KETTERING ON WAR-POWER . . . Page 4

SCIENTIFIC AMERICAN

JULY • 1942

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Photo by Robert Yarnall Richie

Aerial Horsepower

Research workers on war problems may find the answer in the following list

Metals:

Aluminum castings corrosion protection
Foundry cores
Joint seals for pipes
Aluminum drawing lubricant
Tin stamping lubricant
Nickel alloy stamping rust prevention
Metal surface protection
Drawing and stamping of nickel alloys
Sintered bearing lubricant

Paper:

Transparent coating
Waterproofing liquid
Flameproofing agent
Translucent paper
Wax coating

Textiles:

Transparent coating
Olive oil substitute
Waterproofing liquid
Textile lubricant
Flameproofing agent
Flexibilizer for cotton braid
Dye solvent
Textile emulsions
"Nylon" and "Vinyon" lubricant
Worsted and spun rayon lubricant

Ceramics:

Binder for ceramic insulation
Protective coating against mechanical abuse
Binder for vitreous enamels
Binder for abrasive wheels
Binder for porcelain enamel frit

Pharmaceuticals and Foods:

Edible emulsifying agent
Non-staining ointments
Edible fixative oil for candies
Binder for yeast tablets
Enteric Coating
Polish for tablets and pills

Adhesives:

"Cellophane" and cellulose acetate adhesive
Tissue paper to aluminum adhesive
Adhesive for rubber to cloth
Thermosetting cement

Paints, Varnishes, Colors and Pigments:

Pulp color and pigment dispersing agent
Flatting agent for paints and varnishes
Emulsion paints
Lacquer and varnish plasticizer
Soft grinding of lake colors
Increased length of pigment lakes
Non-mar enamels
Water and ink resistant lacquers

Rubber and Synthetic Rubber:

Gasoline resistant finish
Rubber gasket lubricant
Rubber to cloth adhesion
Polishing of hard rubber
Plasticizing synthetic rubber

Cork:

Cork preservative

Cements:

Waterproofing agent

Wood:

Warpage prevention
Flameproofing

Leather:

Sulphonated oil substitute

Plastics:

Plasticizer and lubricant
Polishing
Lubricant for molding

Miscellaneous:

Wax which will not melt in boiling water.

Substitute for Montan Wax, Ozokerite, Japan Wax and other imported waxes.

Dry preservation of anatomical and pathological specimens by the use of a water miscible wax.

Synthetic oils dispersible in water that do not contain soap, or added emulsifiers.

Emulsifying agent for emulsions stable to strong acids, salts and other electrolytes.

Photographic offset plates are improved, giving increased water solubility, spread and wearability by the use of a new type of binder.

Defoaming agent for casein, gelatine, shellac and similar products.

Wax which "dissolves" in hot water.

Oil which remains fluid at —50° C. without freezing.

Abrasive wheels. A temporary binder for abrasive wheels which completely volatilizes on firing.

A wax which combined with oil soluble dyes serves as a light filter and watch glass holder in the dissection of small organs and organisms.

A number of glycerin substitutes meeting specific requirements are now being marketed commercially.

Lanolin for industrial purposes can be replaced by a new compound made from domestic raw materials.

In laundering white garments, if the filler is washed out, the original stiffness and body can be restored by a new water soluble, colorless synthetic resin.

A liquid foam producer to replace Saponin for industrial purposes, is now being offered.

A hygroscopic, water soluble liquid which is an excellent dye solvent and which replaces glycerin in many instances.

Gum Tragacanth Ribbon is being replaced by a new edible gum of domestic origin.

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"HORSEPOWER is Warpower," see page 4, is symbolized by our front-cover illustration of an Allison-powered plane of the United States Army. This striking photograph was made by Robert Yarnall Richie and is reproduced through the courtesy of the Curtiss-Wright Corp., Propeller Division.

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SCIENTIFIC AMERICAN

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

JULY • 1942

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50 Years Ago in . . .

(Condensed From Issues of July, 1892)

PATENTS—"Disparagement of patents is common and easy but it should not be forgotten by those who sneer at inventors that, out of a total of over $8,000,000,000 of capital invested in manufacturing in the United States, patents form the basis for the investment of about $6,000,000,000. Evidently, the United States system of encouraging invention that has resulted in the patenting of over 475,000 inventions, is a system that is exceedingly wise and valuable."

CENTRAL SCREWS—"A new ship has just cast anchor at the Louvre wharf—the steamer *Louvre,* built by Mr. Oriolle of Nantes. When loaded it sinks but 2.8 meters in the water, and is consequently capable of ascending the Seine with a full cargo. This quality is not the only one that makes a truly

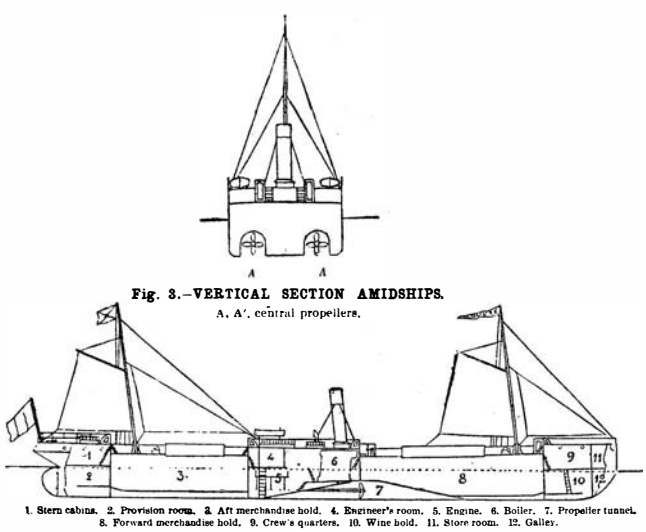


Fig. 3.—VERTICAL SECTION AMIDSHIPS.
A, A', central propellers.

1. Stern cabins. 2. Provision room. 3. Aft merchandise hold. 4. Engineer's room. 5. Engine. 6. Boiler. 7. Propeller tunnel. 8. Forward merchandise hold. 9. Crew's quarters. 10. Wine hold. 11. Store room. 12. Galley.

original ship of the *Louvre*; it is the first ocean vessel provided with two central propellers . . . These two propellers are placed a little forward of the center of the vessel . . . Each revolves in a sort of tunnel having the form of an inverted U . . . The propellers, which are 1.8 meters in diameter, and of 2 meters pitch, in revolving suck the water in front and force it aft. As the tunnels are not closed at their lower part, the cavities that they form on each side of the center of the vessel increase the stability of it."

WRECKED—"The schooner Henry B. Tilton was recently wrecked off the United States Army Ordnance Proving Grounds, at Sandy Hook, by a 575 pound projectile which went astray after leaving the muzzle of a 10-in. breech-loading rifled cannon. The projectile struck the vessel on the starboard counter, crashed through her longitudinally as if she were an eggshell, and before the crew realized that the craft had been struck, the water poured in through a great splintered hole in her port bow, where the shot had emerged."

AIR LOCOMOTIVES—"A compressed air locomotive is reported to have been successfully used for several months in the interior of the Old Eagle Mines, near Pittsburgh. . . . Generally the construction is the same as a steam locomotive, with the omission of the boiler and water tank, these being replaced by two large cylindrical tanks holding the compressed air. . . . The locomotive carries air at 500 to 600 pounds pressure but ordinarily the pressure varies from 250 to 450 pounds. . . . If charged to 500 pounds, the engine can make a distance of 1 1/3 miles, doing heavy work, and it is practicable to make a running capacity of 4 miles with one charge."

SHIP BUILDING—"On account of the contracts undertaken by the Union Iron Works in the building up of our new Navy, the establishment now occupies a position of much general interest. Here in South San Francisco were built and equipped the highly successful cruisers *Charleston* and *San Francisco*, and here also was built the monitor *Monterey,* now receiving her finishing touches, and being supplied with what are believed to be some of the most perfect of high-powered guns yet made anywhere. In addition to this work there is now on the ways one of the largest of the new battle ships, the *Oregon*, to have a displacement of 10,000 tons, and to cost, exclusive of armament, nearly four million dollars."

CABLE—"The United States survey steamer *Thetis* arrived at Honolulu on May 20 from Hilo, where she ended the survey for the cable to be put in between San Francisco and the Hawaiian Islands. The course to Hilo comprised 2,060 miles. . . . The soundings were made at intervals of two, ten and sometimes one mile apart. The deepest was 3,228 fathoms, about 245 miles northeast of Hilo, and the shoalest was 976 fathoms, at a point about 350 miles from Point Conception. Were it not for this abrupt rise, the course would have been almost level."

TEMPLE ROCK—"For more than 2,000 years, a dressed stone containing 12,922 cubic feet—being 71 by 13 feet in size—has rested on pillars in a quarry of Baalbac, in Syria. It was intended for the foundations of the temple of the sun, a mile or more distant, to which four stones nearly as large were actually transported."

GUM CHEWING—"It is a curious fact that in England they do not chew gum but rather look down upon the habit as being vulgar, and of the small quantities that have been shipped abroad, but little has been sold. The time doubtless will come, however, when this democratic habit will overcome the prejudices of our cousins across the water . . . Already Australia has thrown up her hands, and decided that gum is a necessity, and American manufacturers are working that market for all it is worth."

CAMERAS—"While it may be too early to say the old-time plate-holder camera has had its day, it cannot be denied that magazine cameras of various kinds are superseding the old-fashioned camera, especially among tourists and others who desire to accomplish a great deal photographically in a very short time."

AURORA—"Experiments made at the Royal Danish Academy have demonstrated approximately the height of the aurora borealis. M. Adam Paulsen, at Godthaab, by means of two theodolites situated four miles apart, found that different aurora displays varied from one to four miles in height. Experiments near Cape Farewell showed the height of different auroras to vary from one to ten miles. At Spitzenberg the range of height was from one-third to eighteen miles."

OUR *Point* OF VIEW

MASTER SCIENCE — IN WAR, IN PEACE

As most middle-aged and older readers will recall, the chemists were the fair-haired boys in World War I. Today, in World War II, the fair-haired are the physicists —exalted to the level of a kind of war nobility. As the chemist, President Conant of Harvard, has said, it is a physicist's war. (In fact, the chemists are being treated shabbily. The secretary of the American Chemical Society, Dr. Charles L. Parsons, states that several hundred chemists and chemical engineers, including some with seven years of training and additional years of experience, have been inducted into the Army and are now functioning as stretcher bearers, orderlies, pharmacists' clerks—their costly training lost to the nation. These tragedies have been caused by local draft boards which probably don't fully comprehend that a chemist is a basic tool of industry. Yet all efforts to remedy this situation have completely failed, in spite of the fact that the entire matter has been forcefully presented to high authority. This is a physicist's war but chemists still are highly vital to its conduct.)

Day and night, behind locked doors and under watertight oaths of secrecy, the majority of this nation's outstanding physicists are hard at work at what may prove to be the key to the war effort: Canny applications of the interactions of matter and energy—that is, of the science of physics—directed toward the single aim of cracking Hitler.

In the systematic search for the ablest physicist workers, the personnel of physics has been combed over again and again, and now the nation is to be fine-tooth-combed for physicists of lesser degree clear down to the rank of high-school graduates and even below that. Officers and faculty members of high schools are being officially urged to single out youths who have shown innate aptitude for physics and its working tool, mathematics, and to direct their interests more actively into these channels with two ends in view: the help which these youths may later (but not much later) lend to the war effort, and their own peacetime futures in the one science which now seems most likely to be the great science of the future.

Just why is World War II so greatly a war of physics, and in what exact ways are the physicists so close to the core of it? This can be told only approximately at present and, for the rest, the answer must be simply: Hush. Let the War Policy Committee of the American Institute of Physics, representative of the whole body of American physicists, state it: "The present and potential contributions of physics may well have a profound effect on the outcome of the war because new tools have been devised which can swing the tide of victory. These tools utilize results of research in electronics, electric waves, acoustics, mechanics, and optics. Physicists have devised them, and engineers have shaped them for manufacture, and manufacturers are producing them." Top physicist of those who are participating in these defense—or rather, offense —research efforts is Dr. Vannevar Bush, Director of the Office of Scientific Research and Development (OSRD). He has commented on this question most succinctly: "OSRD members listen and do not talk."

As long ago as last October three fourths of the outstanding physicists were heading OSRD research projects for war offensive uses. Since December 7 that percentage has run steadily upward and the need for physicists now increases at the high rate of 1500 to 2000 per year.

In addition, there now is a special need for 100,000 or more individuals who, while not full physicists (eight years of training and experience), are well enough schooled in physics and mathematics to accept training in technical war operations. This is why the governing body of American physics urges a search among ordinary student bodies—college undergraduates and high school—for those who have innate aptitudes in these subjects. (Mathematics is the most important tool of physics.) Our readers may do a service in helping to sleuth out such youth and perhaps influence them, not only to help now, but, if they prove to have special abilities required in large enough measure, to become physicists for life.

Here one may well inquire about the moral responsibilities involved in influencing another's life. Will physicists not become worth but a dime a dozen after the War? Admittedly, some temporary helpers will, but those of them who prove to be born physicists never will. For the physicist—the first-class or research physicist—has a mind and makeup which simply cannot be made to order. To begin with, it must be decidedly a first-class mind. Then an analytical mind. Objective. Free from emotional bias. Capable of dealing in abstractions. In addition to these there is a something, often remarked by scientists—a matter largely of attitudes and outlook. The born physicist is in part detached from reality—he lives in an ivory tower. This explains why he is not well understood by practical people and why he stumbles across so many impractical findings that later turn out to be eminently practical. His mind is altogether free. It soars, though under full control. Sometimes the physicist's mind seems to conventional minds just slightly crazy—usually a matter of wrong emphasis! Crazy like a fox.

A youth who exhibits some aptitude for physics but not enough to become a peacetime research physicist will not in any event have wasted his time. As the Institute of Physics states: "The study of physics (irrespective of any post-war career) is immeasurably helpful in any walk of life, because such study improves the ability to understand the new physical environment which man is creating for himself, and which, far more even than now, is bound to exert a major influence upon social, political and economic trends. Great new developments now appearing behind the veil of secrecy are, beyond all possibility of doubt, establishing the basis for unprecedented peacetime applications of physics in industry. Some of the greatest of these are along lines not yet developed as branches of engineering. They give promise of opening large and fruitful fields for the useful and profitable employment of those well equipped with a broad, fundamental training in physics." In Scientific American last May, Dr. E. U. Condon, Associate Director of the Westinghouse Research Laboratories, explored phases of the same general subject. First-class research physicists can never become a dime a dozen: They are counted only by dozens.—*A.G.I.*

98TH YEAR SCIENTIFIC AMERICAN JULY 1942

HORSEPOWER IS WAR POWER

How American Industry is Powering Our Military Machine

CHARLES F. KETTERING
Vice President of General Motors Corporation, in charge of Research

TODAY'S machine war is horsepower war. It is important for Americans to remember this, because we have available more horsepower per individual than any other nation on earth. We are the world's largest producers and consumers of horsepower. We produce enough power in peacetime to supply 15 horsepower to every man, woman, and child from Maine to California and from Canada to the Gulf. Automotive engines alone supply more than 65 percent of this horsepower in peace.

With the coming of war the power available per individual is stepped up to even greater quantities. For every soldier in a modern mechanized division there are 32 horsepower behind him, twice as much as in time of peace. We call this the machine age; we really are living in the horsepower age.

One of the most important things about horsepower is the fact that man by himself possesses so little of it. While the strongest athlete can exert as much as two and a half horsepower for perhaps a minute at a time, he is good for only about one tenth horsepower in sustained effort. The fact that this amount of power is barely sufficient to turn a 12-inch electric fan will give you some idea of what a small amount of power we can produce by our own muscular effort. Just to make your toast in the morning requires more power than five able-bodied men can generate by turning an electric dynamo. The American housewife, although she probably never thinks of it in this way, has in her home the equivalent of at least 60 servants in electrical appliances to do her bidding. If we add to these 60 servants the 75 or a 100 equivalent horses stabled in the family garage, we see that the typical small American home can boast a staff that would certainly have been the envy of any Medieval castle.

Naturally, these tireless, obedient, reliable servants did not spring into being by magic. There are years of trying and failing and trying and failing and of slow, patient accomplishment behind every one of the thousand little conveniences which we today accept as a matter of course. Our conveniences are the concrete result of industrial research in action.

Since before recorded history man has searched for means of augmenting his puny one tenth horsepower. The lever, the inclined plane, the screw, the pulley, and the wheel provided him with the means of extending the usefulness of his natural muscle power, but they did nothing to increase it. These five fundamental devices, upon which all machines are based, may be considered as extensions of man's facilities, just as the first stone he threw was in effect an extension of the striking power of his arm. In the same sense, the sling which David used with such effectiveness against Goliath, the long bows with which the English farmers routed the French armored knights at Agincourt, the crossbow, the catapult, and the battering ram were simply extensions of man's own muscle power.

THE first significant increase in the amount of power which man brought under his control came when he learned to domesticate animals. With the domestication of the horse, man increased his power tenfold, and he took the first step toward becoming a controller rather than an expender of power. There are few animals that have not at one time or another lent their muscle power to the tasks man proposed. Even the bird—usually thought of as the freest of all creatures—was conscripted to his purposes, carrier pigeons supplying the original airmail service. Hannibal was among the first to use this new source of animal power for war. The elephants with which he startled the Romans in 218 B.C. were simply the forerunners of the present-day tanks. Later, Ghenghis Khan — still the champion conqueror of all time—swept westward through Asia and Europe with great armies mounted on Mongolian ponies. But even more important than his cavalry, Ghenghis brought with him a fantastic new toy, the Chinese firecracker.

HERE was an altogether different source of power. There was nothing muscular about it. A small child could set off, as easily as a grown man, a charge of sufficient force to blow up a whole fort. It was entirely unlike anything that had existed before. Man had discovered how to harness the terrific energy of a chemical reaction. While he had increased his power tenfold by taming the horse, he was now able to increase his power a hundredfold or a thousandfold by taming the chemical animosity of saltpeter, sulfur, and charcoal.

There was another significant aspect to the discovery of gunpowder. Unlike the wind man had used to propel his boats or the water he had used for pumping or grinding grain, gunpowder provided him a form of power that was extremely compact and mobile, that he could use whenever, wherever, and however he wanted it as long as he kept it dry. This becomes especially significant when we understand that the internal combustion engine is simply a first cousin of the cannon. As a matter of historical fact, the first internal combustion engine was a gunpowder engine invented by Christian Huygens, a Dutch scien-

tist, in 1680. There is no essential difference between a cannon and the cylinder of a modern gasoline engine. The piston is simply an adaptation of a shell with a connecting rod attached to it in such a way as to restrict its movement and provide a means of transmitting its power. And the reaction of gunpowder in the presence of heat is no different from the reaction of gasoline in the presence of the spark from a spark plug. You can say that the automobile you drive is run simply by six rapid-fire cannon arranged in such as way as to give you a smooth flow of power at the wheels.

The development of the gasoline engine followed naturally from the discovery of gunpowder. The horsepower which one man could control and direct to do his tasks had now grown to enormous proportions. Manpower, particularly in warfare, had become a relatively inconsequential matter. The French army was certainly numerically superior to the German, but the *panzer divisionen* was as radical an innovation in horsepower as Hannibal's elephants or Ghenghis Khan's ponies. German airpower was numerically superior to the British, but last fall's scheduled invasion of Britain failed because a few Spitfires and Hurricanes had enough well-utilized horsepower to hold off a greater number of Messerschmidts and Stukas.

