself can also be operated on any compressed air source.

Abrasive from the reservoir is fed to a hardened-steel nozzle and is de-

Complete, ready for use

livered in the air stream when the trigger is pulled. The gun and its portable air supply source is manufactured by Paasche Airbrush Company.

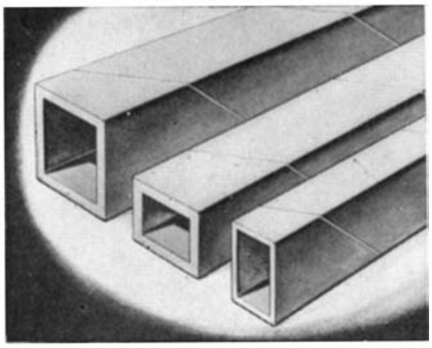
PAPER TUBES

Manufactured With Precision Tolerances

PAPER tubes for electric coils, produced by the use of a specially adapted heat die machine, are now being made to precision specifications.

Heavy compression insures strength and resistance to collapse, accuracy in sizing, superior dielectric properties, lower moisture absorption rate, square corners, and straight side walls.

The improved tubes, produced by Precision Paper Tube Company, are preliminarily formed of dielectric kraft or fish paper, or a combination of both.



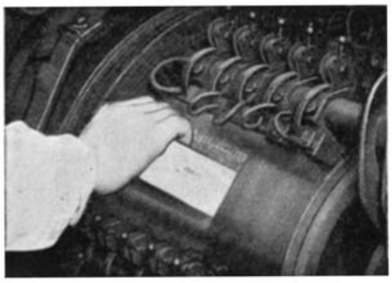
Also in rounds and ovals

The paper is spirally wound on a steel die in an automatic machine. The tube is then pushed pneumatically through the new heated compression die which effects an added compression of about 10 percent. Tubes made by this process can be obtained in round, oval, square, or rectangular cross section and in continuous lengths of any wall thickness with any inside or outside diameter. Tolerances are held to 0.002 of an inch.

COMMUTATORS

Kept Clean With Non-Clogging Stone

EXCESS film and dirt caused by heavy, continuous power loads on motors can be easily and quickly removed from commutators with a new cleaning stone announced by the Ideal Commutator Dresser Company. The stone cleans while the motor or generator is running. It is used by simply holding it against the commutator and slowly moving it across the face. The stone does not clog, nor cut the commutator. It also cleans film from the brush seats and helps to re-seat brushes.



Clean commutators serve best

So called "excess color," "skin" or "film" resulting from oxidation around paper mills, chemical plants, printing departments, Diesel locomotive generators, and so on, are all removed—only the "electric film" remains on the commutator assuring perfect commutation. Regular cleaning of commutators will help in keeping motors and generators on the job 24 hours a day. Only a clean commutator can be expected to function properly, with reduced noise, uniform brush wear and minimum chattering and sparking.

NO SLIPPING

When Floors Are Covered With New Powder

TO provide traction on floors near machines, work benches, and other areas that tend to become slippery, a material in powder form has recently been put on the market by Theo. B. Robertson Products Company. The powder not only prevents slipping but absorbs oil and grease and is swept up and replaced when it becomes dirty and saturated.

OIL REMOVAL

From Metal Surfaces With Special Liquid

AN industrial cleaning material for use in washing machines quickly removes heavy coatings of mineral oil from metal surfaces and leaves a rust-preventing film. This liquid, manufactured by Quaker Chemical Products, is used in the proportion of one gallon with 25 to 75 gallons of water and the resulting solution is maintained at a temperature of 130 to 175 degrees, Fahrenheit. It is claimed that the solution will not attack metals and that there is no danger of fire or explosion through its use.

The oil that is removed by the action of the solution floats to the top and can be skimmed off. Thus the only solution which is lost and requires replacement is that which is removed from the machine on the washed metal parts.

Post-War Possibilities

Extensive Growth Forecast in Employment, in Both Manufacturing and Service Branches of Aviation

ALEXANDER KLEMIN
Aviation Editor, Scientific American.
Research Professor, Daniel Guggenheim School of Aeronautics, New York University

STUDENTS at several universities have written us for information on post-war aviation, a subject which seems to be providing the colleges with possibilities for theses. We have been loath to venture into the realms of prophecy. A *Fortune* Magazine Round Table has been much bolder. If E. R. Breech, Board Chairman of North American Aviation; E. P. Warner, of the Civil Aeronautics Board; and Frederick C. Crawford, President of Thompson Products—certainly authorities on the subject—are to be believed, the outlook for post-war aviation is an excellent one.

Even if we achieve a complete victory over the Axis, there would be needed 24,000 military planes to police the world—since this time we would not allow our present enemies to get into further deadly mischief. The maintenance and ultimate replacement of these planes would, in itself, provide employment for 100,000 workers. Mr. Breech thought that the volume of private planes might reach 10 to 15 percent of the automobile industry's volume in five to ten years, but could not take up the slack in employment for the four or five hundred thousand men now employed in aviation. Mr. Crawford was much more optimistic. "People have not yet become accustomed to this convenience. We have not seen anything yet. I think air transportation of perishable goods is coming. People have no conception of the land crews that will be necessary. We will have more people servicing and repairing and building and flying planes and selling tickets . . . "

Mr. Warner was still more encouraging, though he quite rightly pointed out that it was not price (that is, low price) which would make aviation generally acceptable, but the more complete solution of the problems of aviation. We must solve weather limitations, provide innumerable airports. The unparalleled efficiency of the airplane was stressed by the eminent speaker. "So far as I know," said the Vice-Chairman of the Civil Aeronautics Board, "no vehicle on land or sea in surface transportation has ever yet operated on a basis of normal service per vehicle of more than 80,000 miles a year. However with the airplane 500,000 miles a year is common."

Another interesting thought was that the instruments or devices invented during the war for locating enemy aircraft might be utilized for commercial aircraft and enable them to keep out of one another's way in the foggiest weather.

Predicting an enormous growth in the carrying of passengers by air, Mr. Warner said that the annual operating cost for lines operating within the United States might be between six hundred and eight hundred millions a year.