The soldier of today is still a puny one tenth horsepower machine, but he now uses his one tenth horsepower to direct the greater horsepower which these new weapons have given him. He is like the tiny grid impulse which regulates the heavy plate current of a vacuum tube so that the sound of a pin drop can be amplified and magnified until it booms like a clap of thunder.

Tanks, trucks, planes—millions of horsepower

WORLD WAR I was simply a great proving ground for two power-using weapons—the tank and the airplane. As with every new thing, no one foresaw the possibility that these two weapons would entirely change the existing methods of warfare. Land war had become a contest of endurance between large masses of troops in trenches. All movements were made slowly and in one plane of activity. Because the general acceptance of a new thing is always slow, no one realized that these two weapons, which augmented the feeble power of the foot soldier with that of the internal combustion engine, at once made it possible for him to move swiftly and in any direction he chose. The airplane took the lid off every fortress and island in the world.

Then one man who did not know anything about engineering completely changed our ideas of a fixed warfare and made us accept these new weapons for what they are. He started a program to build 20,000 tanks and 20,000 airplanes and even wrote a book telling people exactly what he was doing. Everyone said he was crazy. When he finally got his 20,000 tanks with from 100 to 400 horsepower each and his 20,000 airplanes with 1000 horsepower each, he was able to substitute horsepower politics for ordinary diplomacy. So far, horsepower has won every battle. Now our job is simply to produce more horsepower than he can.

Time will show that the Axis picked the wrong opponent when they picked the United States to fight a horsepower war. We have the greatest power-producing facilities in the world. The automobile industry, for example, has produced over 80 million vehicles since 1900. If we say that each of these averages 50 horsepower, which is a very conservative rating, we see that we have produced four billion horsepower for use on our highways alone. In one average year we have produced over 200 million horsepower. We have about 40 million horsepower installed in electric power plants. These plants light our homes, streets, and factories; they provide power for our industries; they distribute electrical energy for our great communication systems. In a hundred ways they furnish the power to make our American way of life possible. Forty million horsepower is a lot of power, but it is less than one fifth of the amount of power the automobile industry turns out in an average year. In other words, it takes us less than three months to duplicate all the power production of all the electric power plants in the country.

WHEN military men ask for huge totals of power to win the war, they are not speaking in unknown terms to the automobile industry. When we needed 200 million horsepower a year to keep our American way of life in peace, industry produced it. We have learned, better than any other country, the mass production of power. Every bit of this accumulated experience, together with all the resources of management, machinery, and labor, is being used to produce more and still more horsepower to win the war.

Let us examine the difference between a division in World War I and a modern mechanized division and see if we can gain some idea of the magnitude of the job industry is called upon to perform.

The old division used 4400 horses and 153 motor vehicles of about 3500 total mechanized horsepower. The modern mechanized division, with fewer men, has 2700 vehicles ranging

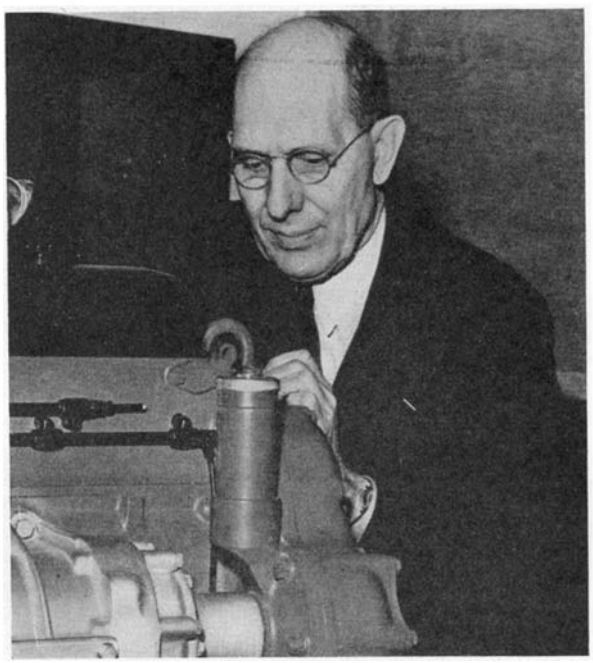
in size from the motorcycle to the heavy tank. More than 400,000 horsepower are available. The old division moved at 3 or 4 miles per hour with 25 miles a long day's advance. The increase in power of the new division gives it a speed of from 25 to 60 miles per hour, and it can easily travel 250 miles in a day. The old division required 39 tons of ammunition per day. The new one 600 tons. No wonder the *panzer divisionen* struck such terror in the hearts of the French soldiers.

This 400,000 horsepower represents the effort that could be exerted by 4,000,000 men. And the mechanical equipment —tanks, trucks, jeeps, peeps, and motorcycles—are no more tired at the end of a long day's advance than they were in the morning. The mechanized division is made up of about 12,700 men and officers with an average of 32 horsepower available for each man. This power is used to increase the soldier's speed and mobility, carry more and heavier guns, and allow for heavier armor to protect him in battle. Each man has available an average of the combined power of 320 men. In a tank, he may have the equivalent of 1000 men acting from his orders.

Many of the vehicles necessary for a mechanized army are now being produced in large quantities and have been for the last year. Other and newer types will soon be in large scale production. For a long time the army has worked with industry to build the vehicles that will be necessary. As we have repeatedly pointed out, it takes time to get an entirely new product into production. Even with industry's great skill in methods of producing horsepower, it does take time to get through the "tooling up" stage. Now that industry is gearing itself to the wartime pace, it is producing horsepower in ever increasing millions. It is easier to criticize others for not doing more, than it is to do. A critic doesn't have to convert a plant overnight from peacetime to wartime production. He doesn't have to design and build tools and dies, make production schedules, train workmen, meet government specifications, and build a product that will pass the rigid inspection of the Army and Navy. And all the while he is working he does not have to be on his guard against talking about his accomplishments. The results are a military secret and have seldom been released. This is entirely as it should be if we are to prevent valuable information from getting to our enemies.

Let us go further and show what this war of horsepower means in the newest form of fighting machine, the airplane. Here the figures are just as astronomical as they are in the mechanized army division.

In World War I, a basic training plane used a 90-horsepower engine. This engine, the Curtiss OX-5, became the standard power for "barnstorming" after the war. The OX-5 engine weighed 375 pounds, or more than four pounds per horsepower. Today a basic trainer uses a 200-horsepower engine weighing about 400 pounds, or two pounds per horsepower.



The author studies a new GM Diesel

THE most outstanding development has, however, come in the high-speed pursuit airplane engine. In World War I, the Liberty engine gained world fame and was to have become the standard high-output engine of the A.E.F. This engine developed 400 horsepower and weighed approximately 840 pounds, or more than two pounds per horsepower. It was just about the same size as the present-day liquid-cooled Allison engine which develops 1325 horsepower at less than one pound per horsepower. The development of the Allison engine was started by industry in collaboration with the army early in 1930, and it was just about ready for production when we needed it.

Far-seeing men in the United States Army asked industry to undertake this development even though there seemed to be no immediate use for the engine at the time. What is important to us now is that all the preliminary work was completed when the engine was needed. There is no way to speed up such development. Two hens can't hatch a setting of eggs any faster than one can. This is a fundamental factor that many people overlook.

The development of this new liquid-cooled engine has meant much to Army aviation. As a result of this development it was possible to increase the speed of a pursuit plane as much as 60 miles per hour on the same number of gallons of fuel per hour. It has taken only two years to increase its power from 1000 to 1325 without any significant change in the design, and this may be increased even further.

What does the huge air force the President asks for mean to us? He wants 60,000 planes in 1942 and 125,000 in 1943. Industry is being called upon to produce in excess of 100,000,000 horsepower this year and in excess of 200,000,000 in 1943 to power these planes. Let us do some more comparing and see what these figures mean. In 1942 we will have to produce as much power in aircraft engines as the combined power of all the railroads of the country. In 1943 we will have to double it. And this power will be for airplanes alone. We already have a good start. One company alone is producing over a million and a half horsepower a month in a factory built where there was a vacant corn field only a year ago.

Today a pursuit pilot has from 1000 to 2000 horsepower to pull him through the air at speeds well in excess of 400 miles an hour. In World War I the 400-horsepower engine pulled him only about 120 miles per hour. Several developments have taken place to make these increases possible. First, the aeronautical engineer has learned more about the aerodynamics of the plane itself. Better wing sections, streamlining, better materials, the reliable monoplane, retractable wheels, and dozens of other improvements have increased speeds.

But there is a limit to the increases that can be made by aerodynamics alone. It takes horsepower to fly at speeds of seven miles a minute. An engineer would say that the horsepower required goes up as the cube of the speed. In layman's language

Two Diesels operate this mobile power plant

Allison airplane engines being packed for shipment

this means that to get twice the speed we have to supply eight times the horsepower. Now we see why horsepower is so vital in obtaining air supremacy. Power means speed.

Fortunately engineers and chemists have given us the means of obtaining increased power from a given size engine by the development of better fuels. This means any engine that burns gasoline as a fuel, whether it drives an automobile, truck, tank, airplane, or motorboat. High octane fuel makes our present high-output engines possible whether they are used for peacetime purposes or for those of war.

THE story of high octane fuels has been told many times. The work grew out of my attempt to burn kerosene in a Delco Light engine long before we got into the First World War. The improvements which we effected in the fuel were made available to the automobile driver early in the 1920's. Since then improved fuels have been responsible for doubling the power we get from an automobile engine. Every driver of a car in the past 20 years has benefited from this development. It was a research project carried on by private industry and made available to motorcar owners in peacetime.

The dividends which this single development has paid to our country have been enormous. The automobile owner has saved about 25 percent of his fuel bill. This amounts to a billion dollars a year. It means also that we have conserved our natural resources. Better fuels have been responsible for just about doubling the output of a given size engine. It has been said that this has increased the installed power of automobiles by about one billion horsepower.

The T.V.A. is one of the foremost of our great power developments. This series of dams will produce about three quarters of a million horsepower, or less than one thousandth of the power gained by the use of better automobile fuels. If all our automobiles were to develop a "miss" in one cylinder at the same time, we would lose ten times the installed horsepower of all the T.V.A. dams together.

But what is extremely important to us at the present time is the fact that without these better fuels such powers and speeds as we require from our military planes would be impossible. It is not surprising that one man high in government office has said that high octane fuels may be the most important single factor in the outcome of this war.

In World War I the Liberty engine had to be designed to run on 50-octane fuel, the aviation gasoline available at that time. The Allison engine utilizes 100-octane gasoline. The difference between the 400 horsepower of the Liberty engine and the 1325 horsepower of the Allison engine is largely due to this difference in fuel.

Because American industry conducted research during peacetime, we are the only country in the world with the capacity and the know-how to produce 100-octane fuel in adequate quantities for our military airplane engines. Fuel research has already added millions of horsepower to our armed forces.

A number of years ago we started a research project with the aim of developing a high-speed, light-weight Diesel engine. We had long hoped that we could bring the benefits in economy of the Diesel to the small engine field. We did not have any particular application in mind, for we knew that any new and better means for developing power would find hundreds of users. Others would put the power to work.

In a few years a new type of two-cycle Diesel was introduced at the Century of Progress in Chicago. That was in 1933. The next year this type of engine was used to power the first of the new high-speed Diesel-powered streamlined trains. Likewise, the Navy had adopted it for submarines. This development of industrial research conducted by American industry in the regular course of its business has been found to be the answer to many naval and military problems. Continued research has resulted in still smaller and lighter high-output Diesels. This family of engines is now powering naval craft of many kinds, large trucks and buses, tanks, and mobile power plants, all for war purposes. Here is an industrial research development which is useful either in peace or in war. The engine doesn't care what it is used to power.

ONE of the most important peacetime uses of the Diesel was in the new 2000- to 6000-horsepower locomotives. This engine has revitalized the railroads and more Diesel locomotives are being built than any other type. These efficient engines, which have speeded up switching, passenger schedules, and freight shipping, are of extreme importance in time of war. We are deriving unexpected benefits from the speeding up of our war material deliveries made possible by this peacetime development. Diesel locomotives may even speed the deliveries of the same type of engine to be used by our Army or Navy for other defense purposes.

We are in a war of horsepower—of Allied horsepower against Axis horsepower. The victory will go to the side which has the most and the best horsepower producers. American industry, which has produced the most peacetime horsepower, is now producing the most wartime horsepower. Our front lines are the engineering departments, research laboratories, and factories. Able and experienced

management, skilled workmen, and engineers second to none are holding these lines. All our efforts are geared to produce power and more power for the armies and navies of the United Nations.

This is a civilization of horsepower as well as a war of horsepower. When the engines of war have fired their last charge of fuel, the engines of peace will immediately start their job of rebuilding. We will not only beat the sword into the plowshare; we will convert the tremendous horsepower of war into the useful horsepower of peace.

• • •

TIN PLATING

Thinner, More Economical By New Process

BOTH tin and electric power will be conserved by a faster, more economical electrolytic process for plating strip steel with tin, announced recently by the Electroplating Division of E. I. du Pont de Nemours & Company. Known as the Halogen Tin Process, this process employs a neutral solution which is said to eliminate sludging and the consequent waste of tin common to many electro-tinning methods.

Strip steel for containers can be tin-plated twice as fast with less electric power by this process as by the "alkaline" electro-tinning method, it was stated, thereby reducing substantially labor and power costs. A thinner, more uniform coat of tin can be applied to strip steel electrolytically than by the conventional "hot dip" method, resulting in savings of from 40 to 65 percent of the tin used.

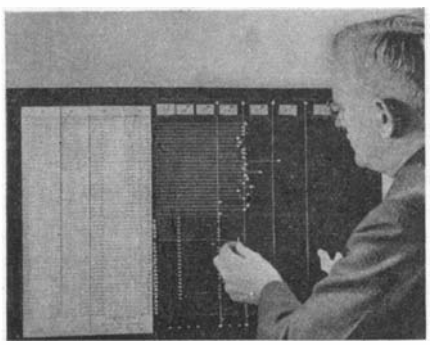
A larger percentage of tin cans henceforth will be plated by electrolytic processes because the War Production Board has limited drastically the amount of tin for containers, and thin coatings of the metal will be necessary. Tin deposited by the Halogen process, it was said, can be heated without discoloration either when tinplate is heated to obtain the bright finish required by some can manufacturers or when treated during the process of applying lacquers or enamels.

CONTROL

Of Production With New "Scoreboard"

BUSY industries in every classification, working on both war and civilian orders, are making use of a new system called "Produc-Trol" which enables production and purchasing executives to see quickly all facts concerning raw materials, parts, assemblies, machine and man hours. Information of this kind is especially essential where multiple-shift production is maintained.

"Produc-Trol", which was developed by the Wassell Organization, lists parts, assemblies, sub-assemblies, or individual operations at the left of the board shown in one of our photographs. Movable tapes working from left to right on pulleys bring all pertinent facts into instant focus. Double rows of peg holes under the movable tapes, and various colored pegs, permit many arrangements of comparative data and control, required for any operation. Units can be obtained in sizes to fit specific needs; models are also available for individual and group-incentive plans.



Keep tab on production

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MODERN INDUSTRY—Fifteen of the nation's major industries have been developed in the last 62 years, creating work for about 15,000,000 persons.

• • •

METAL FINISH

To Substitute for Plating

A COLORED transparent finish for use on polished metal, and which is unaffected by war-time restrictions, is being produced by Maas & Waldstein Company as a substitute for electroplating and bronze-powder finishes.

This finish, which is marketed as "Platelustre," consists of a concentrated enamel, of the desired color, added to a clear lacquer. When applied on polished metals, it makes them resemble copper, brass, bronze, color-treated aluminum and steel, or other metals.

It is applied by spraying or roller coating and can be furnished for either air-drying or baking. Flat stock finished with certain grades can be formed after baking. The colors are fast to light in indoor service, the manufacturer states.

CONVERSION

Of Machine Tools Calls For Fine Ingenuity

CALL it automotive "know-how" or call it conversion, the automotive industry has been faced for more than a year with the task of ingeniously adapting equipment for war jobs.

It was ten months or so before Pearl Harbor when one automotive concern, for example, agreed to produce parts for an anti-aircraft cannon In the loader mechanism of the gun, the automotive engineers and master mechanics found the greatest challenges to their ingenuity. This unit is an assembly of parts, most of which have to be machined in curves that are small segments of circles that range up to 86 inches in diameter.

Under normal conditions such cuts could have been made easily by huge milling machines with enormous rotary tables. But the smallness of the original order ruled out the possibility of using such special purpose machines. So an ingenious device was made—a fixture attached to an ordinary standard-type milling machine. It resembles a wedge of pie.

At the point of their "wedge of pie," the designers placed a fulcrum equipped with hand-screws. With this they could swing gun parts, clamped to the "piecrust," against the milling cutters.

With such unorthodox fixtures, most of the curved parts were machined for the original orders. And, having mastered the "know-how" on these ingeniously adapted machines, the master mechanics were prepared for the change of pace induced by the Pearl Harbor attack. The crisis brought the first large order for guns. They then transferred their "know-how" to similar adaptations of huge automotive rotary milling machines. These were torn down and rebuilt to make radial cuts in the large quantities required.

One of the large machines is now cutting radial loader parts, 17 at a time, out of huge hoops of bar steel.

Though no longer needed for the jobs they performed so ably, the small machines with their "fan-tail" fixtures have not fallen idle. Moved to another department, they are now executing radial cuts on curved airplane parts.—*Automotive War Production.*

INDUSTRIAL TRENDS

RESEARCH PAYS NOW . . . AND LATER

SUBSTITUTE the drive of life-and-death necessity for the dollars-and-cents motive, and there appear amazing results from the research laboratory. That is exactly what is happening in many industries today, particularly in the automotive industry where production is all-out for war and not at all for the civilian consumer who has been the basis on which the industry has been built. In the calm days of peace-time activity, when the prime interests of the industry are to make a better product than competitors and at the same time show a reasonable profit, many of the findings of the research laboratory are at least temporarily shelved because their adoption would be too costly. But when the wheels must turn for military purposes and the profit motive is thrust into the background, the laboratory technician is in his scientific glory; no longer are costs the bugbears that hinder his development work. His main objectives now become the finding of new ways of doing things better and of new materials that, substituted for old ones, are at least as good as or better than the originals.

Before we become specific about this sort of thing, let it be understood that what has been said is not to be taken as an indication that war-time production is being used as an excuse for being wasteful. Far from it. But there is a definite job to be done and all too little time in which to do it. Under such conditions, many of the peace-time rules of industry are thrust aside and barriers are overcome by means that, given other circumstances, would throw the average cost-accountant into a quiet case of jitters.

Here's where it all stems from: As is too well known to bear repetition, there are real shortages in certain materials formerly considered indispensable in the automotive industry. Before the war—how long before makes no particular difference in this discussion—there had been developed many substitute materials for these indispensables, but they had not been put into production for economic reasons. Military approval of a substitute, however, ordinarily demands that the substitute be much more than a mere alternate. It must do its given job as well as the material formerly used; if possible, it must do that job better. This, indeed, is just what many of the shelved results of many research laboratories will do. So now these shelves are being cleaned off, their contents are being brought to light, and the labs are working night and day to produce the wherewithal for the production lines of victory.