AIRPORT CAPACITY

Imposes New Problems on Air Transportation

AIR traffic has reached such proportions as to raise the question of traffic saturation at major airports. During the last Labor Day week-end, La Guardia Field, New York City, handled 1364 airplanes between Thursday midnight and Monday midnight. With the normal distribution of air traffic that prevails at La Guardia this meant that one airplane was handled every two minutes—close to the utmost capacity of the airport. This was in good weather. Bad weather, even with instruments and blind-landing guides, inevitably cuts down the capacity of an airport. So already the capacity of La Guardia may be said to be approaching its limit. A. F. Bonnalie, of United Air Lines, discussed the problem in very thorough fashion at the recent Airport Conference held under the auspices of the Illinois Institute of Technology. How is this situation going to be met, particularly when the present emergency ceases and more equipment is released to our air-transport companies?

Two definite schools of thought exist in regard to future provisions for metropolitan carrier terminals. One school, so Mr. Bonnalie tells us, adheres to the principle of a multiplication of fields at major traffic centers as the only solution of the problem. This is the simplest solution available, but it is subject to the same difficulties as are multiple station facilities for railroads, with their confusion for the traveler and the problems of transhipment from station to station. The second school of thought (to which we think Mr. Bonnalie himself belongs) believes that air carriers can best serve the public from one metropolitan air field.

To serve the public in this fashion, without prohibitive size of the landing area, much thought will have to be given to the spreading out of the traffic throughout the day, and to the design of the airport facilities. Duplicate runways will have to be made available for take-off and landing. Triple runways might have to be provided. The taxi-ways would be arranged for one-way traffic. Hangar facilities and terminal buildings would have to provide sufficient frontage to handle a large volume of traffic quickly.

It is gratifying to see that the problem of airport capacity has already arisen. It will be solved by ingenuity and feeling for organization.—*A. K.*

DYNAMOMETER

Combination Unit Absorbs Full Engine Power

As aircraft engines increase in size, so do dynamometers; these are now being built by the score in sizes up to 4000 horsepower and some are being considered which will be even larger.

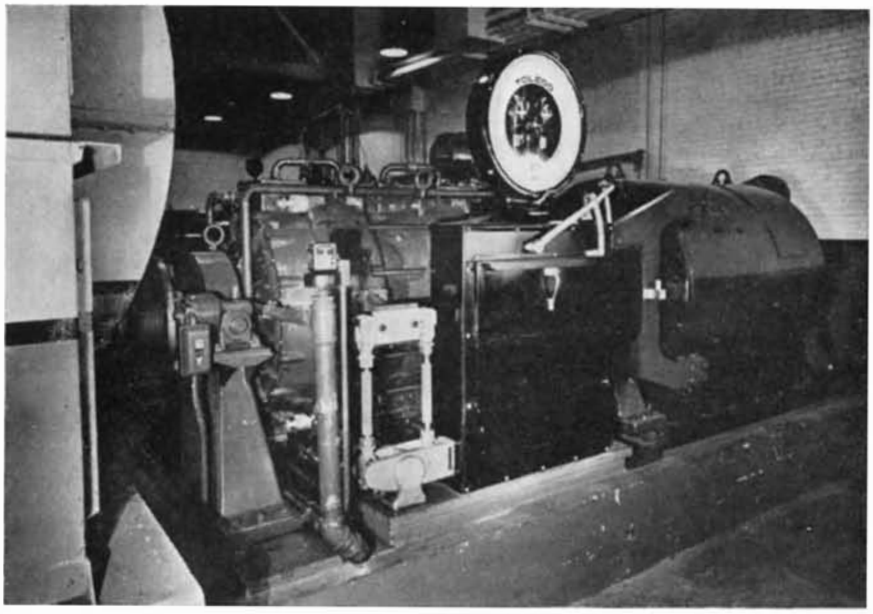
The Westinghouse dynamometers, installed by Detroit engine manufacturers, are representative of these testing installations. In one of our photographs the airplane engine is out of the picture behind the wall at the left. From it there extends, through a flexible coupling, a shaft which drives an eddy-current generator capable of absorbing 2000 horsepower and a D.C. generator that can absorb 750 horsepower. The frames of both are cradled so their tendency to turn can be measured on a set of scales. The energy absorbed by the eddy-current generator is carried off as heat; that developed by the D.C. machine is returned to the power lines through a motor-generator set. This combination dynamometer can absorb the full power of the airplane engine at any speed up to 2000 rpm.—*A. K.*

PRONE FLYING

Has Advantages for Military Purposes

In a recent issue of "The Army and Navy Journal," it is stated that both the United States and Britain as well as Germany have for some time been experimenting with pursuit planes for prone flying. The new Fokker Wulfe fighter plane, developed in Germany and still in the experimental stage, is designed so that the pilot and two-man crew all lie prone instead of sitting upright as in conventional ships.

Prone flying, first of all, tends to decrease the cross section of the fuselage and thus provides less drag and more speed. But it has even more value in decreasing the "blackout" often suffered by combat pilots today. In conventional planes, where the pilot sits upright, the centrifugal force developed when coming out of a dive is virtually perpendicular to the pilot's body and the blood drains readily from the pilot's head. In prone flying, the centrifugal force is almost horizontal to the pilot's body. This tends to reduce "blackouts"; consequently the pilot can make tighter pullouts and spirals. In dive bombing this permits delayed pullouts.—*A. K.*



Soaks up power, records it accurately

CAMERA ANGLES

Conducted by JACOB DESCHIN, A.R.P.S.

Tone Separation

DARK tones against dark areas, light tones against light, bring a loss in the clarity of detail due to semi-absorption of the detail by the background. Unwittingly, however, some workers frequently find themselves faced with such a problem as that shown in the illustration, where the

Tone separation could be better

dark boat model is almost lost in the dark-toned shirt worn by the boy. An excellent picture, made, incidentally, by Robert Toran, of New York City, the print has good composition, good human interest, a fine expression on the boy's face. The lack of tone separation between the boat and the shirt is the only jarring note. A lighter shirt or side or back lighting for the boat would have done the trick and made a good picture better.

Tabletop Trees

ERNEST E. DRAPER, who is frequently referred to as America's tabletopper No. 1 because of the remarkable realism he succeeds in injecting into his pictures, invariably uses the small locust tree to simulate reality. With roads, mountains, houses, and so on, scaled to the tree, and employing a low viewpoint for the camera, the tree looks as real as life, as indeed it is, lending authenticity to the entire scene. Mr. Draper finds the tiny trees in empty lots and other abandoned places, and thinks it is ideally suited to tabletop use.