Here are some cases in point, gleaned from *Automotive War Production:* Alloy steels containing carbon and molybdenum are superior substitutes for steels using nickel, chromium, and other scarce alloying metals, but these carbon-molybdenum alloys require heat-treating processes to bring out their superior physical properties. This heat-treating is too costly for ordinary commercial production in times when other alloying materials are cheap and plentiful. But when the life-and-death motive takes charge of the situation, all such considerations fall by the wayside. Thus, one company making small combat vehicles has saved 41,000 pounds of nickel on one contract by using these steels that research had produced but which had formerly been almost a laboratory curiosity. In another similar type of substitution, copper-silicon castings were substituted for the formerly used copper-tin alloy in the manufacture of anti-aircraft guns; net saving was 20 pounds of tin per gun.

Then there is the case of sheet steel, one of the forms of metals that has relatively little use in wartime production. A shell clip was formerly made by die-casting aluminum. It was decided to change the design and to use sheet steel. Result: An improved clip and expanded use of sheet steel, together with employment of men and machines that work this material. Also, the change-over in this clip alone is reported to have saved, to date, $2,000,000.

Metals are by no means the only materials which are receiving the utmost attention of researchers. Leathers, fabrics, and felts have been developed as alternates for the rubber and synthetic rubbers that were formerly used in anti-squeak pads, bumpers, gaskets, and seals. Plastics have been put into service in steering wheels, replacing the hard rubber formerly used. Other similar plastics, in extruded form, have found application in cooling-system and other hoses. Battery boxes of molded natural asphalt found in Utah are releasing still more rubber.

And so it goes. To summarize: In one combat vehicle, original plans called for 12 pounds of rubber, exclusive of tires. Alternate materials have cut this rubber requirement to one half pound. Another vehicle has been redesigned to use alternates, with the result of saving more than 16 pounds of rubber and almost five pounds of nickel per unit. These brief figures give a graphic idea of what has been accomplished. What this trend — and it extends throughout all phases of vehicle design and construction —will mean to the post-war automotive industry is quite obvious. No one knows today what the civilian automobile will look like when the industry starts after customers instead of after Japs and Nazis, but we can all rest assured that it will have better materials and greater efficiency than ever before.

DIAMONDS OF INDUSTRY

ALTHOUGH the use of diamonds in a variety of industrial tools is not by any means new, such tools as were used in the United States were largely imported from Europe until the outbreak of World War II. Now, faced with the need for precision machine work in so many war industries, diamond cutters and merchants in this country are turning to this outlet for their products and are building a business that is one of the most rapidly advancing industries of the moment. It is worthy of more than passing notice, also, that jewelers are advocating the purchase of gem stones for personal adornment on the ground that the by-products of cutting such stones are small diamond chips which can be used in industrial tools. Thus, they argue, the more gems purchased, the more chips there will be for use in the war effort and, at the same time, the less costly will be these same chips to those who need them.

But larger sales of gems is not our concern: What is more important to the trends of industry is the fact that industrial diamonds are needed and are being supplied in ever-increasing quantity and for ever-expanding uses. Because diamonds are the hardest substance known, they are widely used not only in grinding tools but in dies and gages as well. So hard is the diamond, in fact, that dies and gages are being supplied to industry today with guaranteed tolerances of hundreds of thousandths of an inch; in some cases with no tolerance at all! With such American-made tools available, all industries demanding high precision can put their best efforts forward.

—The Editors

Synthetic Elastomers

How Molecules are Manipulated to Make New Rubber-like Materials in Unlimited Variety

SIDNEY J. FRENCH
Professor of Chemistry, Colgate University

● In our April 1942 number Professor French explained, by means of little sketches or "models" similar to those used in the present article, how the chemist makes higher and higher octane gasolines. In the present article he explains by means of similar models why rubber is elastic, and why the rubber chemist's modern knowledge of the secrets of manipulating moleclues enables him to design and make synthetic elastomers (rubber-like substances including rubber). The little drawings are not, of course, offered as precise representations of atoms and molecules, especially as the precise nature of these entities remains in part unknown. Science does know that atoms are not neat little circles or balls with little fishhooks attached, but it also knows enough about their arrangement to be sure that such conventional models represent their approximate nature. At least, as practical representations these structural formulas serve our purpose in explanation and in every-day use.

Professor French is the author of the recently published books, "Torch and Crucible" and "The Drama of Chemistry," chosen from many popular chemistries to run serially in The Dow Diamond, the magazine of the Dow Chemical Company—the first issue of which appeared in January.—The Editors. ●

SEVEN hundred thousand tons of synthetic rubber by the end of 1943 —to be produced in American factories as yet unbuilt! The world has never before had ring-side seats at such a stupendous undertaking in the translation of science into stark necessities.

Can it be done? Had that question been asked before December 7, 1941, the answer no doubt would have been an assured and cocky, "Yes, if we were put to it!"

Today we are put to it in no unmistakable manner. What is the answer now? There is less cockiness, more seriousness, as there always is when a boast must be turned into a result. But the answer is still, "Yes!" Either we produce synthetic rubber or we go down to defeat. Planes and tanks must have rubber—an amazing amount of it. So must soldiers, cannons, and battleships. In such a diversity of items as raincoats, boots, tires, pads, gas masks, surgical gloves, hose, de-icers, gas tanks, insulation, storage batteries, and on up to 2000 or more items, rubber plays its essential part in war.

Had we faced today's crisis a decade ago, we would have been helpless; we did not know how to make satisfactory synthetic rubber. Today, we do know how; not only do we know how but we are already producing it in modest amounts—not one kind but more than two dozen types of this strategic material.

East Indian natural rubber is out for the duration—possibly forever. It provided 97 percent of our rubber products. Talk of developing the Mexican guayule shrub or any other[1] rubber-yielding plant in time to meet our urgent needs is wasted breath. For the long view such investigations may be worth while but not for tomorrow's view.

It can, of course, be argued that the proposed gargantuan expansion in synthetic rubber is equivalent to pouring money down the neck of an industry due to choke of its own weight after the war when it must face the competition of natural rubber. Perhaps so, but it is costing us only the price of a couple of dreadnoughts, even were we to lose all of it. We expect to lose battleships, and we must be prepared to lose our investment in synthetic rubber. That we shall lose it, however, is far from certain; such mass production is bound to lower the price of synthetic rubber to a point where it may be able to meet the price set on its natural rival even in peace time. Furthermore, some of the synthetic varieties possess properties not found in natural rubber, and will supplement rather than displace the natural material.

During the 1930's, Herr Hitler boasted at least three times that his scientists knew how to make synthetic rubber. Of course, he was 50 years behind the times, since the first synthetic rubber had been prepared — more or less by accident—in 1884. He had even forgotten that the Kaiser's scientists had developed a synthetic rubber—not one to boast much about, however—during World War I. Finally, he conveniently overlooked the fact that the first successful commercial synthetic rubber was developed in the United States and appeared on the market in 1931.

THIS product was neoprene, the brain-child of a modest but brilliant scientist-priest, Father Julius A. Nieuwland[2] of Notre Dame University, and the equally brilliant Wallace Carothers and his associates from the Du Pont Chemical Company. Together they wrote the pages of a fascinating story which translated the findings of theoretical science into the production of thousands of tons of neoprene. Without doubt, before the manuscript for the present article is finished, many of its superflous words will have been erased—with a neoprene eraser. Without doubt this eraser will have to last for several years. Fortunately, it will; because neoprene does not age like natural rubber. That is one of its important and useful qualities.

Today, 11 years after neoprene hit the market, it is still important and growing but it no longer holds the stage alone; it has some 28 competitors and associates to spur and comfort it. Not all of these 29 varieties will prosper but many of them will. Some are so new that we know little about them as yet. In the year 1940 alone, six new American varieties of synthetic rubber were introduced to the public.

With this great array of new elastic materials and new names to bewilder us, the scientists have decided that they must scrap the all-inclusive term of synthetic rubber. These materials are *not* rubber, but rubber-like. To be in the van, we must now call anything whose nature is elastic an *elastomer,* whether it comes from the rubber tree or the test tube. Hence, we have natural and synthetic elastomers.

The all-important question is, how are these synthetic elastomers made? But before attempting to answer this, we had best find out how nature's elastomer is made. This is the path of all science—and of most any other

[1] A systematic survey of these plants—the Madagascar rubber vines, milkweeds, Russian dandelion, goldenrod, rabbit brush, and osage orange—prepared by the United States Department of Agriculture, appeared in Scientific American last month, pages 276-277. This survey concurred with the above-stated opinion of the author: reliance on any of these emergency plants is wishful thinking.—Ed.

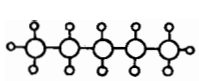
[2] A two-page article on neoprene, by Father Nieuwland, appeared in the November, 1935, number of Scientific American.—Ed.

endeavor, for that matter. First, we study existing models, tear them apart, analyze the construction; then we attempt to build as the model is built; finally, we branch out, modify and change the model more nearly to suit our needs.

The scientist has known since 1860 what kind of units rubber is built of. The trouble was that he knew neither how to make these units nor how to fasten them together. It has taken him three score years and ten, the lifetime of a man, to learn these tricks which, now that we comprehend them, seem rather simple.

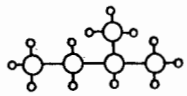
Natural rubber, and most synthetic elastomers, are substances known to the chemist as hydrocarbons. Translated, this means that a rubber band is composed of billions upon billions of tiny, invisible carbon atoms, plus more billions of hydrogen atoms. Yet, for that matter, gasoline, kerosene, mothballs, benzene, and a host of other substances are also hydrocarbons. So the secret of rubber lies not in the mere fact that it is a hydrocarbon. Rather it lies in the manner in which these carbon and hydrogen atoms are hooked together—in the architecture, in the pattern.

WHAT is this pattern so essential to rubber? It is a simple one, fortunately, yet it is as full of potential surprises as a treasure chest. The chemist knows full well the unique habits of carbon atoms. They tend to string along like cranberries in a Christmas chain—and each carbon atom is decorated with smaller hydrogen atoms, like glass-headed pins stuck in to add to the gaiety. There is one sacred rule which no chemist dares disobey. In his model, each carbon atom must, somehow, have four attachments, and these must be distributed between its neighbors in the chain and its attending hydrogen atoms. Thus, we can build our cranberry-pin model of a hydrocarbon as follows:

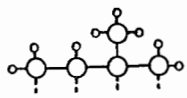


This fellow, called pentane, happens to have five carbon atoms in the chain, but the number five is not sacred; we might have more, or less.

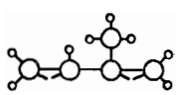
As long as we preserve our sacred rule of four attachments, we can do most anything we wish with this molecule—on paper at least. For example, we might pull a berry off one end and place it on the side of the chain, the berry trading places with a hydrogen "pin," thus:



Now let us behead the four bottom pins, thus:



We have disobeyed the sacred rule! We have left one attachment, or bond, on each berry, waving in the air, tied to nothing. This cannot be. Compromise is a rule of molecules as well as of life, so the waving bonds, finding nothing better to do, tie up with one another in the following pattern:

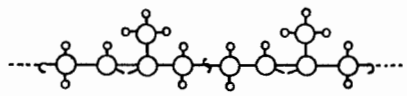


Fortunately, for the existence of rubber, these extra bonds are quite unhappy and superfluous. They are the stags at a dance, ready to flit away in search of a better partner, tolerating their union as a makeshift arrangement only.

THIS lop-sided molecule with its extra stags is a very famous one. It is isoprene, the "rubber brick," the unit of which all natural rubber is composed. The chemist prefers to call it by its generic name of methylbutadiene. And, contrary to popular belief, such a name is not mere gibberish; it gives to the chemist an exact picture of the molecule and its parts. The confusing thing is that he writes it without hyphens, as though he were to write, "the-house-by-the-side-of-the-road" as "thehousebythesideoftheroad." Methyl means a carbon atom with three attached hydrogens. Buta means a four-carbon atom string. Di means two. Ene means stags or, more technically, double attachments. Thus, we have a methyl group tied to a buta chain containing two double attachments.

When we have molecules of methylbutadiene, we by no means have rubber, any more than we have a Paul Jones dance when we have an assortment of people all with hands in pockets. We must get these molecules to join hands, and this, of course, is where the stags enter the picture. Without them, there would be no hands to join—and no rubber. But before this joining of hands can take place, there must be proper introduction. Finding the proper introducer is no small task. It has been, and still is, one of the most difficult jobs of the budding synthetic elastomer industry.

Once this important personage has been found, the rest is easy; each methylbutadiene molecule links up with a neighbor, end to end, as is illustrated, the necessary stags swinging around to meet those from each neighboring molecule:

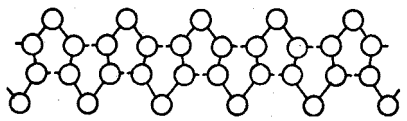


When billions upon billions of these molecules become linked in this manner, we have a rubber fiber. But notice what has happened. Not all the stags could participate in this Paul Jones affair. Two stags in each molecule are still left disconsolate. They pair off in the middle of each "brick." Perhaps we can provide suitable partners for them yet.

JUST why should this linking of molecule to molecule in such a manner give a substance which can be stretched to several dozen times its original length and rebound once more when released? With all the exhaustive work they have done on rubber in a century, the chemist and the physicist together are still unable to give a complete answer to this question. But they have several very good theories. They know, for example, that long molecules built up in this way are not straight, but coiled like a spring. But this is true of any long carbon chain molecule, yet not many of these have the stretch of rubber. We must look elsewhere for the complete answer.

The X-ray has shed light on many a scientific problem; it sheds surprising light on the structure of rubber. When X-ray photographs are taken of crystals, the positions of the very atoms themselves are exposed and these positions reveal a perfect regularity of pattern. In a liquid, on the other hand, we get only a smear, indicating that the molecules are gloriously and irregularly mixed. Under the X-ray, relaxed rubber behaves like a liquid, stretched rubber like a crystal. Is relaxed rubber, then, a liquid? Well, the scientist is inclined so to regard it. The atoms are so gloriously mixed that they do not know to which molecule they belong. For this state of affairs we can no doubt thank the remaining stags. In their search for partners, they reach out to take hold of atoms further up the chain, out of line, so to speak. In doing so, they cause the long string to fold back on itself somewhat like a folding ruler.

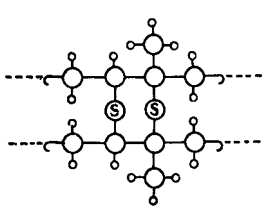
We might picture it thus, showing only the spiralled carbon chains and the stags (in dotted lines) holding the folds loosely together:



When the rubber fiber is pulled, the stags give, like tiny springs, the molecules are literally stretched into shape and the X-ray reveals a crystal pattern. Actually, the scientist believes that the rubber units sort of fold into, and dissolve in, one another when the rubber is relaxed.

IN THE year 1844, United States patent number 3633 was issued to Charles Goodyear on the vulcanization of rubber with sulfur. This is the patent which brought about at one and the same time the most famous lawsuit of the century and the great rubber boom. Pitted against the oratory of Rufus Choate, Daniel Webster won the suit for Goodyear. But, regardless of who won the suit, the case for rubber has been thoroughly established. Without sulfur, rubber is soft, pliable, and has little tensile strength. When sulfur is added, we obtain products ranging in stretch and hardness from the rubber band to the hard rubber insulator. Why this amazing shift and range of qualities upon mere heating with sulfur?

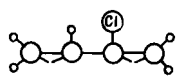
Perhaps you have guessed it. The stags once more! These remaining stags are delighted to join hands with sulfur atoms, each sulfur atom — S within a circle — taking on two stags as shown:



Thus, we have several fibers of rubber joined together — braced, as it were, by sulfur atoms. Each fiber lends its strength to the other. No wonder the tensile strength goes up. But the stretch goes down, because the stags are no longer available to tie fold to fold. If we put in just enough sulfur to use up every second stag, we can still have some fold and stretch left, but if we put in enough to use up all the stags, stretch is gone and we have brittle, hard rubber. It is little wonder, then, that we can get almost any combination of stretch and hardness by varying the sulfur content. There are, of course, many other substances, such as zinc oxide and carbon black, which play important roles as fillers and hardeners in rubber.

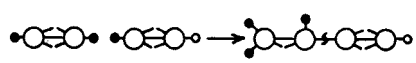
Little enough has yet been said about synthetic elastomers but, in reality, little need be said about them. The principles, with a few modifications, which apply to rubber also apply to synthetic elastomers. Once we knew what kind of molecules composed rubber, and how they were linked together, we could go about building synthetic materials along somewhat similar lines.

Neoprene is composed of units of chlorbutadiene — you have guessed it: a molecule of neoprene differs from natural rubber only in having a chlorine atom (Cl within a circle) in place of a methyl group, thus:

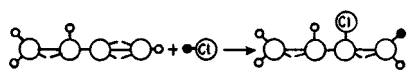


It is as though we had placed a cherry on a cranberry chain. This chlorine atom gives to neoprene several surprising characteristics. The stags are now so active that no introducer is necessary to unite the molecules into chains; they do it of their own accord. The remaining stags then cross-tie the strings into strong bundles of fibers. Vulcanization is unnecessary and, in fact, impossible in neoprene.

THE source materials for neoprene are abundant and cheap. Acetylene molecules join hands to form vinylacetylene:



(Notice how some of the hydrogen atoms — those shown in black — have shifted to effect this union.) Vinylacetylene then reacts with hydrogen chloride to form chlorbutadiene:

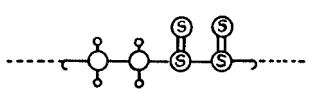


(Notice how the stags have been reduced in number by these processes.) The chlorine comes from salt. The cost is in the manipulation, not the materials.

The German synthetic elastomers about which Hitler boasted so loudly are known as Buna S and Buna N. Both are made from butadiene, but not from it alone. Interspersed with the butadiene molecules in Buna S are styrene molecules, somewhat complicated, but possessing the ever necessary stags. To introduce styrene to butadiene, the metal, sodium, is used. The chemist's symbol for sodium being Na, you have the origin of the name Buna S — Bu- for buta chains, na for the sodium introducer, S for styrene. In Buna N, acrylonitrile (N) takes the place of styrene.

Before succeeding in making these alphabet bunas, Hitler's scientists had succeeded in making plain bunas (butadiene molecules strung together). These early perbunans—note the derivation of the name—were almost as bad as the Kaiser's cumbersome elastomer in World War I. But the alphabet bunas are of high quality. They can be vulcanized, have high tensile strength and resistance to wear. The raw materials come from petroleum buta- chains — often previously wasted — resulting from the manufacture of gasoline. With our vast resources of petroleum, it is little wonder that we stand ready to lead the world in making all types of buna elastomers. And it is for these products largely that our great government-endowed expansion program is planned. Already the American public has met three such brands: Ameripol, Hycar, and Chemigum. It will meet many more in the near future.

NOW that we have learned how to make stagged molecules and to hook them together, we are no longer limited even to hydrocarbon chains. Thiokol (thio means sulfur) elastomers have sulfur atoms right in the chain. Here is a model unit of a thiokol elastomer



made from acetylene and sulfur. There are at least three commercial varieties of thiokol on the market.

Then, there are elastomers which are neither entirely fish nor fowl. They are hybrids of elastomers and plastics. They lack the stretch but have the great flexibility and water proof qualities necessary to make them useful in hundreds of ways. Such a product is Koroseal, made from acetylene with chlorine as the introducer.

Finally, another group stemming from petroleum, the butyl elastomers, is fast coming upon the scene. As yet, we know little about these products but they show great promise.

Delighting in high-sounding names — which, nonetheless convey real meaning to him — the chemist dubs these endless molecules, made by the

joining of hands of numberless small identical unit molecules, polymers. If the small molecules are not identical, the product becomes a copolymer. The process is polymerization or copolymerization.