Kodachrome or Kodacolor

NOW that we have them both, which shall we use? First, it is a matter of camera equipment. If you have a 35mm camera only, you are limited to Kodachrome, since Kodacolor is not available in that size. However, if you have a 35mm as well as a larger roll-film camera, and there is a choice, we would say offhand that the pictures you take on Kodacolor will be those you will want to give to friends or place in an album, while Kodachromes will be used for scenery, flower studies, and similar subjects. Another aspect to consider is the comparative speed of the two materials, Kodachrome being rated Weston 8 and Kodacolor Weston 20. The two mediums may, therefore, be used in somewhat the same manner as slower and faster black-and-white film is employed, suiting the medium to the requirements of the situation. Where Kodachrome is too slow, for example, for a required snapshot exposure, Kodacolor may do the job very well.

Filmo Moviquiz

THE quiz craze has now been introduced by Bell & Howell in the 16mm rental film field in the form of the "Moviquiz." Explaining how the game works, the company says:

"The participant, student at school or guest at a party, is given a printed sheet of questions, and is asked to indicate the answers in the spaces provided. A film is then shown, in which the correct answers are found, and from then on, the grading of papers, rewriting of answers, or paying of 'forfeits,' is up to the teacher or host, as the case may be."

There is a choice of several series of new, one-reel films, for each of which a "Moviquiz Kit" is provided. This kit contains a set of question sheets, a master list of correct answers, and suggested methods of scoring.

How Do You Hold Your Camera?

EVERY worker has his own particular argument for the way he holds his camera, but the next fellow may present just as strong a brief for some utterly different method that happens to suit him. Both are

Convenience comes first

right because the method adopted by each worker is the best for him. It's just a matter of habit and convenience. The chap in the illustration finds the method shown especially helpful because of the way the Kalart synchronizer unit is attached. Turning the camera upside down gets the picture just the same and, for this photographer, with greater comfort.

Panda Bites Photographer

They call her Ylla, the famous European photographer of animals, and being rather pretty besides, she got ready permission to enter cages of animals at the Bronx Zoo in New York City, in order to make close-up shots with her twin-lens reflex. She was getting along fine when, one day, she entered the cage of the panda, ordinarily a harmless creature but on this occasion very effusive in her greeting of the lady photographer. Ylla insists even now that the panda was only playing and that the bites and scratches inflicted by the animal were mere tokens of affection. And, to top it all, Ylla is coming back again, explaining that the next time she is going to wear slacks as it appears the panda had taken a fancy to her legs which, the photographer having worn a skirt, were free.

Background of Cobbles

Backgrounds in outdoor photography are frequently a bane to the amateur worker who has been cautioned against setting his subject in front of a cluttered-up scene, with the distracting effect that inevitably results. The usual method, where possible, is to shoot the subject against a sky background by having the camera low or setting the subject on an elevation. Another recommended procedure is to use water as a background; a third, a plain wall. A novel approach to the problem, recently reproduced in a fashion photograph in one of the leading women's magazines, was a figure set against a background of cobblestones. The shot was naturally made from above with the camera tilted down in order to get an over-all pattern of cobbles.

The Smoker

Smoking a pipe, even when working in the darkroom, is something Robert Bagby likes to do. But ashes have a way of falling out of the bowl when the pipe is tilted a bit. Bagby never has any trouble with this difficulty, however, as he habitually smokes a pipe of the so-called outdoor type, with a hinged perforated hood. Designed for the hunter and sportsman who likes to smoke a pipe outdoors without the disadvantage of having ashes blow into his face, it seems to work as well for the outdoor photographer and indoor darkroom worker.

"Big Brother"

In the contemporary annals of pictorialism, the name of David Darvas, of Cleveland, Ohio, is coming steadily into a place of leadership. One contributory cause is the reproduced print, "Big Brother,"

"Big Brother"

hung in the recent New York salon of the Pictorial Photographers of America. Mr. Darvas, who is a superb technician as well as a fine camera artist, manages in this print to satisfy both documentarian and pictorialist. We do not know the circumstances surrounding the making of this picture, but Mr. Darvas certainly is to be complimented on his skill and understanding in getting the children to assume such a natural attitude and expression.

Acetate Diffuser

A diffusing material, intended for use by architects as an overlay in making tracings, has been found to be of exceptional value in photography. The material, which has an acetate base, transmits about 75 percent of the light, as compared with only half that or less when using other diffusion materials. Supplied 21 inches wide, the material is available in art stores, being sold by the foot. Because of its generous width, ideal diffusion is provided over a great area.

That Darkroom Sink

Having trouble with a leaky wooden sink? Then try this stunt. Get some white lead and a supply of candlewick. Fill in the cracks with the white lead and then stuff the candlewick in liberally. Of course, the sink must be thoroughly dried before these repair operations can be satisfactorily begun.

Ground Glass Manipulation

The ground glass back on a view camera does not have to remain on the camera while arranging the subject. When trying for different angles, it is rather a cumbersome and time-consuming job to keep moving the camera itself. It is easier and just as effective to remove the ground glass back and hold it at different angles until the subject composition looks right. Then move the camera to the wanted position, and there you are. The camera is moved only once, saving labor, to the position previously determined by manipulation of the free ground glass.

Our Book Corner

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

ANNAPOLIS: GANGWAY TO THE QUARTERDECK

By Captain W. D. Puleston, U.S.N.