The great significance of polymerization is not so much that we have at last learned how to make these synthetic elastomers, important as that may be in these grave days; it is that we have mastered the secrets of making these stagged molecules, of finding the proper introducers, of building endless molecules to *our own specifications*. We have just made a start, and at present we are still trying largely to imitate the qualities of natural rubber.

But there is no apparent limit to the diversity of products which we may obtain through copolymerization. We may go on building these experimental endless molecules till we find some that far surpass natural rubber in elasticity, some that surpass it in wearing quality, some that surpass it in weathering quality, and in resistance to tear. So we shall have, eventually, not a single imitation of nature's product but thousands of new useful products, each with its own valuable qualities, adapted to its own particular uses.

Nor will we stop with these diversified rubber-like materials. After all, elastomers and plastics belong to the same great family of polymers and copolymers. We shall go on mixing the breeds till we have produced elasto-plastomers and plasto-elastomers almost without end and with every conceivable gamut of qualities.

And for our starting materials all we need are limestone, coke, water, sulfur, chlorine, and petroleum. There is no shortage of these in America!

• • •

BEST WAVELENGTH

For Short-Wave Communication Can Now be Predicted

AUTOMATIC recordings of electrical conditions in the upper atmosphere now make it possible to predict with accuracy the best frequency to use for short-wave communication at any given time. The automatic multi-frequency recorder used for this work is a development of an "echo" technique for investigating the ionosphere, the radio-reflecting layers of the upper atmosphere whose heights affect short-wave radio.

Personalities in Science

SIR C. V. RAMAN

AT TRICHINOPOLY, in Southern India, Chandrasekhara Venkata Raman was born on November 7, 1888. He received his early education at the Hindu College, Vizagapatam, where his father was a Professor of Mathematics and Physics. Later, he studied for four years at the Presidency College, Madras. He graduated from this institution at the age of 16, and two years later took his master's degree, in both cases with the highest distinctions. Even as an undergraduate at the Presidency College young Raman displayed his genius for original research and independently carried out his first investigations in optics and acoustics. His capacity for scientific research greatly impressed academic circles at Calcutta and led to his being invited by the University of Calcutta to accept a newly endowed chair of Physics. In April 1933, Raman left the Calcutta University and accepted a call from the Indian Institute of Science at Bangalore, where he now works.

The research papers published in the last 20 years by Raman, and collaborators in his laboratory, include over 600 titles and concern themselves with a variety of subjects such as the dynamics of vibrations and sound, the theory of musical instruments, diffraction problems, meteorological and colloid optics, X-ray diffraction in liquids and solids, magnetism and magneto-crystallic action, electro- and magneto-optics, photo-elasticity of solids and fluids, dielectric behavior, and ultrasonics. By far the best-known work of Raman is his discovery early in 1928 of the new radiation effect known by his name and which was the natural culmination of the investigations on the scattering of light, systematically conducted in his laboratory since 1921. The 14 years that have elapsed since the discovery of the Raman effect have witnessed the fulfillment of the confidently expressed hope of the discoverer that it would throw new light on many problems in physics and chemistry. Several thousand papers have now appeared on this subject, but the possibilities of further advances in both physical and chemical applications are far from being exhausted.

Impressive though his own personal contributions to science have been, Raman's greatest achievement in his leadership in the renaissance of science that has been taking place in India during the past quarter of a century. The progressive enthusiasm for scientific studies and research that exists in India today has largely been inspired by him and encouraged and sustained by his efforts. His personal example of self-dedication to a scientific career, the brilliance and originality of his researches, the international recognition that his work has received, his gift for eloquence which has served to stimulate a widespread interest in science, his achievements as a scientific administrator in creating facilities for research and establishing new schools of science, and his success in founding journals for publication of scientific work in India are among the factors which have profoundly influenced the progress of science in that country.

The world was not slow to recognize the importance of Raman's achievement as an investigator and a leader of scientific research. Scarcely had he completed six years as a Professor of Physics when the Royal Society of London elected him a Fellow in 1924. He was knighted by the British Government in 1929. He was the recipient of the Matteucci Medal of the Italian Society of Sciences in 1928, of the Hughes Medal of the Royal Society in 1930, and in the same year he was awarded the Nobel Prize for Physics.—*Dr. W. F. Meggers, National Bureau of Standards, in the* Journal of the Optical Society of America.

A Pier in Time —

Psychology Joins With Engineering Skill to Produce a "Hospital" Pier in Record Time of 43 Days

A. D. RATHBONE, IV

DRIVING creosoted piling into the chill waters off the rim of Staten Island, in New York harbor, during late February and early March, is no job for a sissy. But there weren't any sissies in the 120-man pier-building crew of the George W. Rogers Construction Company. Mostly husky, raw-boned, taciturn Scandinavians and Finns—men to whom the words Oslo, Stockholm, Köbenhavn, Helsinki meant members of families still in Nazi-occupied, influenced, or threatened countries—this gang of burly workmen spoke little, drove hard, and completed a 700-foot utility pier for the United States Navy in the record time of 43 days as part of their contribution to beat the Axis Powers.

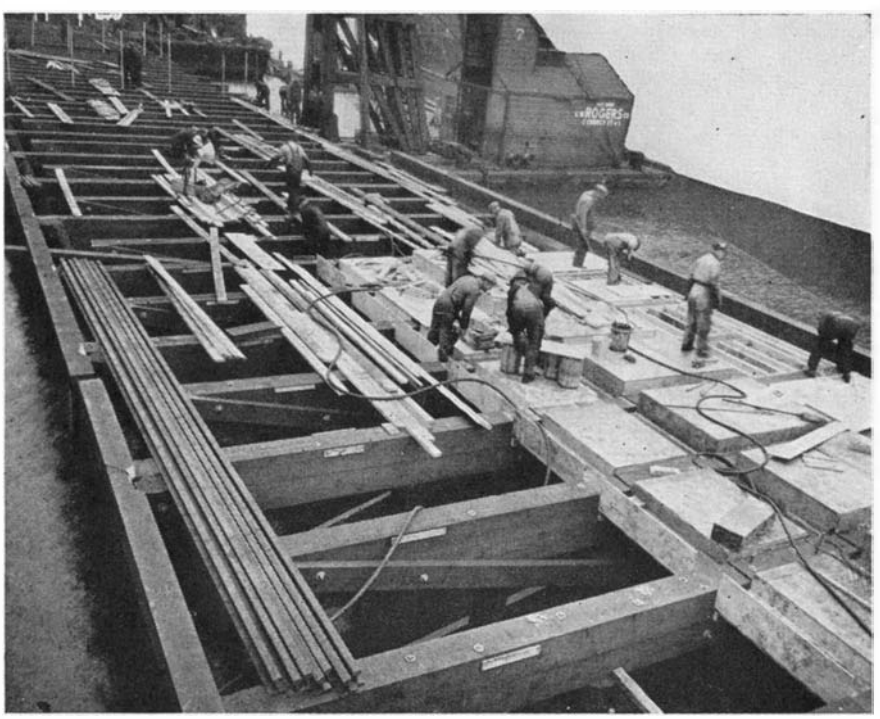
Prosaically known as Pier 10, this engineering job forms the final factor of a three-part unit comprising a ship-launching way flanked by fitting-out piers, Numbers 10 and 11, in the Bethlehem Steel Company's yards, and is unique not only for the necessary precision maintained during the speedy building of the unit, but also for the somewhat novel method of construction. The shipway, designed by Lockwood Green Engineers, Inc., has an unusually heavy concrete deck carried directly on the heads of the piles, which extend six inches up into the slab.

As it was considered undesirable to break the creosoted skin of the piles by nailing stay-laths to them, a hanger system was devised by using Richmond tie hangers carried on sections of light rails, which in turn rested on the heads of the pilings. On this suspended framework the criss-crossed reinforcing steel rods were laid and hand wired at approximately a million separate crossing points. The forms were then constructed and, with the above method of suspension, proved to be satisfactorily stiff and solid. "High-early" strength, pre-mixed concrete was poured, at some points under pneumatic pressure, and such was the speed on the job that, with the quick-setting cement, trucks could be and were driven over the deck 24 hours after pouring. The deck on this shipway varied from 12 to 25 inches in thickness, being generally 12 inches at the sides and 24 inches under the keel blocks.

The piles for Pier 11, which was constructed first, 72,500 linear feet of them—about 13.5 miles—were driven by floating pile drivers equipped with 75-foot leads and Vulcan Number 1 steam hammers. It was necessary to force the pilings through some 12 feet of mud, then to penetrate 12 to 14 feet of hard material — clay, sand, and gravel—before reaching the underlying strata of rock. The nicety and accuracy of the job can be realized when it is known that the piles were shaved to a specified level and the general surface line-up graded by surveyors.

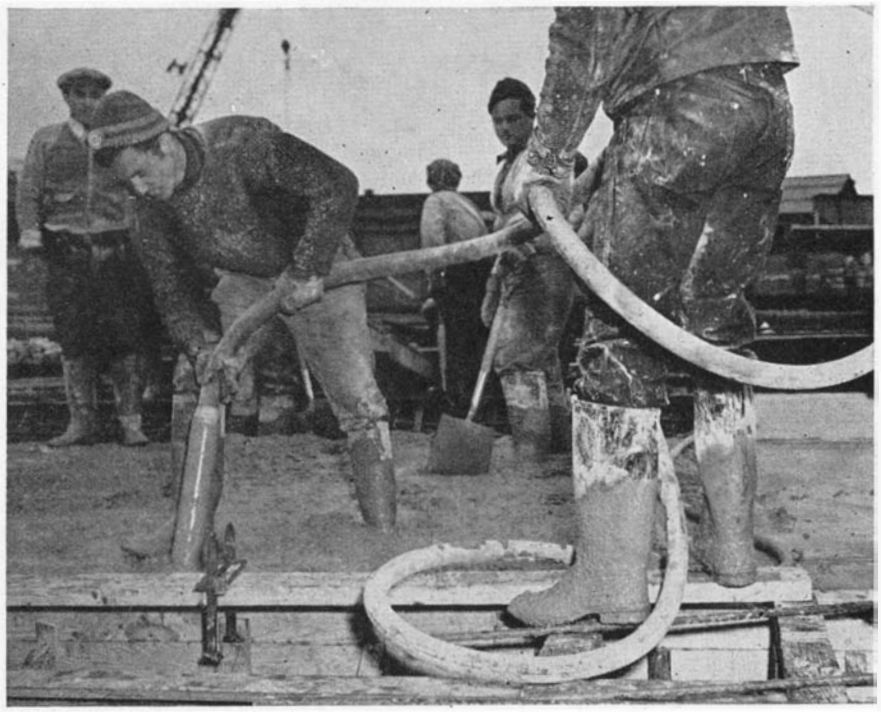
In the middle section of the launching way, after the piles had been driven and batter piles placed both ways longitudinally, riprap was placed in an area 60 feet square to resist the thrust during launching. The outer end of the way was built of creosoted wood for a distance of 84 feet. This wooden apron extends from about half-tide to a point two feet below low water, and here the construction work was accomplished largely by employment of a crew of divers.

More than a million wired joints, each twisted with special anti-Axis gusto, went into preparation of framework



A crew of Scandinavians and Finns, moved to extra efforts by thoughts of homefolk in occupied countries, rushed construction of "700 Feet Toward Victory"

Although the shipway and one of its flanking piers were completed sufficiently ahead of schedule to permit laying the keel of a ship nearly four weeks earlier than planned, all that happened last year, before Pearl Harbor. Then the Bethlehem Steel Company and the Navy informed George W. Rogers, President of the firm that bears his name, that his original estimate of 90 days for completion of Pier 10, the final unit in this group, would have to be cut to 45 days. Inasmuch as this was a lump-sum contract and not on a cost-plus basis, the speed-up proposal, however much it might mean in our shipbuilding program, was something for any contractor to conjure with.

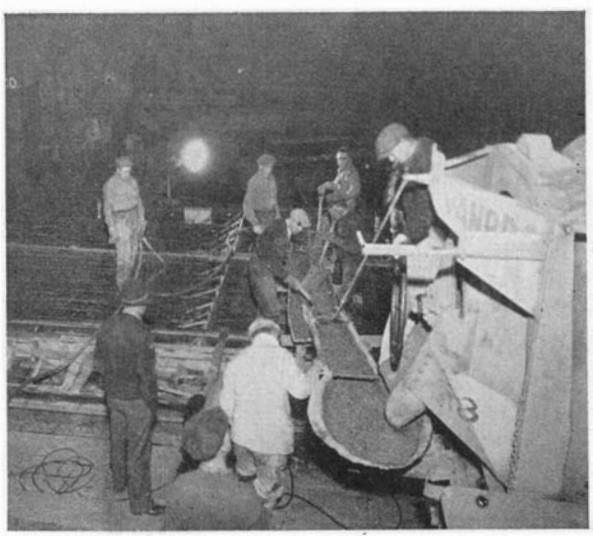


Such was the speed-up on the Pier 10 job that at one time cement was being poured at shore end of the pier while piles were being driven at outer end

However, Rogers, whose grandfather began building piers for the government in 1869, and whose father continued the family construction tradition during World War I, has been doing things with men, and steel, and concrete since he, himself, finished his trick in the Navy in 1919, and he said he believed it could be done.

There were, inevitably, some temporary shortages of material, although everything possible was done to prevent hold-ups, even to trucking special loads of piles from as far away as Wilmington, Delaware. "At one time," reminisced Mr. Rogers, "we were pouring cement at the inshore end—which was then virtually completed—while we were still driving piles at the outer end—a crazy method to run a pier job, but there just wasn't any other way."

Despite a scarcity of skilled dock builders, the 700-foot-long Pier 10, composed of 42,700 linear feet of creosoted piling, 200,000 board feet of creosoted timber, and 22,700 square feet of concrete, was completed in the unprecedented time of six weeks and one day. The work was done on a two-shift, seven-days-a-week basis, and although flood-lights shone over the cold, black waters to help the night shift, all driving of piles was done in the daylight for the sake of safety. Before the concrete of the deck was poured, huge H-beams were placed horizontally at their specified points, with no deviations allowed. The rails on which the 100-foot-high cranes move back and forth astraddle of the ship, lifting and placing armor plate, turrets, or heavy guns, were laid over the H-beams. At the dedication ceremonies both cranes were on their rails.



Night and day, many tons of "high-early" strength premixed concrete flowed into forms in a steady stream

One of the cranes has a capacity of 15 tons and the other can handle 20 tons. A unit of two outfitting piers, such as numbers 10 and 11, and the shipway they flank, has aptly been referred to as "hospital piers," for here all manner of shipbuilding operations may take place. They may be used to graft machine guns, cannon, additional armor plate protection to a merchant vessel in the course of its conversion to some type of warship. Newly launched hulls may receive what it takes to make a fighting ship strong and powerful. "When a ship's battered," says Rogers, "it needs a hospital. When you have guns, tanks, planes, you need ships to take them places. No piers—no ships."

To commemorate the completion of this Navy utility pier in the record time of 43 days, 25 days less than the previous record, a bronze plaque was sunk into the newly poured last yard of concrete deck, and the entire job has been looked upon as something of a barometer of wartime co-operation and effort.

Realizing today's urgency for this type of construction in our shipyards and knowing his Scandinavians and Finns for what they were, Rogers combined psychology with engineering knowledge. He mingled freely with them at all hours of the day and night, asked them what they heard from their folks in Norway, Sweden, Denmark, Finland. It worked! Tight-lipped, they replied little, but seemed to delight in venting pent-up emotions on the huge timbers and steel beams, on the tangled reinforcing rods and ever-flowing concrete. They hung up a sign designating Pier 10 as "700 Feet Toward Victory," and with this brand of co-operation and the simultaneous co-ordination of suppliers of materials, Rogers' promise to the Navy and to Bethlehem Steel Company was fulfilled.

RW Tauri

A Remarkable Eclipsing Variable Star with a Gaseous Ring Whirling About One Component

HENRY NORRIS RUSSELL, Ph.D.
Head of the Department of Astronomy and Director of the Observatory at Princeton University. Research Associate of the Mount Wilson Observatory of the Carnegie Institution of Washington

AN UNUSUALLY interesting piece of news (now published in a technical journal, and hence available for these columns) comes from Dr. Joy at Mount Wilson. For years this veteran observer has been following eclipsing variables with the spectrograph, and measuring their radial velocities. This is scientifically remunerative, for if the orbital motions of both stars of a pair can be recorded, the real dimensions of their orbits, and the actual sizes, masses, and densities of the two stars can be calculated. But it is also very laborious, for the bright stars of this interesting type have long ago been worked up, and the faint ones demand long exposures.

In some of the most interesting systems, the star of larger diameter is fainter than the other, and the eclipse is total. By observing while the small bright star is completely hidden, we may then study the spectrum and motion of the larger without disturbance by the light of its much brighter companion — which, when both are visible, drowns the other out completely.

To work up such a problem demands great patience, for the total eclipses last at most a few hours, while the intervals between them are measured in days. For a large percentage of the eclipses, the star will be below the horizon, or too near it to be observable. More than half of the rest will come in the daytime, or twilight. On the average, fully three quarters of the eclipses will be unobservable for these reasons.

In a great observatory, where the time of the telescope must be divided among many astronomers, a considerable part of the possible chances will come on nights when the instrument is equipped for some quite different type of work, or when the moon is "wrong." This cryptic remark means that some types of observation—such as direct photography of faint nebulae—can be done only on clear, dark nights. Moonlight, which drowns nebulae out altogether, does not bother the spectroscopist, since little or no moonlight gets through the narrow slit of his spectroscope, upon which he keeps the star-image centered. The dark of the moon is therefore sacred to the nebular program, and certain others, while spectra are photographed when the moon is bright. Two spectroscopic observers may, and frequently do, exchange nights when one of them has something of exceptional interest, but a general indiscriminate exchange of working hours is impracticable.

When the long-awaited eclipse comes at last on an available night, it may be cloudy — even in the best of climates — or, though the stars are visible, the irregular refraction in our atmosphere, known as "bad seeing," may enlarge the image of a star so much that only a small fraction of its light gets through the slit of the spectroscope.

FOR an ordinary star, this necessitates a much longer exposure — which diminishes the total amount of the night's work, but not the value of each plate. But, when the eclipse is short, and the star faint while it lasts, the lengthened exposure may run over the time allotted by nature. The observer, realizing that he can get only a blend of total and partial eclipse, which he does not want, will regretfully turn to some other star on his list, and hope for better luck next time.

RW Tauri—the star here discussed—is peculiarly laborious to observe. Normally of magnitude 8.1, it drops to magnitude 11.5 at intervals of $2^d\ 18^h\ 45^m$. The fainter component obscures the brighter one completely for only an hour and 20 minutes—less than one fiftieth of the period—so that the chance of finding it faint at a random glance is very small, and the observer who wishes to study it at minimum, though provided with accurate predictions of its occurrence, must waste no time. During the total eclipse, the photographic brightness is nearly half a magnitude fainter than the visual, showing that the companion is reddish. At this time, when the glare of the bright star was cut off, Joy discovered a visual companion of magnitude 12.5, at an apparent distance of 1″ from the variable. Small as this seems, it must be several thousand times the distance which separates the eclipsing pair, and it will be many years before it can be determined whether this companion is really related to the variable, or merely in line with it, but much nearer or farther away.

ALLOWING for the light of the third star, it is found that the larger component of the close pair emits but 1/36 as much light as the star which it eclipses. Only one or two cases of greater disparity in brightness are known. To get a spectrum of a 12th magnitude star showing good detail in so short a time demands very powerful equipment. Only the 100-inch reflector is really equal to the task; but with this Dr. Joy has secured several spectra during totality on different nights, some with exposures as short as 45 minutes.

These plates show a spectrum of Class KO, (similar to that of Arcturus) with well defined lines, while those taken outside eclipse show an equally well defined spectrum of Class B9 (corresponding to a star a little hotter than Vega) belonging to the brighter star, which drowns out its fainter companion completely. The great difference in temperature between the two stars accounts for the difference in brightness.

Many other totally eclipsing pairs are known, in which the difference in brightness, though large, is less than for RW Tauri. The distinctive peculiarity of the system is that, at the time of total eclipse, remarkable bright lines appear in the spectrum. These were observed by Wyse at the Lick Observatory in 1933, but not followed up until Joy's recent work.

A spectrogram taken in 1940, with an exposure of 65 minutes, covering almost the whole duration of the minimum, showed that the hydrogen lines, Hβ, Hγ, and Hδ, were bright and widely double. The two components of each line were shifted equally far to the red and to the violet of the normal positions, by amounts corresponding to velocities of 350 kilometers per second in each direction. Fainter emission lines of ionized magnesium, calcium, and iron were also observed on this and later plates.

This enormously wide doubling of

the emission lines cried aloud for explanation; and this was forthcoming when observations during the total eclipse were made during 1941.

These show that if the exposure was commenced as soon as the eclipse became total, and stopped at or near its middle, only one of the two emission components was visible for each line, namely, the one on the side toward the red. For an exposure beginning at mid-eclipse, and continued till close to its end, only the bright lines on the violet side of the normal position appeared; and, upon a plate taken during the middle of the eclipse, there were no bright lines at all. The first plate, with its longer exposure, was evidently a composite photograph, combining effects observed at different times into something that could not have been seen at any one time.

THESE apparent complications may be interpreted as illustrated in Figure 1 (which is drawn approximately to scale). Let B represent the brighter star, and F the fainter companion. The Earth is supposed to be in the plane of the page, at a great distance below. F may be drawn as revolving around B in a circular orbit O. (In fact, both B and F describe orbits about their common center of gravity, keeping on opposite sides of it; but to put this into the diagram would complicate it needlessly.) As F moves along this orbit, it will hide more and more of B, till, finally, when its center reaches the point F_1, the eclipse will become total, and continue so till its center is at F_2.

Now suppose that B is surrounded by a gaseous ring of very low density (containing hydrogen and small quantities of metals, and emitting bright lines) which is rotating rapidly about it in the same direction as the orbital motion of F. After the total eclipse of the luminous body B has begun, the part of the ring at R_1 will still be visible. It is receding from the Earth, and the bright lines which it emits will be shifted toward the red. Toward the end of totality R_1 will be hidden by F, while the opposite side of the ring at R_2 will be visible, and give bright lines shifted toward the violet. Since both bright components disappear for about 30 minutes at mid-eclipse, the outer diameter of R must be considerably smaller than that of F.

This explanation is as simple geometrically as it is convincing. The question remains how this gaseous envelope can exist permanently in such rapid motion. It is not carried around by the rotation of the star below it, for the lines in the spectrum of this star are fairly sharp, and show that its own rotation, though doubtless in the same direction, must be much slower.

It seems probable that the gases of the ring are in orbital motion about star B—held up by the centrifugal force of their own motion, just as a solid satellite would be, and high enough above the star's surface to avoid friction with its atmosphere. Rough calculations show that an

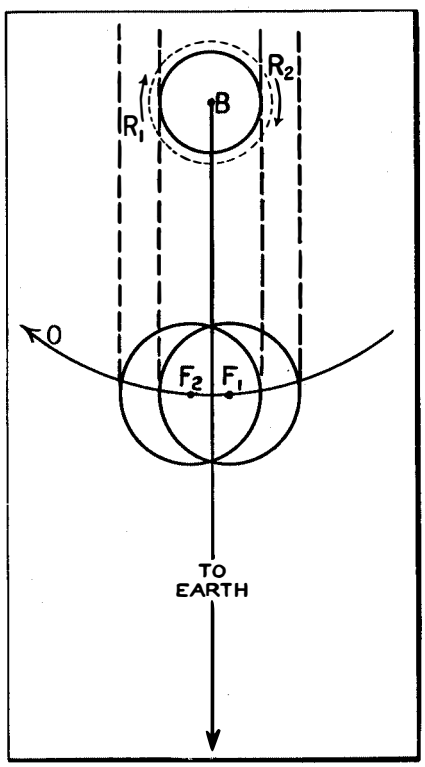


Figure 1: See the text

orbital velocity of 350 kilometers per second should be expected in this region if the mass of the bright star was about 1½ times the Sun's, and that of the fainter ones about one third as great. These are plausible enough values—though rather smaller than one might expect.

When enough observations of this remarkable star have been secured, the masses of the components may be found, and the equilibrium of the ring studied more fully.

How such a mass of gas "got that way" is a problem which is best left alone till we know more about the details than we do now.

Whether other stars have similar rings revolving about them is unknown. The possibility of such a thing was suggested by Struve, some years ago, from consideration of certain stars with peculiar emission lines, bright enough to be observable though the star itself is unobscured. The present ring, however, is so faint that it would hardly be observable if the eclipsing companion were not unusually faint, and it may be hard to detect other cases.

It is remarkable that two stars of such different brightness should be so close to one another. A large number of similar cases—though less extreme—are found in the lists of eclipsing variables. Indeed, such pairs have been called "typical Algol systems."

It is practically certain, however, that such systems are not typical of the short-period double stars in general—such as are detected in great numbers as spectroscopic binaries. There is no more striking example of the power of observational selection—forced upon us, independent of our intentions, by the very nature of the case.

THE great majority of variable stars have been discovered by comparing photographs of the same region taken at different times. In such a search, large variations in brightness are practically sure to be picked up, while smaller ones may be missed. Under what circumstances can a large variation—reducing the normal brightness to one sixth or less—be produced by an eclipse? At the middle of eclipse we see the light of the star which is in front of the other, and often an uneclipsed part of the light of the other. Hence, to meet the condition just imposed, the eclipsing star cannot have more than one sixth of the total light of the pair, or one fifth that of its companion. Deep eclipses can come only from pairs of unequal brightness. Even among these they cannot happen if the fainter star is much smaller in size than the other; for then, if it is squarely in front of its neighbor, it will cut off only a moderate fraction of its light. When the fainter component is the larger, it may completely obscure the light of its companion, and there is no geometrical limit to the depth of the eclipse. The fact that no eclipses of a depth as great as five magnitudes have yet been observed indicates that cases in which the larger star has as little as 1 percent of the brightness of the smaller ones must indeed be exceedingly rare.

The large, faint components of these pairs are "sub-giants"—brighter than normal main-sequence stars of the same temperature, but fainter than ordinary red giants. Their masses, when known, are smaller than those of ordinary stars of the same luminosity. Their constitution presents an interesting theoretical problem which has not yet been solved.

—Princeton University Observatory, April 29, 1942.

A Maya Temple Grows Up

Archeologists in Guatemala Reveal the Evidences of a Five-Times-Reconstructed Temple

LINTON SATTERTHWAITE, JR.
Assistant Curator, American Section,
The University Museum, Philadelphia

MODERN archeology is the business of digging into ruins and rubbish piles of forgotten peoples. Any archeologist will tell you he is trying to reconstruct the history of the people concerned. Some will claim that they are helping to discover laws governing the rise and decline of human societies. I believe this may be so, but that scientific curiosity is the immediate force which drives diggers to plan and sweat, and institutions and public-minded citizens to foot the very considerable bills. You, yourself, are reading this article because you are curious to know about the illustrations that accompany it.

These illustrations — the drawings on the opposite page — are reconstructions on paper of a single Maya temple and the various alterations to which it was submitted. It was part of a religious center or "city," now called Piedras Negras, in the semi-tropical forested part of Guatemala, Central America. Its ruins cover a square mile and have been extensively excavated by the University Museum of the University of Pennsylvania. I had charge of several seasons of work on the city, work which was begun by Dr. J. Alden Mason, Curator. Investigating this particular structure was part of my task, and I was assisted by William S. Godfrey, Jr., who made the drawings.

There are five isometric perspective drawings, showing how the temple was changed from time to time. The photographs will give an impression of the size. The upper left-hand drawing of the five shows it at the start. Later, the Maya had cut down the walls of the building to doorway height, as shown. The same thing was done by Godfrey on paper in the case of the fourth drawing, so that the reader can see into the room. The separate drawing shows the same building, after some changes, but with the roof in place.

As drawing succeeds drawing, the date of the new construction shown is later and later, yet each drawing is of essentially the same thing. There was a temple building at the top; this cannot be shown in the second and third drawings because little or nothing was left of it. The building rests on a low platform, and this stands on another with a stairway, except at the time of the second drawing. Below this is a platform of either two or four terraces, with its own stairway, and this is on a terrace with yet another stairway. These platforms form an example of what have been called "Maya pyramids." They are made of solid rubble — that is, shapeless, broken rocks — which was laid up in rectangular sections. The rough platform thus built was then given a skin of plastered stone masonry. The stones in the outer walls forming this skin were laid in mortar. This is limestone country, and limestone was burned to get lime for the mortar and plaster, and, toward the end, for ornamental stucco-work. In the photographs, the plaster has peeled off.

The purpose of these bulky platforms was to elevate the temple building and the little round stone altars in it and before it. The structure provided an awe-inspiring setting for elaborate religious processions, sacrifices, and ceremonies.

The time-span of the five varieties of the temple is probably four or five hundred years. During this time the building has become smaller and more complex in design. Only in the last two periods do we find it with a fire-proof masonry roof and sculptured decoration in stone and stucco.

The building has been rising higher and higher and, therefore, more remote from the common people who watched the proceedings from the great court below. The rituals must have become more exclusive. In the old days of the first drawing, a good many priests could crowd into the temple and on the broad platform, and the people could probably pretty well see what was going on.

BESIDES this hint of changing relations between priesthood and ordinary folk, these drawings tell a story of practical considerations. The priests commanded, or the people willingly gave, an enormous amount of labor for religious building. But they did not reach their top achievements overnight. New generations, imbued

Photos and drawings by William S. Godfrey, Jr.

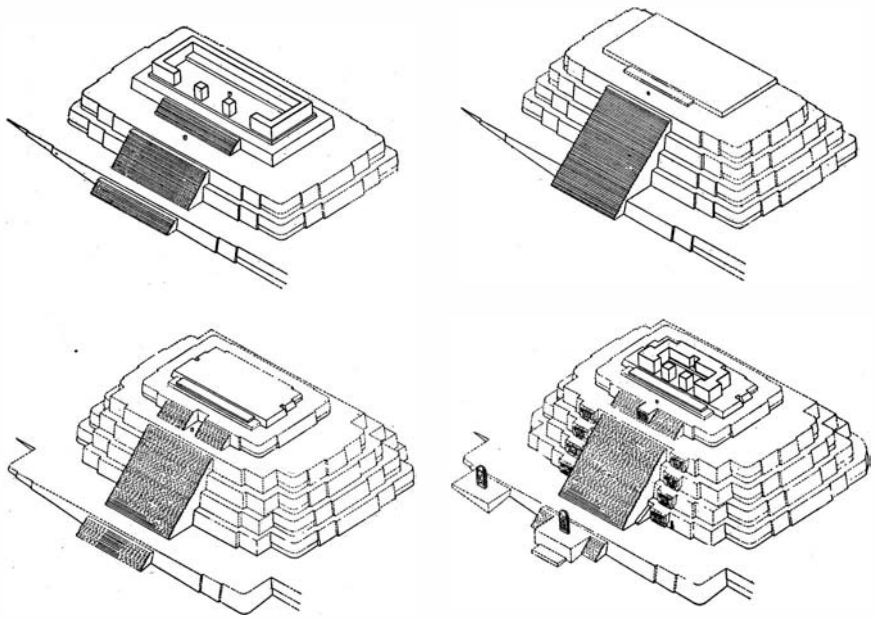
Dissecting the Guatemalan temple. Two men stand on the stairways shown in the first two drawings on the opposite page. A stucco Sun-God mask glares at the right

with a "bigger and better" spirit, tore down here and there. This was, perhaps, to get building stone for new works more easily. But they did not waste the labor of their ancestors by removing whole platforms. They built new ones over and around them, sometimes, as here, making use of parts of the oldest walls to the end. So they gained grander and grander effects with the least labor. The great high "pyramids" of the Middle Americans *evolved.*

THIS is important to know. Many books state that the Indians were taught to carve and build by wanderers from Egypt, Asia, or from continents now submerged in the oceans; the underlying idea being that the Indian civilizations did not evolve, and that their most advanced achievements were accomplished at the start. This would be expected if they had learned all their arts from the outside. As digging progresses, however, such sequences as these at Piedras Negras show, on the contrary, more and more clearly that the Indian taught himself how to cut stone and wood with stone tools, how to burn lime, and how to build progressively more imposing settings for the worship of his gods.

Middle Americans were obsessed with an end-of-the-world idea. The coming end apparently depended on the heavenly bodies. So Maya priests were astrologers, and studied the movements of the sun, moon, planets, and stars. They carved extracts from their calendrical calculations on stone monuments, or stelae. Two of these are shown in position in the final two drawings, and in the photograph on the opposite page one is shown propped up on its side at the left. Probably this was to help future generations of priests to improve their astronomical formulas by checking against past observations and predictions. One of the recorded dates in a full inscription

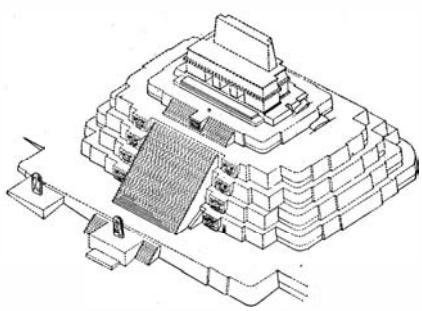
A workman points to an altar hidden in a cavity behind the shoring of poles



Four stages of the odd 500-year evolution of the Maya temple, as it was modified by succeeding architects who were not content to leave well enough alone

was approximately that of the time it was carved and the monument set up.

With the hieroglyphs, scenes are often carved, apparently showing priests conducting rituals to avoid the evils indicated by the current calcu-



The fifth stage of modification

lations. Those at Piedras Negras are among the finest, and mark a peak in Indian sculpture. That is one reason why this seemed to be a good place to dig. The carvings to be rescued, and new ones to be discovered, were of the finest; Dr. Mason saved many. In addition, here was the longest series of legibly dated monuments. This promised a maximum chance to use the Maya calendar in working out the development of their architecture.

We will give an example of how these carved dates can be used. Some day we shall know what the date on the central monument in the fourth and fifth figures is, in terms of our own calendar. About 675 A.D. is more than a guess, but this may be wrong. We can call it "Date X" for the present. The masonry roof on the building of the fourth drawing rests on an inverted, V-shaped, false arch, or "Maya vault." The fact that it first appears with the monument makes us fairly sure this vault was built about the time of the monument; that is, at Date X. It is one of the simplest and most easily built vaults at Piedras Negras, and therefore probably one of the earliest. Far to the east, at another site, the Carnegie Institution of Washington also has been dissecting Maya buildings. There they found a building with a vault which was erected earlier than an associated monument. The monument date is much earlier than Date X, which places that vault much earlier than ours. We have made a start toward proving that the vault was invented by another Maya group to the east. In time its use spread to Piedras Negras. Thus can an item for an outline history of Maya architecture be obtained.

A modern bomber synthesizes ideas from many sources: Explosives were invented in ancient Asia, rubber came from the American Indians, the fundamentals of radio from Europe, and the practical means of flight from white Americans. So, on a smaller scale, but in an entirely similar manner, one ancient Middle American group borrowed what it thought it could use from another, whether the borrowing involved a plant, like corn or tobacco, a deity, or a method of building construction.

The fact that, after feeding and housing themselves, these ancient Indians devoted most of their labor and genius to their gods is all to their credit, for they thought this was necessary in order to preserve their way of life for their children. Their religion, like our war, was "all-out" for the good of the tribe.

Food For Fighters

New Dehydration Process Uses Steam Baths and Heat Treatments to Reduce Vegetable Weight and Bulk

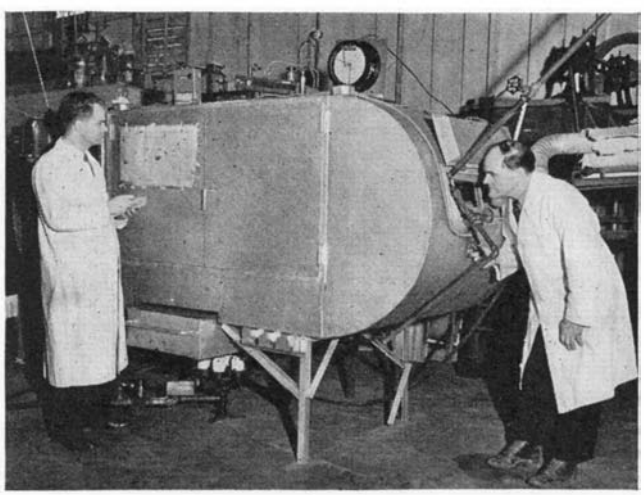
ANDREW R. BOONE

SINCE it is still true, during these days of high-speed tanks, jeeps, and sundry other wallop-packing vehicles, that an army travels on its stomach, Uncle Sam intends that American soldiers and sailors shall enjoy body-building and health-giving vitamin-laden vegetables along with their meat and dessert, at all distant outposts. Particularly will carrots, onions, cabbage, and potatoes be present on daily Army and Navy menus.

All vegetables contain large amounts of water, and water is heavy and bulky. Thus, when a food ship pulls into some distant outpost, bearing fresh or canned vegetables, nine tenths of the load is water, which is costly both in ship space and time to transport, and utterly without value as a food.

To avoid this wasteful practice, the army plans to feed military men in Alaska, Eritrea . . . on a score of fighting fronts . . . millions of pounds of dehydrated vegetables during coming months. When a company cook, fretting about the dinner menu, starts to prepare the evening meal, he will open two or three five-gallon tin cans, scoop out a few pounds of peas hard as baked clay and sweet corn more wrinkled than a sun-dried prune, and a half-dozen compressed cabbage disks. He'll toss the peas, corn, and cabbage into kettles of cold water. Thirty minutes later, he'll start these vegetables simmering. Another half-hour, and the vegetables will be ready—sweet, attractive, and nearly as fresh to the taste as the day they were harvested back home.

Researchers in a laboratory maintained by the United States Department of Agriculture at Los Angeles are seeing to it now that these foods will reach the fighting fronts bearing virtually all the food values of fresh vegetables. There Dr. E. A. Beavens, and others, working under direction of Dr. E. M. Chace, chairman of the department's dehydration committee, have discovered means not only of preserving the vegetables for long periods in all kinds of climate, but also of retaining virtually all the vitamins A and B, and more than half the vitamin C. Keeping vitamin C, number one scurvy preventer, which dissolves in water and just seems to evaporate from both leafy and solid vegetables between the field and home, is an achievement of the first magnitude.