In the year 1845 (the year of the founding of Scientific American) there came into being the United States Naval Academy. How this world-renowned institution for the training of naval officers evolved from earlier experiences and controversies regarding training methods and requirements, and how it has developed to its present stage of efficiency and thoroughness is told in the pages of "Annapolis" by a naval officer who is well qualified for the job in hand. Captain Puleston, known to readers of this magazine as a Contributing Editor and for his splendid articles on naval matters, was graduated from Annapolis in 1902. Since then he has had a brilliant and all-embracing career in the Navy. With this background he has welded together the running story of progress in naval training at Annapolis, told as only one can tell it who is imbued with love for and loyalty to the service which has commanded his life-long devotion. The information contained in this latest of Captain Puleston's books will serve to give the reader a greater appreciation of the glorious traditions upon which have been built the United States Navy that is today facing the supreme test on far-flung battle lines. (259 pages, 8½ by 5¾ inches, a number of photographs, glossary of naval slang.) —$3.10 postpaid.—*O. D. M.*

JEWELRY AND ENAMELING

By Greta Pack

Instructor in the Art Department of Case Technical High School, Detroit, gives definite instructions on basic processes and applications—instructions that tell you exactly what to do, seriatim, by definite steps, not simply vague elusive talks about the work. These cover a lot of territory, such as annealing, pickling, soldering, casting, chasing, repousse, modeling, carving, wire working, domes, balls and stamped forms, enameling, stone setting, ring making and so on. (377 pages, 5½ by 8½ inches, 114 illustrations, mostly multiple.)—$2.60 postpaid. —*A. G. I.*

DOCTORS ANONYMOUS

By William McKee German, M.D.

Revealing insight into the role of the pathologist sleuthing out the correct diagnosis of diseases—a romantic side of medicine which is almost unknown to the average layman. This most readable account, by a pathologist who is introduced in a foreword by Paul de Kruif, will make the public more conscious of the importance of choosing hospitals which have well-equipped laboratories for tracing down diseases. No dull reading here! (300 pages, 5½ by 8¼ inches, unillustrated.)—$2.85 postpaid.—*F. B. I.*

MACHINE SHOP WORK

By John T. Shuman

Comprehensive treatise for apprentices and others. Covers not merely the lathe, but fundamental phases of all the major machines and operations: hand tools and their work; drilling machines; lathes; grinders; planers; shapers; milling machines; gearing; broaching; turret lathes. The illustrations are so numerous and clear that the book is suitable for men working alone. It is decidedly on the practical side, and on no other. Author is Co-ordinator in the Williamsport Technical Institute. (499 pages, 5½ by 8 inches, many illustrations.) —$3.60 postpaid.—*A. G. I.*

AUDEL'S MECHANICAL DICTIONARY

Compiled by N. Hawkins, M.E., and E. P. Enderson, E.E.

In scope, this book covers much more ground than is indicated by its title. Actually, the text borders on the encyclopedic, giving not only the correct definitions of words but, in many cases, tables, rules, formulas, recipes and practical hints, helps, and suggestions as well. The book was designed to give a full and correct vocabulary and background of the meanings of words in the world of mechanics; hence practically all non-mechanical matter is excluded. Indicative of the broad coverage, however, is the fact that brief biographies of a number of pioneers in the mechanical and scientific world are included, giving what amounts to a condensed history of mechanical progress. Approximately 17,000 words, terms, and phrases are presented. (918 pages, 5½ by 8 inches, unillustrated.) —$2.10 postpaid.—*A. P. P.*

THE TRISECTION PROBLEM

By Robert C. Yates

Gem of a work—compact, crisp, concise—for two categories of readers: those who believe it possible to trisect the general angle with compasses and unmarked straightedge alone (the old rule of the game), and those who don't. Main content: solution by mechanisms (graduated ruler, compasses of Hermes, three-bar apparatus, pantograph, carpenter's square, the isoklinostat); approximate methods (six familiar types); quixotic cases (tilting at windmills); and bibliography of 52 most important published sources of other literature on the same problem. This book, by the associate professor of mathematics at Louisiana State University, embodies the mathematician's answer to the would-be trisector, and within two covers rounds up all the chief dependable data on this never-ending dispute. (68 pages, 6 by 9 inches, 43 figures.)—$1.10 postpaid.—*A. G. I.*

THE CONDENSED CHEMICAL DICTIONARY

Edited by Thomas C. Gregory

In its third edition, this inclusive compendium on chemical products is much enlarged and its usefulness expanded by the addition of descriptive data on a large number of compounds and preparations sold under proprietary names. While most of these are only briefly defined, the information about them is valuable to anyone interested. As in previous editions, data on properties, preparation, grades, and uses of chemicals and related materials are given briefly. Tables of useful information occupy 61 pages. The encyclopedic scope of this work makes it an invaluable reference. (756 pages, 6 by 9 inches.)—$12.10 postpaid.—*D. H. K.*

FRESH WATER FISHING

By Myron E. Shoemaker

With a chapter devoted to each important specie of fresh water fish found in north American lakes and streams, descriptions of their habits, guidance as to lures and methods of use, and an interesting history of angling, this book warrants a place in any fisherman's library. Outstanding, too, is the emphasis placed on the relation between the deterioration of our fishing and the wanton destruction and depletion, through ignorance and otherwise, of our natural resources, with a conclusion that restocking of streams will not alone solve the game fish problem. (218 pages, 6 by 9 inches, four color plates and numerous line drawings.)—$3.10 postpaid.—*A. D. R., IV.*

DOCTOR WOOD

By William Seabrook

Brisk, breezy biography of the noted Johns Hopkins physicist, among world scientists outstanding as an experimental physicist, yet always a "big kid," ever full of practical jokes, who, at 72, is still one of science's pet "characters." On the serious side, in addition to first-rank contributions in pure science, most of them abstruse, recorded in 263 published papers, he made numerous discoveries bordering on inventions, for most of which others received main credit because Professor Wood hit on them too soon: the bucket diving rig, the electric thaw for frozen pipes, methods of color photography, ultra-violet and infra-red photography, an electric nose for locating mercury-vapor leaks, sodium vapor lamp, method for measuring pressures in gun barrels, hydrogen welding torch, so-called "Vienna" method of crime detection. He also invented the fisheye camera, mercury telescope, war-time signal telescope, Wood's glass. On the frivolous side he wrote the famous book of nonsense verse, "How to Tell the Birds from the Flowers," played some 9,356,268 practical jokes (the score still rises), and always was the iconoclastic, stuffed-shirt-hating *enfant terrible* of science. Famous foreign and domestic academies have publicly honored him with dignified degrees, medals galore, chuckled privately over his pranks. This book will make you chuckle, too—especially if you think professors of science wear long pink whiskers and are only half human. (335 pages, 5½ by 8½ inches, 15 illustrations.)—$3.85 postpaid.—*A. G. I.*