Dehydrator for selecting vegetables for processing

In this "house of dehydration," Dr. Chace and his associates have solved a problem of many years' standing. Key to their taste-color-texture-vitamin preserving method is a combination steam bath and dehydration process, the latter being accomplished in a small plant containing features so new they haven't been patented yet. Here garden-fresh cabbage and carrots become brittle shells of their former selves in two hours. Two large heads of cabbage, enough to feed 20 hungry men, are compressed, after dehydration, into a disk small enough to fit in the hand. Yet, in those few ounces, there is enough cabbage to feed those same ravenous appetites.

Suppose we follow the trail of a batch of carrots through the new process. We'll start with six crates, each weighing 33 pounds. They were pulled an hour ago, and now they're being topped, trimmed, washed, and scraped. Clean and crisp, just as you would serve them for dinner, they are cut into disks about a quarter-inch thick. After being spread evenly on wire trays, they are placed in a square receptacle resembling a laundry tub, and covered. For six minutes steam rises from jets below, scalding each bit thoroughly. This process is called blanching, and it performs the important task of inactivating the enzymes, organic catalysts which cause chemical transformations in plants, thereby halting processes which ordinarily would destroy the color, flavor, and vitamins.

From the steam bath, the carrots are carried to the nearby dehydrator. This device, built undersize for experimental purposes, resembles a medium-size, all-metal automobile trailer standing on rigid legs. It is not intended to dry large quantities of vegetables, but, as Dr. Beavens explained, makes possible the selection of the varieties which will yield the best dried products. Within, after the doors are closed, air flows along baffles of a newly developed pattern, passing in parallel lanes over the material. Flowing at high velocity, from 900 to 1100 linear feet a minute, with the temperature carefully regulated in the 150 to 180 degree range, the dehydrator will turn out the dried food in periods ranging from an hour, for spinach and other greens, to four hours for corn.

But back to the carrots. The contents of six crates require several runs. So we wait, and at last we have a small pile of crinkly disks. We weigh them. Seventeen pounds. They fill two five-gallon cans. Were they intended for army use somewhere across the world, the shipper would drop a small chunk of dry ice into each can before filling it. He would seal the lid tightly with shellac. The dry ice, turning to gaseous carbon dioxide, would halt any oxidization, preserving the contents of the can for a year or longer. And the two cans would occupy about one-ninth the space now required for six cases of fresh or frozen carrots on that heavily laden transport.

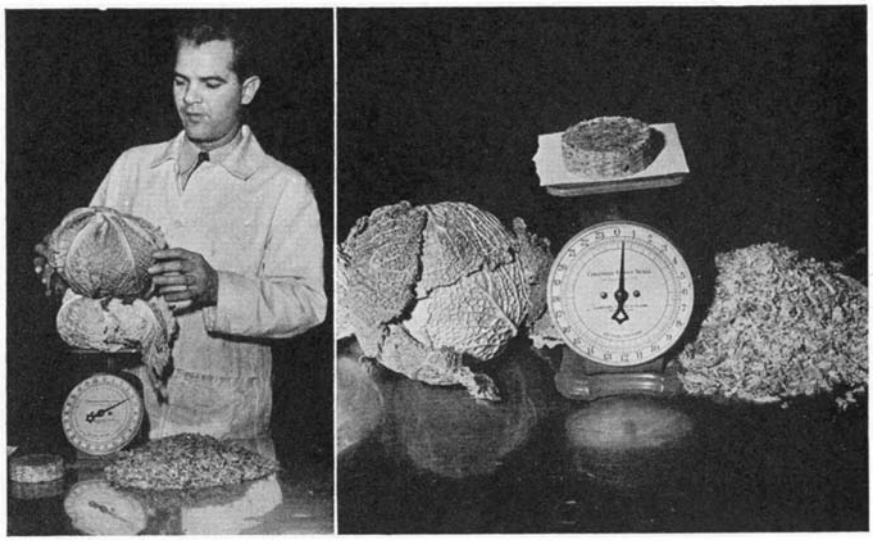
Our fighting men are due for more surprises, now hatching in this laboratory. While the war department is mainly interested in carrots, onions,

cabbage, and white potatoes, Dr. Beavens is hard at work on sweet potatoes, string beans, lima beans, peas, chard, mustard and other greens. He faces three "musts" before the army will accept his results. The vegetables must keep well in all climates for at least a year, they must rehydrate within an hour, and 92 percent of the moisture from potatoes and from 95 to 97 percent moisture must be removed from all other vegetables.

Speaking of spuds, Dr. Beavens has already achieved a dish that will delight fighting men yearning for steak and French fries. He's going to give them shoestring potatoes. They'll look like dried string when they tumble from the can, but a brief soaking and quick frying will restore their firmness. Even "canned willie" will taste like T-bone when accompanied by this delectable morsel.

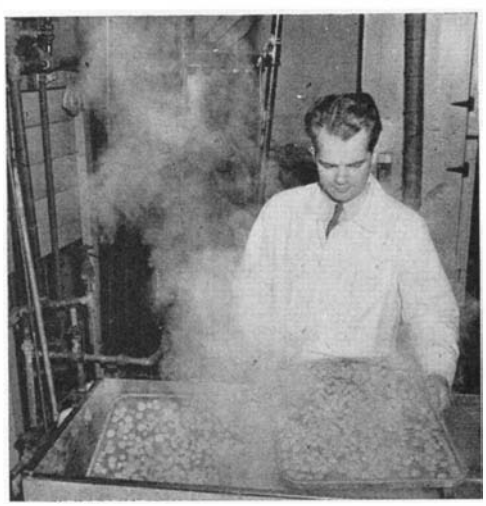
Seven firms produced 7,000,000 pounds of dehydrated vegetables last year. Then the British began asking for dehydrated tomatoes, and inquiring about dehydrated carrots. Arizona carrots got a big boost recently when Margaret C. Smith, University of Arizona chemist, reported the copper state's product contains from three to ten times more carotene, source of vitamin A, than other carrots.

"Carrots," reported an R.A.F. officer, "ought to give our fliers cats' eyes by preventing night blindness." Walt Disney drew up three sketches showing carrots winging their way through the sky. Copies, wired from Hollywood to London, are posted in all R.A.F. barracks, urging pilots and bombardiers to eat carrots in all available forms. As a result of inquiries, from fighting forces both at home and abroad, production is zooming. It is estimated 25,000,000 dehydrated pounds of all vegetables will be produced during 1942—enough to provide 300 servings for 1,000,000 soldiers.



Cabbage before and after dehydration. Two heads (four pounds) shrink to a six-ounce disk. Disk is compressed from shredded leaves (at right) after dehydration

Civilians will get to know these foods better, too, as time goes on and transportation facilities take on heavier defense loads. Although most popular now in the nation's markets is a little package containing a scoop of chicken fat, some noodles, and pieces of dehydrated vegetables, which becomes a quart of noodle soup after the addition of water and a few minutes' boiling, you can also get several other soup-making mixtures and such individual items as potato shreds, onion flakes, carrot cuts, pea and bean powders, tomato pieces and flakes, and spinach and celery flakes. In each case, all you need do is add water, heat, and eat. They'll increase in weight from eight to 40 times their dry weight as they take up water. But all the food essentials are there, just as in canned and fresh vegetables.



Steaming (blanching) at 212 degrees, Fahrenheit, precedes dehydration of carrots

Don't let the word "dehydration" fool you into thinking you'll get tough, stringy, hard-shelled beans and carrots and peas and corn, when these vegetables are prepared by the modern method. True, dehydration means that nine tenths or more of the water is removed. Processes developed in the last few months do that, and more. After you rehydrate the vegetables in your kitchen and simmer them a half-hour, they're practically as good as garden-fresh vegetables.

The other afternoon I carried home from the Los Angeles laboratory four samples: A scant handful each of dehydrated corn, small lima beans, and mixed peas and carrots. They had been dehydrated in the new apparatus nearly two months earlier. The beans were almost hard as rocks; the corn, shrunken to a fourth its natural size, brittle and sugary; the peas and carrots only apparent shells of their former selves.

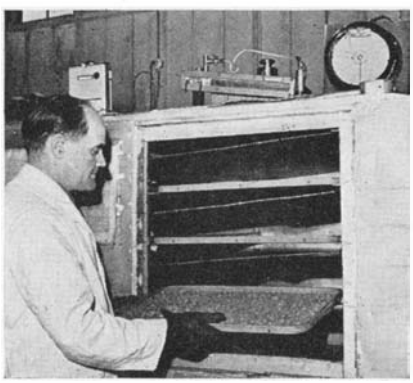
That evening, the samples were soaked a half-hour in cold water, then simmered a half-hour. When fully done, we had enough to feed eight people. All four vegetables had returned to their normal shapes and sizes, the peas had their accustomed green sheen and the corn looked as if it had just been cut from the cob. Except for a stray kernel and an occasional pea, all were sweet and juicy. Had I not seen them before cooking, I would not have known them from fresh.

We stay-at-homes know little of the dietary deficiencies which soldiers suffer when they go without fresh fruit and vegetables for a long time. One of the dread diseases faced by fighting men on some distant desert or arctic base, should their supply lines be cut, is scurvy. As early as the Civil War, semi-dehydrated vegetables were fed Union troops, but they were unpleasant to the taste, and possessed no anti-scorbutic properties. Again, during World War I, both the Germans and Americans used dried vegetables. Many doughboys fighting in France will remember dumping his ration on the ground to avoid eating them, but these vegetables were entirely different from those which are now being made available.

Once tasteless and lacking in nutrition, dehydrated vegetables now provide both food and medicines. In a wide-scale California experiment, nutritionists and chemists for Ana-

bolic Food Products, Inc., are feeding 20,000 acres of parsley, turnip greens, and beets special diets to increase their tissue-building values, and possibly to add a little extra zip in the form of vitamin C. The diets are prescribed after analyses of the soil and water indicate what plant foods are deficient.

Formerly potash, phosphorous, and nitrogen were thought to be the essential food elements for growing plants. Now, in addition to the Big Three, the dehydrators are turning their attention to the so-called trace elements such as boron, manganese, sulfur, calcium,



Removing carrots from dehydrator

iron, and phosphorous. Dr. J. W. Wigelsworth is cultivating super-vegetables, and already has turned out strains of leafy plants containing three times the average amount of iron.

When these dehydrated vegetables reach far-flung American military and naval fronts, soldiers and sailors alike may be sure they're getting more iron in their parsley, added bone-building calcium in their turnip greens, extra manganese in their beet greens, and abundant copper in the green sprigs of parsley.

Army chiefs know soldiers will complain, no matter how tasty the chow. But they're making sure the steamed and dried carrots and peas, and all their kin, will return to their original form, size, and appearance; cook tender; and give off nearly all the odor and flavor of the fresh article. They may be bone dry at 11 o'clock. But when the chow bell rings at high noon, they will be "garden fresh."

In fact, recent tests at the University of California showed dehydrated peas, string beans, carrots, and spinach to be actually superior in color, after cooking, to the canned product.

When it comes to shipping, as has been pointed out, great savings will be effected. One pound of dehydrated pumpkin contains 12 times more fuel value than a pound of fresh pumpkin. Not only does a ton of fresh cabbage yield 215 pounds of the dehydrated product, but the fuel value of the dried leaves actually equals 2279 pounds of cabbage freshly boiled in the kitchen. One cargo ship will do the work of 16 when it comes to hauling tomatoes, because this vitamin-rich vegetable loses 93 percent of its weight when dehydrated.

Those are some of the reasons why Uncle Sam is so interested in food during this war, and they explain how he is planning to carry more bullets and bombs to distant places without cutting into food rations on the firing line.

• • •

HALLUCINATION

You Can Be Trained To "Hear Things"

PERFECTLY normal persons can be taught to "hear things" where there is no sound. Details of how such hallucinations can be produced by the simple form of learning known to psychologists as "conditioning" have been reported by Prof. Douglas G. Ellson, of the University of Mississippi.

Nearly half of a group of subjects taking part in Prof. Ellson's experiment under the most favorable conditions, learned to hear a tone when it was not being sounded. They had been prepared to "hear" it by a learning period during which the tone was sounded regularly every 30 seconds for 30 repetitions.

When the actual sounding of the tone was introduced and ended gradually, the subjects tended to have the hallucination of a tone after it had ceased to sound. If the start and termination were abrupt, however, only a few (8.5 percent) developed the hallucination.—*Science Service.*

POISON IVY

Infection Prevented by Protective Ointment

AN IMPROVED protective ointment against poison ivy has been developed and proved effective by the United States Public Health Service. The new ointment, made with either of two bases, will remain effective for several weeks if kept in a closed container.

The ointment should be thickly applied to exposed parts before contact with poison ivy. Clothes must be removed after exposure before the ointment is washed off, otherwise the unprotected skin may be exposed to clothes which have been contaminated. Tools and instruments or clothing which have been used in cutting poison ivy must be decontaminated before being used again. Decontamination can be effected by washing clothes or immersing tools for 15 to 20 minutes in a 1 percent solution of calcium hypochlorite.

The two formulas were developed by Drs. Louis Schwartz, John E. Dunn, and F. H. Goldman of the Public Health Service:

Formula 1

Castor oil	21.5%
Olive oil	21.5%
Lanolin, anhydrous	21.5%
Diglycol stearate	12.9%
Paraffin, refined	8.6%
Boric acid	2.0%
Sodium perborate	10.0%
Duponol WA pure	2.0%

Formula 2

Cetyl alcohol	35.1%
Stearyl alcohol	5.3%
Ceresin	3.5%
Castor oil	20.8%
Mineral oil	21.9%
Duponol WA pure	1.7%
Sodium perborate	10.0%
Boric acid	1.7%

IN THE BRAIN

Sex Perverts Found Not Lacking in Hormone

DRAMATIC transformation of seven "somewhat effeminate," jealous, jittery young men into he-men with beards, an interest in girls, and enough ambition to advance in their professions or to get off relief rolls into regular jobs was recently reported by Dr. Jacob Kasanin, director of psychiatry at Mount Zion Hospital, San Francisco, and Major Gerson R. Biskind, Letterman General Hospital, San Francisco.

These young men had undeveloped male sex glands, but had not "become sexually depraved in the sense of becoming interested in homosexuality," the physicians reported. Treatment with the male sex hormone, testosterone, by implanting "banks" of the hormone in their muscles to supply the deficient amount from their glands, brought about the personality changes reported.

A group of patients examined on account of homosexuality, on the other hand, did not show any evidence of lack of sex hormone secretion. "This points to the fact," the physicians conclude, "that homosexuality and sexual perversions are probably psychological in origin."—*Science Service.*

When Lightning Strikes

Applied Research Has Reduced Greatly the Damage Done by Natural Lightning, Yet Much Study is Still Ahead

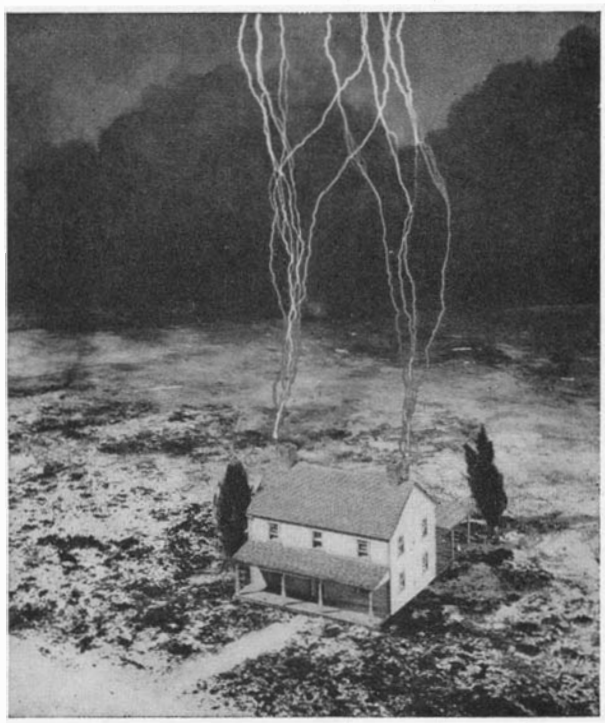
Dr. GILBERT D. McCANN
Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

EACH year about 16 million thunderstorms occur on the earth, causing an average of about 50 lightning strokes to the earth each second, or a total of about two billion strokes a year, which are a potential source of destruction. If these strokes were equally distributed, about eight strokes a year would strike each square mile of the earth's surface.

In the United States alone lightning strokes cause about 400 of the annual 92,000 accidental deaths, about the same number as street-car or airplane accidents. They produce some $12,000,000 worth of damage to farm buildings, 55 percent of all oil-tank fires, and untold damage to forests through fires. Lightning constitutes a serious hazard to aircraft, munitions dumps, and explosive manufacturing processes. It is a hazard and a source of interference to both telephone and radio communication. Electric power systems, however, constitute by far the greatest potential targets for lightning destruction. The extensive character of transmission lines and distribution systems contributes to their being struck frequently by lightning, and maintenance of continuous service and prevention of damage to equipment places stringent requirements on lightning-protection devices of various types.

There are today in the United States about 83,000 miles of high-voltage transmission lines transmitting large blocks of power from our 42 million kilowatts of generating machines to many load centers. Lightning is by far the most serious cause of trouble on these lines. Aside from the serious damage it can cause to electrical equipment, the loss of service it can produce not only results in considerable inconvenience to power consumers but also may produce damage and result in the loss of many hours of operation for certain types of manufacturing processes for which even a momentary loss of power is serious. Maintenance of continuous service is particularly important in these times of national emergency.

Studies of the number of times transmission lines are struck by lightning reveal that in the eastern part of the United States a mile of line is struck, on the average, about once a year. Thus, a 100-mile line would be struck 100 times. Storm density, of course, varies throughout the country, but it is estimated that the 83,000 miles of transmission lines are struck at least 60,000 times a year.



A model house protected from artificial lightning by lightning rods. Although the rods were struck many times, neither house nor nearby trees were hit

Twenty-five years ago knowledge of lightning and the protection of power systems was so limited that every time a line was struck at least a service interruption occurred. Today, through knowledge gained by lightning research, a 100-mile line can be protected so that it does not have an outage more than once every four or five years, instead of 100 times a year.

In addition to high-voltage transmission lines, many thousands of miles of distribution circuits feeding individual consumers in both rural and urban areas must be protected from direct strokes and from induced voltages produced by a lightning stroke in the vicinity of the line. The electric fields associated with a stroke may produce dangerous voltages on such circuits.

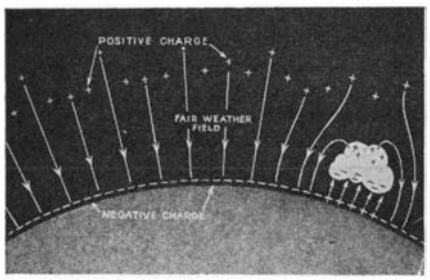
Through co-operation of the public utilities and electrical manufacturers, and through the use of special recording instruments, such as the Klydonograph, cathode-ray oscillograph, surge-crest ammeter, Boys camera, and the Fulchronograph, valuable information has been obtained regarding the mechanism of the stroke discharge and the voltages and currents associated with lightning. Also of great importance have been the data obtained by the United States Weather Bureau on the variance of storm density throughout the country.

This knowledge has led to the use of ground wires and vertical grounded masts located over and around transmission lines and substations to intercept lightning strokes and conduct their high currents harmlessly to earth, thus preventing lightning from directly striking live conductors carrying power. Their principle is similar to that of lightning rods on buildings. Contrary to a common belief, lightning rods, properly applied, provide effective protection. This misconception has largely been due to the fact that a great many applications in the past have been faulty and ineffective. This type of protection has also been found applicable to oil tanks, munitions dumps, or any object that can be damaged by a direct lightning stroke.

Voltage-limiting protective devices such as lightning arresters have been so perfected that they effectively limit voltages produced by lightning on power systems to magnitudes which will not damage equipment. They are also used effectively for protection of radio transmitters and telephone equipment. The Bell Telephone Company has so developed lightning

protection of its systems that loss of service rarely occurs and it is quite safe to use the telephone during thunder storms.

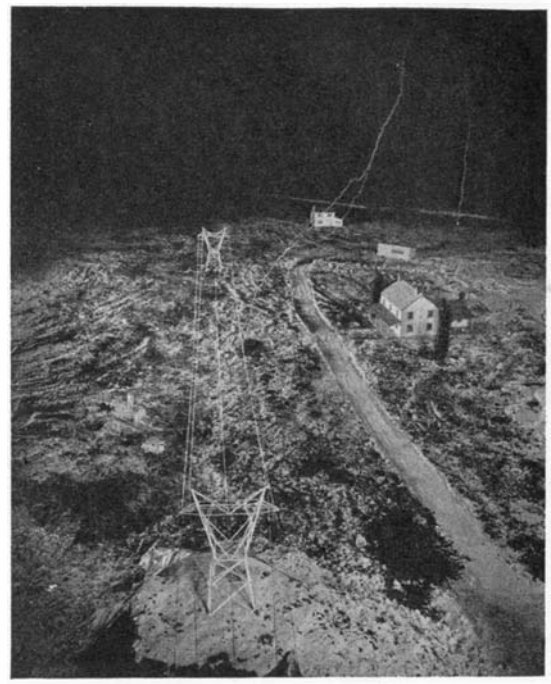
It has been found possible to duplicate many of the important properties of lightning in the laboratory and thus study the performance of protective devices. The voltages and currents associated with lightning are of extremely high magnitude—millions of volts and hundreds of thousands of amperes — but they are frequently only a few hundred-millionths of a second in duration. However, it has been found possible to duplicate and measure them. It is possible also to reproduce the essential characteristics of the stroke discharge from cloud to ground in model laboratory sparks and thus study with model transmission lines, substations, and the like, the performance of shielding ground wires and vertical masts.



When the air, a low-value conductor of electricity, can no longer withstand the electrical stress of the field of a thunder cloud, lightning strikes and the electrical balance between earth and air is restored

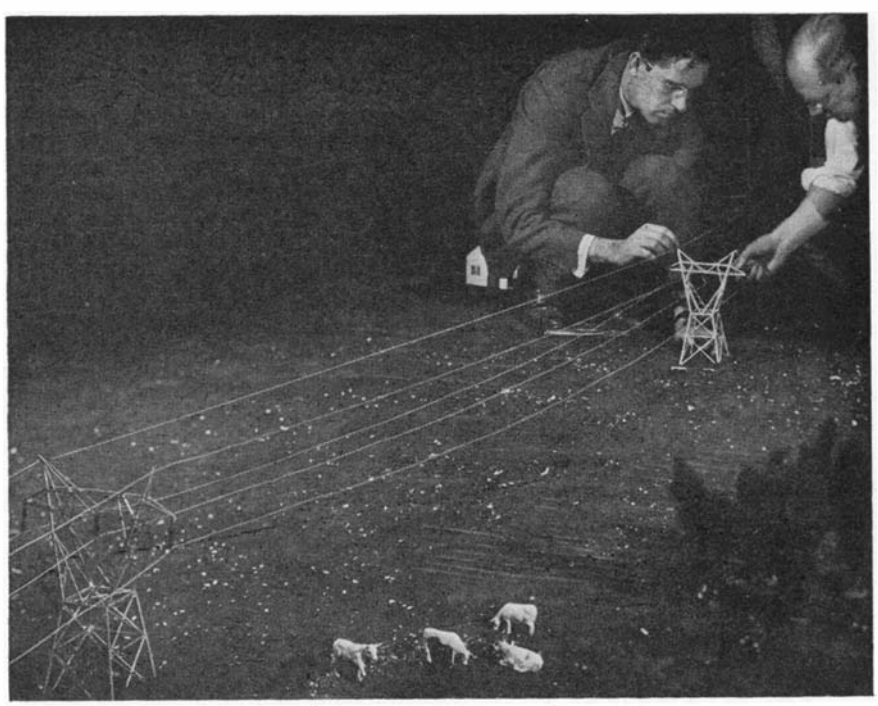
It is important to measure and study the electric and magnetic fields produced by lightning strokes. These are the source of "static" interference in radio reception, a type of interference which also bothers telephone circuits. These fields are so intense and of such high frequency that they can induce dangerous voltages not only on power and telephone circuits but also in certain manufacturing processes using explosive materials. A spark caused by a flashover from such an induced voltage is a potential source of explosion or fire. This is a problem which has become more important with the expansion of our war industries. The most effective way to eliminate this hazard is to shield the building or area in which the explosive process is taking place with a conducting shield or "Faraday cage" which completely surrounds it. This prevents the penetration of the electrical field produced by a lightning stroke.

Lightning is a hazard to all types of aircraft. Captive balloons attached to conductive cables are likely to be struck during a thunderstorm, and airplanes are sometimes struck by being in the path of a stroke to ground while flying below a thundercloud or by precipitating a cloud-to-cloud discharge while flying in the thundercloud itself. Aircraft can become electrically charged while passing through a thundercloud, and when they land they may be discharged by a spark which can be hazardous. This is particularly true of seaplanes making forced landings, as they often lighten their load by dumping gasoline.



Artificial lightning strikes the models

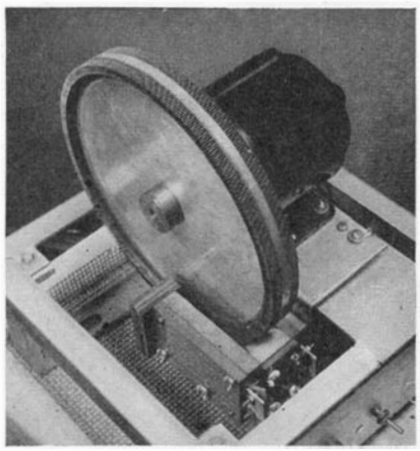
For the solution of such problems a knowledge is required of the fundamental processes involved in the formation of charge in the thundercloud. The energy of this charge formation is supplied by highly turbulent upward air currents, which are essential to the formation of the cloud itself. This turbulent condition in the cloud is also important as a hazard to aircraft. It also is essential to the formation of precipitation. Thus, the electrical properties of a thunderstorm are closely associated with all of its other properties and for this reason of much concern to meteorologists.



Building a miniature transmission line for studying lightning effects

THE thunderstorm plays an important and fundamental role in the natural state of the earth. Although it is not commonly realized, the earth, besides being a magnetic body, is also electrically charged. We are all familiar with the fact that there are magnetic fields produced by magnetic materials concentrated mainly at the North and South Poles. However, there is also at all times a negative electric charge distributed over the surface of the earth and a positive charge in the outer regions of the earth's atmosphere. These two sets of charges produce an electric field in the air directed vertically toward the earth.

During fair weather this field is about 30 volts per foot at the earth's surface. Measurements of the charge density on the earth indicate that the total charge on it is at all times about 500,000 coulombs. Owing to a certain degree of conductivity of the air in the form of free ions, the air has a low conductivity and the presence of the electric field produces a leakage current from the earth, tending to discharge the earth's negative charge. If it were not for some restoring agent the earth would be completely discharged in five or six minutes by this leakage current. Lightning plays the fundamental role of returning this charge back to the earth and maintaining it in its normal charged condition. Thus, there exists a continuous cyclic process of discharging and recharging the earth. The key to this process is the ionization of the earth's atmosphere which makes possible its conductance and the leakage current. This ionization also plays a role in the formation of the charge in the thunder cloud and the breakdown of the air which produces the spark discharge of the stroke to earth. This ionization is produced by three sources:



This motor-driven wheel, carrying many small steel strips on its periphery, measures lightning. When lightning strikes, a small coil magnetizes each strip as it passes a given point. By later measuring the magnetism of each strip, a fairly complete picture of the lightning stroke can be drawn for further careful study

1. Alpha, beta, and gamma rays (or X-rays) emanating from radioactive minerals in the earth's crust. 2. Radioactive gases in the atmosphere, which are products of decomposition of radioactive minerals in the earth. 3. Cosmic rays emanating from the outer universe.

Lightning is not altogether destructive. It is also a beneficial agent to plant life, for it produces in the air large quantities of nitrous acid which are carried into the soil by rain. It is estimated that the 16 million storms that occur annually produce about 100 million tons of this fertilizing agent. This gigantic amount exceeds by far the total output of the nitrogen-producing industry.

As a result of the concentrated efforts of the various research organizations that have been studying lightning and the electrification of thunderstorms, great strides have been made in the past 25 years and many of lightning's properties have been well established. Also, many of the problems of protecting against its destructive effects have been overcome. However, there are still important properties of lightning about which more knowledge is needed, and although considerable progress has been made, many questions still remain for further investigation.

• • •

BLACKOUTOLOGY

Why Red Light is Better than Blue

EYES have two-way vision—one set of sense organs (the cones) for daylight seeing and the other (the rods) for darkness. Both operate at the same time only when the light is about as bright as full moonlight. Differences between the eye as a night-vision instrument and the daylight eye, important for night warfare and blackouts, recently were described by Prof. Selig Hecht, of the Laboratory of Biophysics, Columbia University.

Night eyes are thousands of times more sensitive than are day eyes. The night pilot who has been flying in the dark for an hour or more could see the light of a candle 12 miles away even if it were exposed only for a thousandth of a second. If it burned continuously, he could see it over 200 miles away, were it not for interference of fog and haze at night, or for smoke and the curvature of the earth. For this reason it is dangerous in a blackout to use a flashlight, or light a match or even a cigarette in an open space. The flame of a match can be seen by a pilot many miles away.

On the other hand, night eyes cannot see as *sharply* as day eyes. When it is necessary to recognize small forms and slight differences in shade and shape, you must have good lighting and use your daylight eyes. You need your day eyes to read an instrument or your watch.

But the brightness of different colors is not the same when you see them at night as when you see them in the daytime. This is particularly important when you want to use colored lights to see best during a blackout without giving aid to the enemy. Blue and green are easiest to see. Red and orange, which seem so conspicuous in the day, are hardest to see at night.

Nothing could be more dangerous than the use of blue lights during blackouts, Prof. Hecht declared. "For reasons which are none too clear at present, the notion has gained prevalence that blue lights should be used to illuminate objects, and that these would furnish less light to distant aviators because blue is supposed to be a dim light. Indeed, the Germans and the English, and at the beginning we ourselves, used blue lights during blackouts."

When we need a light during a blackout—to watch a dial, read a compass or a road sign—we must use our day vision for this purpose. The enemy aviator, however, needs only his night vision in order to spot that light.

Your night eyes and your day eyes happen to be equally sensitive to red light. If you see the light at all, you can also see it with your color-sensitive day eyes and you have the day vision's advantages of ability to recognize shapes.

But, for blue light, your night vision is 1000 times more sensitive than is your day vision. In other words, if you have enough blue light so that you can see a road sign, the light will be 1000 times as bright to the night-seeing pilot as would be a red light of equal effectiveness.—*Science Service.*

• • •

WOOD FARMING—Mississippi farmers now are planting millions of pine seedlings provided by the Masonite Corporation, manufacturers of hardboard and insulation board products. The new industrial demand for pine wood has given cash-crop value to land previously considered worthless in the South.

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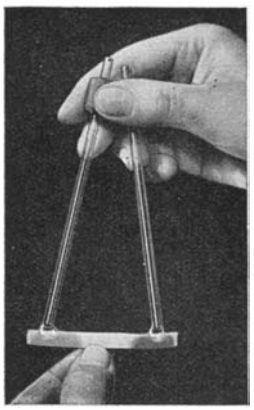
TEST FOR pH

Made Quickly With Simple Equipment

CONTROL tests for pH (degree of acidity or alkalinity of solutions) can now be made rapidly by unskilled workmen with simple equipment. Also, quick preliminary tests can be made in laboratories where more elaborate pH apparatus is available.

The simple technique of pH testing using the Cargille Buffer Set depends upon the use of 17 buffer tablets which, when dissolved as directed, provide 17 solutions of known pH value.

These solutions, applied to a strip of test paper, bring out a specific color on the paper for the pH value of the solution used. Thus, when making tests, a drop of the solution to be checked is placed on the test paper and the resulting color is compared with the chart furnished with the paper. A solution of known pH value, close to the pH value indicated by the first test, is then placed on the test paper



Checking color produced on test strip by sample and by solution of known pH gives quick determination of pH of the sample

beside the sample. By proceeding in this manner until differences in color are scarcely perceptible, the pH value of a sample can be quickly judged to about 0.5 pH unit.

It is claimed that color comparisons made in this manner are more accurate than those which are made with a color chart alone.

JAP NYLON

May Enter World Markets— After the War

JAPANESE industrial chemists are already preparing for an industrial struggle to follow cessation of the shooting war. This is the conclusion that may be drawn from three articles published in Japanese, in the *Journal of the Chemical Society of Japan,* during 1940 and 1941. The author, K. Hosino, research man for the Oriental Rayon Company, Ltd., tells how he analyzed nylon, the synthetic plastic fiber that has made the United States independent of silk. After he had determined how the molecules were put together, he duplicated them and then made modifications which he claims are improvements over the American product.

This procedure, reminiscent of prewar tales of how Japanese mechanics would build a duplicate of any machine that Occidental manufacturers would sell to their employers, might give Japanese textile factories the means to compete to great advantage with nylon mills in this country and Europe. Japan has persistently refused to enter into any patent treaty with any foreign country, so that the du Ponts, originators of nylon and owners of basic patents thereon, will have no protection against Japanese attacks on their business, especially in the export market.

Nylon, the Japanese chemist states as a result of his analysis, is a "polyamide of hexamethylenediamine combined with adipic acid."

If Japan goes into the nylon business, the silk industry, already hard hit first by rayon and then by the cessation of American silk purchases even before the outbreak of war, may never come to full revival. It is reported that hundreds of thousands of mulberry trees have already been felled in Japan, to make room for more food-crop production. Quite possibly these groves may never be replanted. Silk may again become what it was in the Middle Ages and early modern times—a luxury for the rich.

• • •

PROTECTION — Tiny robot sentries — new secret devices built into miles of high wire fences enclosing some of the nation's great war production plants—are said to be saboteur-proof by du Pont engineers who developed the system. The acoustic fence "overhears" birds chirping, the snip of a wire-cutter, the scrape of a shovel, even whispers, relaying these sounds to a central control room from whence a squad car rushes to the precise point of disturbance.

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SALT ROADS

Wear Better, Resist Frost

THE practice of using rock salt in the subsurface of roads, which originated in Nova Scotia as a means of protecting roads against extreme winter conditions, is spreading in this country with remarkable results reported. First employed to keep frost from heaving the road surface, salt has been found to do more than serve as an anti-freeze. Through a simple action it also stabilizes the soil used in the subgrade so that the road bed is firmer, giving longer life to the wearing surface.

One of the most interesting examples of subsurface treatment with salt is found in Cayuga County, New York. The first salt road in Cayuga County was built in 1936, and in succeeding years additional salt roads have been laid down. According to Gail Ball, County Superintendent of Highways, none of these roads show any sign of frost damage.

"Employing a system that we have used successfully ever since," he said, "we first used the salt not in the subsurface but in the original surface. We were convinced that salt worked into the surface would give us a longer-wearing road and we put down about eight tons of rock salt to the mile, raking and rolling it in. After two years, in which the salt-surfaced road held up excellently, we gave it a light sprinkling of salt, and then put on a macadam surface. Although other untreated roads nearby have suffered severely from frost since that time, this road has shown no frost damage whatever. We feel that we are getting extra value from the salt in this matter of frost-heave prevention, since that was not our primary purpose in using it."

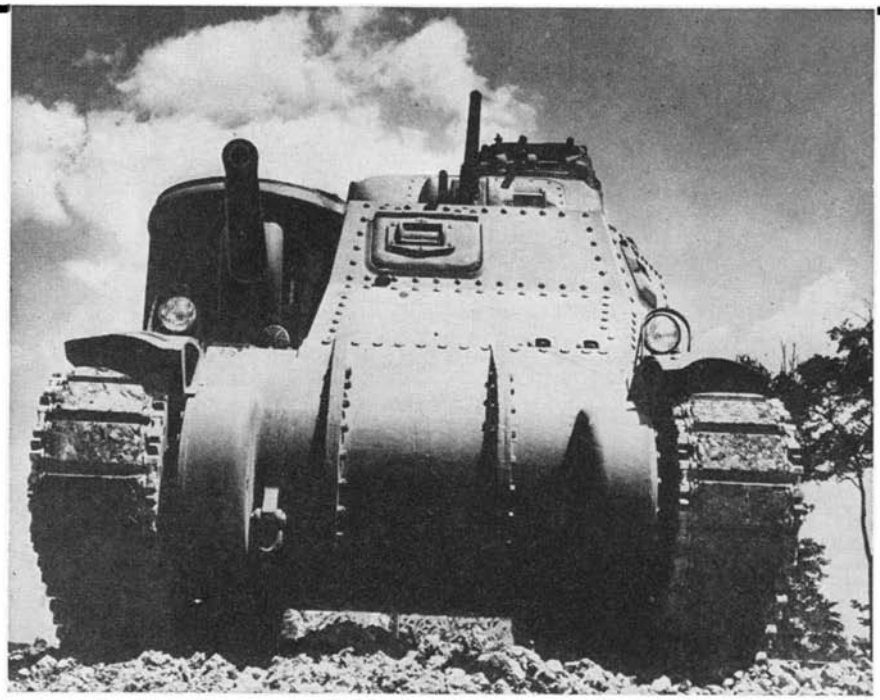
EMPLOYEE DESIGNED

Work Simplification Program Aids Production Drive

AN assembly fixture, designed in his spare time by Albert Wender, an employee, and manufactured out of scrap materials, has raised the output of siphon tubes for Army tank fire extinguishers from 100 to 400 parts per eight-hour shift at the New Jersey plants of Walter Kidde & Company. John Space, another employee, has worked out another scrap steel device that increased the output of valves for gas-type airplane fire extinguishers by 25 percent. Gains of 71 and 100 percent in other typical assembly operations have resulted from this showing of employee inventiveness.

These are the tangible results of the Work Simplification Program that is playing a major part in the war production drive. This program, which was inaugurated two months ago, is itself the invention of a Kidde employee—B. P. Corcoran, who until recently was a worker on the assembly line. Night school courses acquainted Mr. Corcoran with the principles of motion study, and his years of ex-

John Space and his scrap-made unit



Men in the Armed Forces
—Soldiers, Sailors, Marines—

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perience as a worker gave him the idea of applying these principles to the men themselves.

The basis of work simplification is the fact that the man on the job often knows more about improving that particular job than a highly trained engineer. The basic problem is how to bring out these ideas and the two major difficulties are expression and shop psychology.

Under the Work Simplification Plan, the workmen work out their own ideas and present them as accomplished facts. The starting point is the foreman or group leader. Regular classes are held for these men in which they are acquainted with the principles of motion study, expressed in simple shop language rather than engineering terms. In these classes they are given assistance in working out their own ideas, and prepared to help the men under them.

In addition, a machine shop, completely equipped with hand and power tools, has been provided for the employees so they can develop their own devices. Employees can use this shop either on their own or on company time, and a skilled machinist is always present to aid the worker with an idea.