UNDER THE SEA-WIND

By Rachel L. Carson

NATURALISTS' picture of ocean life, consisting of descriptive narratives that unfold the life of the shore, the open sea, and the sea bottom. Somewhat romanticized, but scientifically accurate. Author is a biologist on staff of Fish and Wildlife Service. (314 pages, 6 by 8 inches, illustrated.)—$3.10 postpaid.—*A. G. I.*

ENJOYMENT OF SCIENCE

By Jonothan Norton Leonard

FOR those who want to burrow into science but do not know which books to read, this is an excellent guide, since its main feature is a detailed discussion of the outstanding books in each branch—biology, anthropology, entomology, microscopy, geology, astronomy, physics. A sort of master control of reading, to enable the owner to direct his reading intelligently and not hit-or-miss. It is chatty and friendly—as if the author were answering informal questions. (327 pages, 5½ by 8¼ inches, unillustrated.)—$2.60 postpaid.—*A. G. I.*

MINERALS IN NUTRITION

By Zolton T. Wirtschafter, M.D.

COMPACT, semi-popular, semi-scientific monograph on the newer findings with regard to the minerals as an extremely small but all-important factor in the human dietary—comparable in importance with that of the vitamins. Salt, potassium, calcium, magnesium, phosphorous, sulfur, iron, iodine, aluminum, arsenic, manganese, bro,-mine, zinc, copper, cobalt, nickel, selenium, fluorine—all these are in the body and needed in the dietary; without them the vitamins are of but small value. This exposition is popular but leans toward the serious. It also carries extensive bibliographies to special articles in the professional journals. The author is Clinician in Charge of the Diabetic Clinic at Mt. Sinai Hospital, Cleveland, and instructor in medicine at Western Reserve University. He is also visiting physician, of the Department of Medicine, at the Cleveland City Hospital. (175 pages, 5 by 7½ inches, unillustrated.)—$1.85 postpaid.—*A. G. I.*

CURRENT BULLETIN BRIEFS

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

THE HISTORY OF COMBAT AIRPLANES, by Charles G. Grey, is a 158-page unillustrated brochure which deals with the evolution of fighting planes from pre-World War I days to the middle of 1941. The text is non-technical, giving an over-all picture of military aircraft. *Norwich University, Northfield, Vermont.—$1.00.*

RESISTANCE THERMOMETERS is a 30-page pamphlet which gives a comprehensive presentation of the nature, design, performance, and application of a broad range of resistance thermometers in industrial processes, scientific work, refrigeration, air conditioning, and so on. The types of thermometers are illustrated and fully described. Request catalog No. 9004. *The Brown Instrument Company, Wayne & Roberts Avenues, Philadelphia, Pennsylvania.—Gratis.*

THE JONES HEAVY DUTY HAND TACHOMETER is a four-page leaflet describing an indicating instrument for measuring speed directly in revolutions per minute or feet per minute. *James G. Biddle Company, 1211 Arch Street, Philadelphia, Pennsylvania.—Gratis.*

REFRIGERATED WELDING is a four-page folder which describes the "Frostrode" welding process and the advantages which it offers to industrial welding. *Weltronic Corporation, Frostrode Division, E. Outer Drive, Detroit, Michigan.—Gratis.*

DEFINITIONS OF ELECTRICAL TERMS is a 300-page bound volume, thoroughly indexed, presenting for the first time, under one cover, the definitions of the important terms common to all branches of the art as well as those specifically related to each of the various branches. *American Institute of Electrical Engineers, 33 West Thirty-Ninth Street, New York, New York—$1.00 in the U.S.A., $1.25 outside of the U.S.A.*

A PRIMER ON GRINDING WHEEL SAFETY is a 24-page illustrated booklet which presents important facts for grinding-wheel operators in brief text and interesting cartoons. *Norton Company, Worcester, Massachusetts.—Gratis.*

20 MODEL RAILROAD PROJECTS, by Frank Taylor, is a 120-page illustrated book which gives full and complete details on the construction of various types of model railroad cars, stations, signals, and other accessories for the model railroad hobbyist. Detailed drawings supplement the text. *Kalmbach Publishing Company, Milwaukee, Wisconsin.—$1.00.*

SQUEEGEE TYPE PUMP is a folded circular describing an industrial pump operating on an entirely new principle. It consists of a flexible rubber tube which is alternately squeezed and released in a rocking-squeegee manner so that the liquid or gas is "breathed" into or out of the tube. The pumps are available in capacities ranging from one-half to 50 gallons per minute. *Downington Manufacturing Company, Huber Pump Division, Downingtown, Pennsylvania.—Gratis.*

HOW ARE BALLS MADE ROUND? is an eight-page folder which describes in photographs and text the essential processes in the manufacture of highly accurate ball bearings from the original pressing to the gaging of the finished product. *SKF Industries, Front Street and Erie Avenue, Philadelphia, Pennsylvania.—Gratis.*

THE AUTOMOBILE USERS' GUIDE WITH WAR-TIME SUGGESTIONS is a 66-page manual designed to help the public get the most out of its automobiles and to make them last longer by describing how to save gasoline, tires, and repair bills; also how to prolong the life of a car and keep it looking new. *Customers Research Staff, General Motors, Inc., Detroit, Michigan.—Gratis.*

THERMOCOUPLE DATA BOOK AND CATALOG is a 32-page manual for thermocouple users. It lists various types of commercially available thermocouples and accesssories and gives valuable information on their design and use. Bulletin No. S2-3, *Wheelco Instruments Company, Harrison and Peoria Streets, Chicago, Illinois.—Gratis.*

HOW TO RUN A LATHE is the 41st edition—128 pages, over 365 illustrations—of this popular book, complete with a number of changes which bring it completely up to date. It covers lathe operation, grinding tools, making measurements, boring, drilling, and so on, plus reference tables. *South Bend Lathe Works, South Bend, Indiana.—25 cents.*

CARBOLOY TOOL MANUAL is a 32-page thoroughly illustrated bulletin covering such aspects as tool design, application, grinding, brazing, and tool handling. *Carboloy Company, Inc., East 8 Mile Road, Near Van Dyke, Detroit, Michigan.*—Gratis to industrial readers, libraries, technical schools, and colleges. Request this bulletin on your letterhead.

MAGIC BOTTLES is a 20-page illustrated booklet describing specifically the uses of compressed gases in aviation for such purposes as fire fighting, oxygen supplies for high altitude flight, and life-saving rafts and vests. *Aviation Division, Walter Kidde & Company, Inc., 140 Cedar Street, New York, New York.—Gratis.*

FLUORESCENT ACCESSORIES is a folder describing a complete line of fluorescent lamp starters, lamp holders, starter sockets, and other devices for use with these increasingly popular light sources. *General Electric Company, Appliance and Merchandise Department, Bridgeport, Connecticut.—Gratis.*

CASCAMITE WATER PROJECTS, by William F. Crosby, is a folded sheet describing plans which are available for the construction of small boats, water skis, aquaplanes, a sailing skiff, and an ice boat. *Casein Company of America, 350 Madison Avenue, New York, 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"

THAT the equatorial type of mounting for telescopes is superior to the simple alt-azimuth mounting is something which many of us take more or less for granted. The alt-azimuth has two axes, one vertical, the other horizontal, and, in order to make it follow a star across the heavens, the observer must keep moving it in two directions—the "up," or else the "down," direction (altitude), and the "across" direction (azimuth). For ordinary small telescopes this manipulation is not so bad as it sounds, since the two little movements are made quickly and in a sort of stairway pattern. Many who have used both types of mountings defend the alt-azimuth with vigor against all who pick on it. They don't claim that it is better than the equatorial, or even quite so good, but they do assert that, in some ways, it is almost as good, and that in any case it is not to be looked at down the nose.

However, when the telescope is to be driven mechanically, and especially when it is to be used for photography, an equatorial mounting, having one axis parallel with the Earth's axis and the other at right angles to it, is a necessity; for here the alt-azimuth is, or thus far has been, out of the running, since it will not make the necessary double corrections automatically.

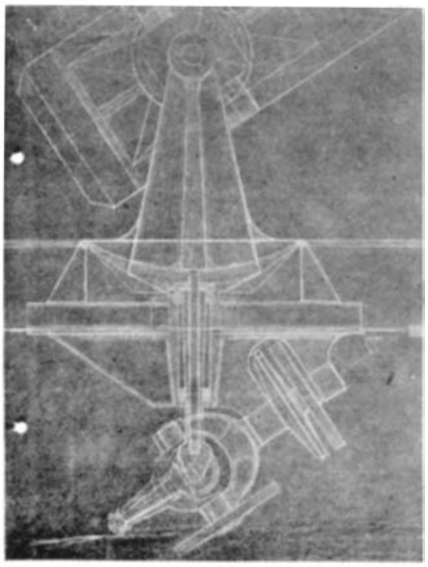


Figure 1: **Original sketch, 1936**

This is one reason why all our great telescopes are equatorially mounted.

This situation struck A. B. Hendricks, Jr., 115 Wendell Ave., Pittsfield, Mass., one of the earlier followers of the amateur telescope making hobby, as remediable. Why not use a mechanical linkage that would combine the altitude and azimuth motions automatically into a single, smooth equivalent of the equatorial motion?

After some study he drew up the simple sketch shown in Figure 1 (taken from an old notebook and therefore not in ideally reproducible form). In the upper part of this sketch is a telescope tube mounted on a vertical axis which rotates in azimuth. This vertical axis is driven through a linkage from another axis set diagonally (parallel with that of the Earth) and therefore an equatorial axis. Hendricks, when he sketched this proposal in 1936, called it a "transformer, equatorial to alt-azimuth." The diagonal element is driven at a uniform rate. The object sought is essentially to drive the altitude and azimuth at the desired *non-uniform* rates. In 1936 this sketch (Figure 1) was offered, through R. W. Porter, for the 200" mounting, but it proved that this type of mounting had already been considered by those who were designing the telescope, but not employed because of the difficulties involved in over-

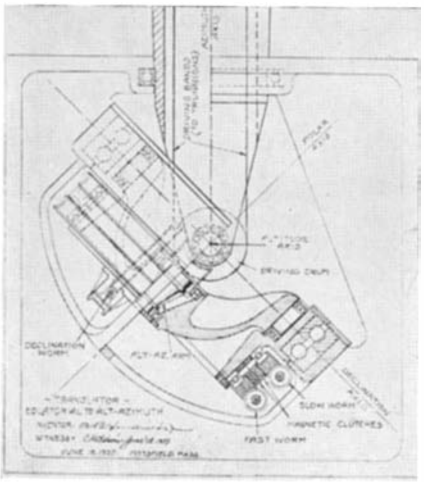


Figure 2: **Subsequent version**

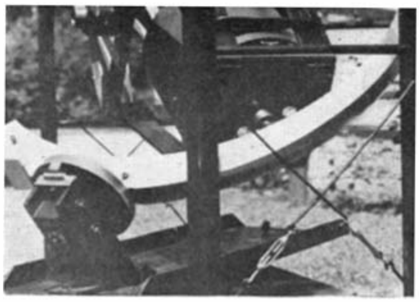


Figure 4: **Polar axis and bearing, setting and az circles, rear of tube**

coming the rotation of the image on plate, inherent in it.

A year later Hendricks evolved the proposal shown in Figure 2 (another notebook sketch). This again shows a miniature equatorial placed below the alt-azimuth. In Hendricks' language, "the arched declination axis carries, pivoted within it, a spindle rigidly connected in a radial direction to the driving drum, which in turn is pivoted horizontally in the lower end of the azimuth axis on ball bearings. The horizontal component of the motion of the declination axis is transmitted directly to the driving drum, and through the axis of this drum (altitude axis) to the hollow vertical spindle (azimuth axis). The vertical component is also transmitted directly to the driving drum and thence through the steel driving bands to the telescope trunnions, through a cross-shaft within the pedestals, and two additional sets of drums and bands. Some parts are shown in half section."

In 1936, Hendricks had discussed the problem with H. F. Morse, Sasco Hill, Southport, Connecticut, and Morse set off

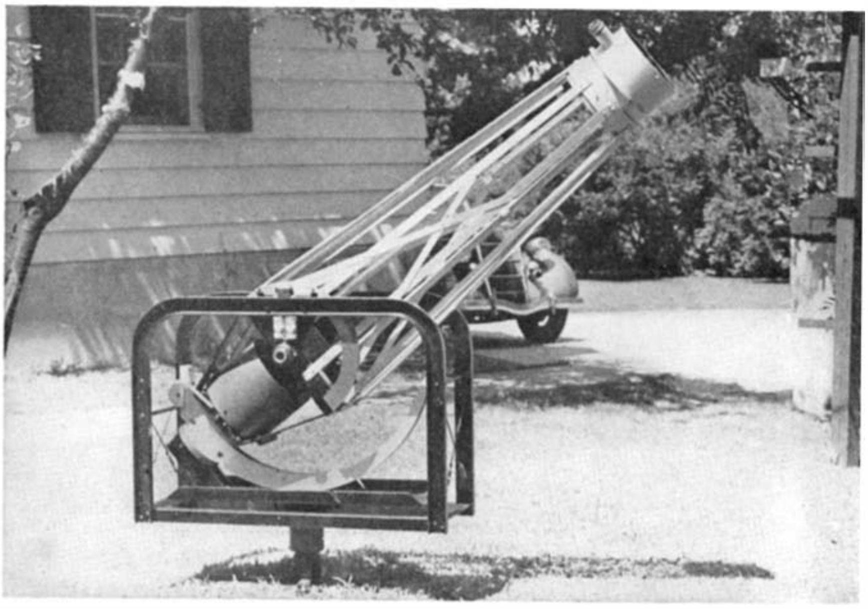


Figure 3: **The altogether unique Morse alt-azimuth mounting**

to accomplish the equatorial-to-alt-azimuth transformation in an entirely different manner (Figures 3, 4). He made the telescope mounting shown, and has exhibited this telescope several times at the conventions of amateurs held at Stellafane, near Springfield, Vermont, where it is always surrounded by a knot of by-standers.

To many, on first seeing it, the working principle is a puzzle. The principal unique feature of the Morse mounting is the curved, scimitar-like member seen in the photographs. This is the link, in the Morse

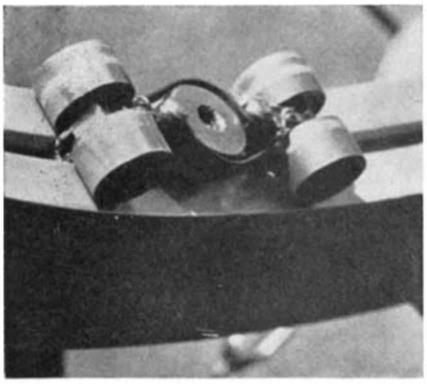


Figure 5: Close-up of carriage

version of the concept, which automatically brings about the desired transformation of uniform motion into non-uniform motion.

But let's begin at the beginning. The following is a composite of Morse's description and your scribe's efforts—errors, if any, being chargeable to the latter.

At the very bottom (Figure 3), almost hidden in the grass and the shadow, is a bird's-foot base, holding in its center a short, stubby, vertical shaft.

Supported on this shaft by Norma-Hoffman ball bearings is a large rectangular frame of fabricated metal, which can be rotated about this vertical axis.

Near its top part this frame supports the horizontal axis bearings. The hollow end of one of the horizontal axis trunnions shows clearly in the photograph.

Supported on the upper end of the stubby vertical shaft of the base mentioned above, in addition to the rectangular metal frame just described, is a trough-shaped platform (see also Figure 4) which is tightly clamped to the shaft. At one end of this platform rises a diagonal bracket. This bracket contains the bearing for another stubby shaft, the polar axis shaft.

On this stubby polar axis shaft is mounted the long, curved member—the alt-azimuth circle. This curved member, which is supported only at one end, can be rotated about the polar axis just described; that is, in Figure 3, swinging toward and away from the eye (like a sickle turning in the hand when the wrist is rotated but not otherwise moved). Its radius of curvature in any such rotational position remains in the common point through which the three axes—optical, horizontal, and polar—pass.

Slidably mounted on the curved inner surface of the alt-azimuth circle is a small carriage (Figure 5). Between the two sets of wheels of this carriage is a disk with a central hole (actually, this disk is a small ball-bearing). This disk is mounted in such a way that its bore always points toward the point through which the telescope's axes pass. The telescope tube, mounted on the horizontal axis, carries, at a central point in its bottom, a short pin, and wherever the tube is pointed this pin remains inserted in the central hole of the bearing.

In Figure 3 the tube is so positioned that its optical axis coincides with the polar axis and *in this one special position alone* the curved member can be swung without moving the tube. However, when the carriage is moved along the curved member (Figure 4), and the curved member is then moved (by rotating the short polar axis at its end), the optical axis is caused to rotate around the fixed polar axis and the telescope is automatically constrained to follow the star toward which it is directed.

Another way to explain this unique drive would be the following: Follow a star for a time by means of an ordinary alt-azimuth mounted telescope. Then the trace of a given point at the rear of the mirror would take the form of a curve like the curved member of the Morse telescope.

When handling the tube of this telescope one has the feeling that an invisible spook also has hold of it, since it resists attempts to move it in any direction other than one which would follow a star. For example, if one tries to move it only in azimuth, it insists on moving at the same time in altitude. The "spook" is the curved guiding member.

What advantages does Morse claim for this mounting?

"The object," he states, "was to avoid certain inherent shortcomings in large equatorial mountings.

"Estimates indicate a much lower cost. Materials could be better used—with lessened total weight.

"Because there would be no transfer of weight from one bearing to another, there would be no distortion of parts.

"Because of ease and flexibility of the adjustments, less precision work would be required on various details.

"Astronomers would work in an always level position and in a constant temperature room at either end of the horizontal axis, where light could be directed with three reflections.

"Because the tube moves about the horizontal axis in one plane alone, the tube could be made very rigid and at the same time relatively light. The whole instrument could be floated in an annular tank of mercury, thus leaving only enough weight on the annular track (precision ground) to insure accurate rotation around the vertical axis."

AMATEURS who aspire to build 200" telescopes usually start more modestly, say with a 100" telescope, and work up by 100" stages. Erl A. Dart, 2466 S. Bannock Street, Denver, says he had never before built a complete telescope, so he simply started right out on the 200" telescope shown in Figure 6. The job consumed 60 hours of time, $4 worth of brass and two watch crystals (for the mirrors): it's a model, 3/32"=1 foot.

IF you don't want to buy, or in present times can't buy, a synchronous motor for a telescope drive, there is a way to make one yourself, and C. J. Myers, 417 N. Virgil Ave., Los Angeles, Calif., explains it thus:

"It may be that most amateurs are not aware that almost any AC motor can be converted into a synchronous one. A washing machine motor, fan motor or, for that matter, any squirrel cage motor will do.

"All that is necessary is to determine the number of poles and cut an equal number of flat spots on the rotor. For example: a 4-pole motor would have a rotor divided into 8 equal spaces. Cut every second or alternate area down about 3/16". The easiest way to do this is to set the rotor off center in a 4-jaw chuck—although a milling machine will do a better job, as the rotor should be balanced afterward. The motor will now have about one-third its original H.P. at synchronous speed.

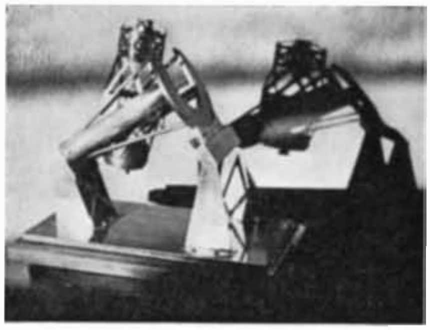


***Figure 6:* The 200" and its ghost**

"The number of poles equals the frequency × 2 × 60 divided by the nearest synchronous speed up (based upon the number of cycles).

"Most small motors are 4-pole. If the rotating element is cut, it should be balanced. The usual method is to have two parallel knife-edges (any sharp straight metal) on which the motor is rested on its bearings. Small holes are drilled in the heavy side until it will come to rest in any position.

"The governor fly balls on all generators at Boulder Dam are driven with this type of motor. The speed drift is about the lowest in any power house built today."

Asked to supply a little background data on motors, Myers writes: "This motor speed business seems to confuse a lot of people. All motors having salient poles (with teeth) run synchronous. All motors with round rotors (without teeth—smooth) will have a definite slip below synchronism in proportion to load. This is where my formula comes in. Usually the name plate on this class of motor indicates the speed at full load. For example: the synchronous speed for a 4-pole motor, on 60 cycles, is 1800 rpm, but the average motor runs 1760 rpm. The same motor on 50 cycles synchronous is 1500 and the motor runs 1440. The formula for a synchronous motor is frequency × 2 × 60 divided by number of poles. In other words, any motor that is converted will speed up about 5 percent. Any good winding shop could change the number of poles within limits depending on the size of the motor."

NO convention of amateur astronomers will be held at Stellafane, Springfield, Vermont, this summer. Reason: War. Few could attend because most amateurs are doing war work (also saving tires). Springfield itself is too busy (working seven-day weeks) and too overcrowded to entertain.

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Printed at Williams Press, Albany, New York, U.S.A.

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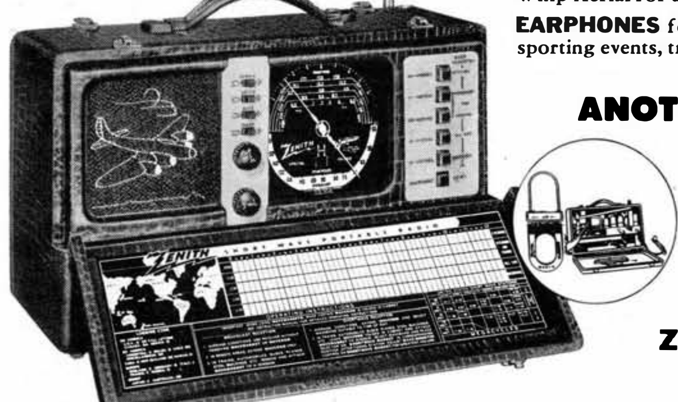
FIRST TIME! Zenith Famous Radiorgan Tone Device on a portable radio.

RESULTS—in test air flights, train trips and cruises, have amazed even the country's best radio research brains.

TESTS—in far-away vacation, fishing and hunting locations where daytime radio *broadcast* simply is not heard—showed *short wave* radio bringing in favorite programs direct from New York, Boston, Schenectady, etc., over the super-distance air waves.

POWER—from self-contained battery and standard lighting current ingeniously interchangeable at a second's notice. Also, Telescope Whip Aerial for use in getting *extra* distance.

EARPHONES for privacy. Special low impedance earphones for sporting events, traveling and the hard of hearing (extra equipment).



ANOTHER GREAT ZENITH FIRST

ZENITH

TRANS-OCEAN CLIPPER

ZENITH DE LUXE COSTS MORE —BUT *DOES* MORE

ZENITH LONG DISTANCE RADIO . . . ALWAYS A YEAR AHEAD

Time is short. In the beginning, we had *years* in which to prepare. Then it was *months* . . . next *weeks.* Now, *seconds* count. Not only must we "Keep 'Em Flying!" but we must keep 'em flying FASTER. That is the objective of every man, woman and machine at SKF. As a result, an endless stream of ball and roller bearings flows from the SKF factory to the insides of warplanes all over America. The time to *waste* time has gone forever.

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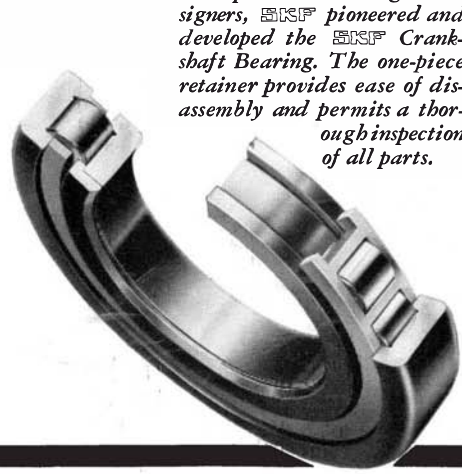
SKF INDUSTRIES, INC., PHILADELPHIA, PA.

SKF
BEARINGS



• *In cooperation with engine designers, SKF pioneered and developed the SKF Crankshaft Bearing. The one-piece retainer provides ease of disassembly and permits a thorough inspection of all parts.*