CORRECTION

In "From The Ground Up" Article

SEVERAL of our readers have called our attention to discrepancies which appeared in the article "From the Ground Up," by Douglas M. Considine, which appeared in our June 1942 issue. In the last paragraph of the second column on page 279 of the article, continued to the top of the third column, production of TNT should be read in pounds instead of tons. The same correction should be applied to the discussion of picric acid and smokeless powder, in the same paragraph. It appears that this error crept into the final typescript during transcription from the original.

MILK PROTECTION

Ultra-Violet Rays Kill Bacteria

A NEW U-shaped Sterilamp, using beneficial ultra-violet rays, may be the future means of keeping milk fresh for many hours longer, in addition to providing completely sterile bottles. Designed primarily for use in dairies, this new development of the Westinghouse Sterilamp may easily be adapted in other bottling operations such as soft drink manufacture, canning factories, and pharmaceutical concerns.

Highly efficient methods of washing milk bottles now employed by modern dairies may be improved upon by use of the Sterilamp, it is reported. At the present time, bottles returned to the dairy are put through a process of warm and hot water solutions. After that, the bottle is washed with germ-killing chemicals. At this particular point, the bottle is sterile, but it must be rinsed. Most city water used for that purpose has been proved

U-shaped Sterilamp in laboratory

to have considerable bacteria, and although harmless in most cases, they cause milk, if left standing, to turn sour.

The ultra-violet rays of the Sterilamp will correct this. After the bottle has been washed, it will pass along the conveyor belt to a battery of Sterilamps, one of which will be inserted in each bottle for a period of ten seconds, the time required to kill all bacteria. Then the milk will be poured into it immediately and a sealed cap will insure its purity.

ELECTRONIC GADGETEERING

May Replace "Hams'" Interest in Communication

FROM now on we shall see a rapid development of electronic gadgeteering—the non-radio application of radio technique—according to Charley Golenpaul, of the Aerovox Corporation.

"I believe the era of electronic gadgeteering is now opening up in a big way," states Mr. Golenpaul. "In the first place, the ban on amateur radio communications is not going to leave the enterprising 'ham' twirling his thumbs. Of course many 'hams' are already or will soon be in our armed and technical services. Many will find wartime jobs with other United Nations. But those remaining on the home front are going to put their experience, equipment, and ambition to work on new and startling applications in the home, shop, factory, and elsewhere, far removed from customary radio practice.

"I suppose most radio men have heretofore been too busy with radio proper to find extra time and energy for non-radio or electronic gadgeteering possibilities. However, many of them now are going to use their 'rigs' and parts for new functions. I can visualize some interesting developments — light-beam telephones for conversing over considerable distances; automatic photo-electric garage-door openers; photo-electric switches turning lights on and off with darkness or daylight; checking the stoking of furnaces or boilers by the chimney smoke; various comparators or instruments for comparing and matching colors and shades; checking solution concentrations and chemical studies by conductivity means; and so on.

"As a starter, electronic gadgeteering can be based on well-known elementary principles and basic circuits long known to radio and electrical workers. Many industrial plants are already electronic-gadget conscious. I know of radio servicemen who've gotten themselves good jobs in plants because of their ability to do things better, quicker, and less expensively by electronic means.

"Make no mistake about it, the temporary suspension of 'ham' communications may well turn out to be a boost. It will generate a lively interest in electronic gadgeteering. And when 'ham' communications are resumed again with the return of peace, I venture to predict that electronic gadgeteering will comprise a greater field for radio parts, particularly the quality or extra-heavy-duty components, than all amateur radio activities put together. Furthermore, many a 'ham' will find an interesting way of making real money out of his hobby, and that's something."

CELLULAR RUBBER

Is Light in Weight, Used in Life Rafts

NEW lifesaving devices, made of the newly-discovered cellular rubber, which has twice the buoyancy of cork, include a raft composed of a spider-like network of disks of the new material strung together with ropes, and self-lighting electric lamps which will float in the water beside victims of a sinking ship to guide rescuers at night.

Because of the extreme lightness of the cellular rubber, which is composed of millions of small cells filled with

nitrogen gas, the raft will support up to 30 persons, according to the United States Rubber Company. An advantage of its construction is the ease with which it may be grasped in the water. It is of particular significance in torpedo sinking because it can be thrown overboard when there is not time to launch a regular lifeboat or raft.

The new form of hard cellular rubber is also being used as insulation under decks of mosquito type torpedo boats, and the soft material in life jackets for the United States Engineers. Also, a fire resistant, hard cellular rubber is being used as supports of self-sealing gas tanks in airplanes.

SABOTAGE PREVENTION

Aided by Electron Tube Equipment

THE use of electron tube equipment for detection of intruders has become a major factor in protecting property from sabotage, according to a recent issue of *Electronics*. One company alone, it is stated, has installed 4100 photo-electric alarms, of which 1300 are operating outdoors. Capacity systems protecting safes and acoustic systems guarding vaults electronically are too numerous to estimate.

Electronic intrusion-detectors may operate "local" signals, ringing bells, blowing horns or whistles and turning on floodlights. They may also actuate "proprietary" system signals, calling guards from somewhere within the protected premises to the threatened point, or they may operate remote signals in "central station" offices maintained elsewhere by firms specializing in the installation, operation, and maintenance of protective systems.

For many years industrial, mercantile, and residential premises have been protected against burglary by electrical alarm devices supplementing the work of guards. Such electrical systems have now been joined by electronic intrusion-detection devices. These are proving useful where supplemental protection is desired, where series wiring cannot readily be installed and where alarms must signal at the approach of an intruder rather than after an attack upon premises or fixtures begins.

Photo-electric intrusion-detectors substitute a beam of light for older methods of protective wiring using foil pasted over windows or show cases housing valuable objects. Here, interruption of the beam projected from light source to light detector actuates a local or remote signal. Sharply-focused lenses, hoods, and masks, plus "modulated" light beams, simultaneously make it difficult for intruders to paralyze photo-electric alarm systems by shining the beam from a flashlight into a phototube and walking through while the relay is held in the stand-by position. Light-beams are very nearly invisible even in smoky or dusty air as most projectors now contain optical filters confining emission largely to the infra-red region. Mirrors are generally used indoors to break beams up into curtains of light criss-crossing the area to be protected. Three or four reflections are commonplace and as many as a dozen have been successfully used.

Weather-proof cases and carefully chosen components which continue to function properly despite wide variations in temperature and humidity permit systems of the type described to function outdoors. Useful beam-throws of as much as 500 feet have been achieved by mounting projector and detector units on heavy pipes embedded in concrete blocks sunk into the ground to maintain alignment. Where extremely long beam-throws are required, duplicate projectors and detectors rather than mirrors are advisable for turning of property boundary corners. Because of other advantages inherent in design, such equipment is useful for indoor as well as outdoor applications where somewhat

greater cost appears justified by the additional protection afforded.

One unusual installation has guarded a waterfront stretch of nearly 3000 feet for more than five years, transmitting few false-alarms despite dense harbor fogs. A special projector unit using an 18-inch lens and an airplane beaconlamp (to widen beam-spread and avoid operation of the alarm by sea-gulls) was built for this job and the projector unit as well as the detector unit floats in comparatively calm tidal water off the end of a dock. Its purpose is to detect intrusion from the sea side of the property. Standard projector and receiver units have since been designed for such marine application.

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SUN FOR HENS—Modern poultry farm hens now bask for several hours a day under portable sunlamps developed specially for animals. The new sunlamps, source of Vitamin D, eliminate the daily doses of cod-liver oil usually fed to chickens but now threatened by war shortages.

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IT STRETCHES

Synthetic Rubber Thread For Military Uses

WHAT is believed to be the first synthetic rubber thread ever developed in this country has been made from Ameripol synthetic rubber. In announcing the development, W. S. Richardson, of The B. F. Goodrich Company, said:

"Primarily this development has been for military purposes, to conserve the natural rubber thread that formerly went into products used by our armed services. There is at present no possibility that any of the thread can be diverted to the manufacture of civilian products, but we hope that future circumstances will allow that course."

Some of the potential military uses for the synthetic rubber thread are in harnesses for parachutes, in gas masks and respirators, and in other equipment.

As now planned, the thread will be sold to textile manufacturers for military purposes in either the "naked" or uncovered form, or covered with yarn by the rubber manufacturer. "Naked" rubber thread is later covered in the textile mills. Cotton is the textile fiber most commonly used, although rayon, nylon, and silk are also employed.

Rigorous tests on the new synthetic rubber thread show 700 percent elongation, comparable to the rubber thread previously made from natural rubber compounds. Its comeback, or "kick" is comparatively the same, while its physical properties, under accelerated aging, are better.

The thread resists the effects of dyeing or bleaching much more than the natural rubber products, resists

Synthetic rubber thread has been developed, for military use only

the action of body oils carried in perspiration much better, and has greater resistance to chafing or cutting by the needles of the knitting machines. It is non-toxic and made only in black.

• • •

NYLON—A new du Pont nylon plant in Virginia, which started production in November, 1941, will be spinning by mid-summer a million miles of nylon yarn—per day!

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SOYBEANS

Face a Bright Immediate Future

CHINA'S great contribution to America's victory farming, the soybean, will receive greater attention than ever during the coming crop season, according to G. G. McIlroy, director of the American Soybean Association, reports *Science Service*. Nine million acres, 54 percent more than last year, are expected to be planted to this versatile crop, which can contribute feed for the production of meat and milk, oil for explosives, paint, soap, and human food, or can be plowed under to give the soil the nitrogen which diversion of nitrates into munitions is taking out of commercial fertilizers.

Needs for handling this unprecedented soybean crop are stressed by Mr. McIlroy. We must have, first of all, available acreage. There must also be adequate machinery for cultivating, harvesting, and processing. There must be ample storage space for the beans, and for oil and cake after pressing. And finally, proper markets for oil and meal. The market for oil and meal need give no concern, at least for the duration. We are going to need all the oil for food and industrial uses that we can produce, not only as long as the war lasts but through the period of dearth that will inevitably follow it. And the same will doubtless be true for meat and milk.

FORESTS SPRAYED

To Protect Trees on Basis of their Value

SPRAYING of woodland areas has developed into something of a "big business" with a scientific background. Modern high-pressure spraying machinery and other equipment has been evolved to meet the necessity, the United States Department of Agriculture reports. This technique now has wide application in all parts of the country.

The adaptability of the autogiro for applying arsenicals over forested areas has been demonstrated and this type of equipment bids fair in time to completely supplant the use of ground machinery, say the forest entomologists. It may lower the cost of the application of insecticides to such a figure that it will be economical to protect forest lands from insect depradations on the basis of the value of the threatened timber stand rather than on the additional threat of spread to and destruction of forests in other areas.

WALL PANELS

In Colors, To be Cemented in Place

PLASTIC-COATED wall panels which are completely pre-finished and require no "on-the-job" treatment after installation are a development urged to speed up emergency housing con-

Three types of new wall paneling

struction and remodeling. Supplied in sheets as large as four by eight feet, the pre-finished boards are a product of Barclay Manufacturing Company.

Designed for either new structures or for speedy modernizing by covering old walls and ceilings, the sheets are best applied by a water-proof adhesive, but may also be installed with brads. They are available in 10 colors which are permanently bonded to the sheets by heat treatment. The surface is water-proof, stain-proof, dirt proof, vermin proof, and may be cleaned with soap and water.

Available in three types—Tileboard, Panelboard, and Streamlined Board—the sheets may be installed by any competent carpenter. Besides the more obvious applications in bathrooms and kitchens, the plastic-coated panels are also recommended for playrooms, nurseries, closets, laundries, service stations, barber and beauty shops, meat markets, bakeries, restaurants, hospitals, boats, and trailers.

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VEHICLES—The rise of the motor vehicle as an instrument of government is revealed in figures of the United States Public Roads Administration, which show that while private motor vehicle ownership in the United States has risen 20 percent in the past decade, the number of vehicles owned and operated by federal, state, and local governments has risen 146 percent.

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SUGAR BEETS

Improved Seed, New Labor-Saving Devices

Two tedious hand processes have kept sugar-beet growers dependent on field workers. Nature's generosity in packing each beet seed with the germs of several plants has meant hours of back-breaking labor down the long rows, thinning the clumps of new beets by hand until those remaining could have space to grow and be healthy. Right now, when we need it most, comes "singled" seed. A machine developed at the University of California breaks the beet seed into segments, each containing the germ of but one plant. Planters are easily adapted for sowing the singled seed, and the small number of multiple plants can be chopped out by hoe or cultivator. One farmer cut his thinning costs in half last year by using singled seed. The seed itself is more expensive, but only one third as much, by weight, need be planted.

The second laborious hand process is the harvesting. A Colorado farmer has been tinkering for years, trying to evolve a machine for lifting beets

out of the ground and topping them. He has achieved it at last and a farm-implement manufacturer has refined his crude design. Now a machine marches down the rows where before men stooped and pulled, shook the dirt from the fibrous roots, cut off the tops, and stooped and pulled the next. Another single-row topper-lifter has been developed at the University of California, and in that state of vast farming operations there are already several multiple-row machines in use.

These thinning and harvesting problems pre-suppose good seeds. Again the timing has been right. Government agricultural experts have long been at work improving the seed strains, so that now the yield is better by three tons per acre than formerly. Resistance to the curly-top disease that menaced all beets west of the Rockies, where nearly one third of the nation's crop is grown, has been successfully developed also.

The sugar beet growers have been called upon to produce well over one third of the 5,300,000 tons of sugar which Leon Henderson has designated for civilian use during 1942. Anticipated contributions from other sources are: 500,000 tons from Southern cane, 600,000 from Hawaii, 1,100,000 tons from Puerto Rico, and an equal amount from Cuba and others. Our Allies and war materials will get the remainder of Cuba's output.

OIL PROOF

Aprons and Gloves

Find Many Uses

DEVELOPED expressly to prevent dermatitis, folliculitis, and other occupational skin diseases prevalent in many industries, is a new line of oil-proof and solvent-proof gloves and aprons recently announced by Resistoflex Corporation. The gloves and aprons are made of an extremely tough, flexible material with high resistance to tearing and abrasion, and the aprons are supplied in both a transparent type and a heavy-duty type employing a flexible fabric coated on both sides with a sturdy film of the same material.

According to the manufacturer, these gloves and aprons are immune to all organic solvents, including aliphatic, aromatic, and chlorinated hydrocarbons, and even to that highly active inorganic solvent, carbon disulfide. The gloves are said to be successfully used in dry-cleaning and degreasing operations where protection is needed against carbon tetrachloride, trichlorethylene, perchlorethylene, benzol, or petroleum solvents, and in magnaflux operations where they are

Protection for work and worker

unaffected by kerosene, varsol, and so on. Because the gloves contain no sulfur, they do not tarnish highly polished metal surfaces and are recommended for inspection of ball bearings, aircraft parts, and the like.

Although the gloves are not as pliable as rubber or synthetic rubber gloves, they are sufficiently flexible to afford unrestricted movement of the fingers, and because of their immunity to the above mentioned solvents they do not require repeated washing with soap and water.

• • •

SPEED—Close teamwork between American steel makers and truck and plane transportation recently enabled a British factory manufacturing tank bearings to receive a shipment of especially treated steel within four days. The steel ingots were made in the midwest and rolled into rods which were then shipped overnight by express truck to a wire-drawing concern in New England and drawn into wire. A second express truck then rushed the wire to another manufacturing plant for heat treating to specification. A plane then rushed the wire to the English plant ahead of schedule.

• • •

INSULATION

For Buildings Offers New Cotton Use

ABOUT 25 times as much cotton insulation will be used this year as last —12 million pounds compared with half a million pounds—the United States Department of Agriculture estimates. The Agricultural Marketing Administration says that the new insulating material will go into defense housing and other buildings and into refrigerator cars, trucks, and other transportation outlets. In 1941 the Department actively promoted demonstrations of the new cotton insulation, and the increase in demand is regarded as a result of satisfactory experience in the early test.

This new building material offers one promising outlet for part of the anticipated large carryover of lower grade short-staple cotton. High grade long-staple cotton is urgently needed for military purposes, and cotton farmers have been asked to plant plenty. But, as Secretary Wickard recently pointed out, an estimated three fifths of the cotton now produced is short staple, that is, one inch and shorter. Some of this is used for coarse fabrics, but much of it would be more serviceable in cotton insulation.

Use of cotton insulation, says the Agricultural Marketing Administration, is not restricted by priorities, and much of it is already going into defense housing. Private individuals who are building or improving homes are not barred from using cotton insulation. It is easily installed in new houses at the time of building. It is applicable to existing dwellings in accessible parts, such as under the roof in attics, or in unplastered side walls.

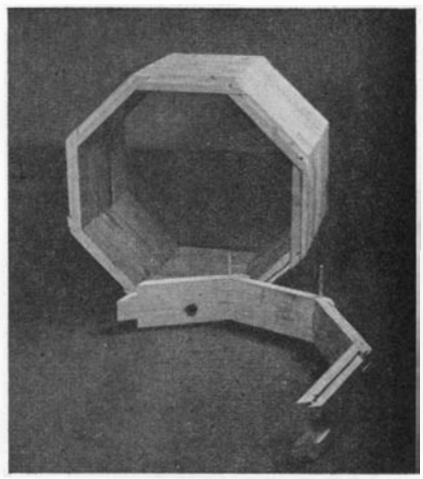
CULVERTS

Of Wood, To Replace Metal

AN all wood culvert, designed by The American Rolling Mill Company, is now in production and serves as one solution to the problem of building drainage structures without the use of critical materials. On war projects, where steel is required for engineering reasons, sufficiently high priorities are granted to fill the request. However, on many drainage

operations there is a definite need for substitutes. For such purposes the wood culvert was developed.

In the case of army camps and cantonments, the wood culvert will serve the expected life of the projects. Where the culvert is used in a permanent installation, post-war replacement can readily be made either by threading a conventional corrugated metal pipe through the wood culvert, or by packing a metal pipe around it.



Designed for the duration

But replacement with steel is for the tomorrow of peacetime. Right now the wood culvert is filling the need of the present.

Because the culvert's construction employs very short lengths of wood, sizes which ordinarily would be discarded may be used to make the wooden drainage product. The only field work required is to join standard sections into any desired length, and skilled labor is not needed. Prefabricated, the culvert is light, easy to handle and to transport and assemble at the scene of operations.

• • •

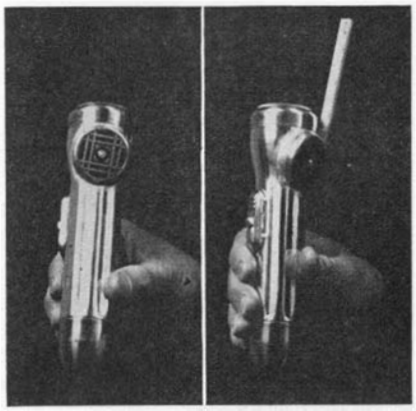
VITAMINS—Variance in Vitamin A content of each shark liver is due to several factors —grounds where the sharks have been feeding, grounds where they are caught, the season of the year. Also, male sharks have a much higher vitamin content than female.

• • •

FLASH-RULE

Combination Has Many Uses

A HANDY combination of flashlight and six-foot steel rule, illustrated in one of our photographs, was originally developed by Giffords, Inc., for use by fuel-oil delivery men who must measure oil tank levels in dark cellars. The combination had been found adaptable to other uses as well and



Light, tape measure, sling

hence has been made available for general distribution to the public.

Another feature of the combination is that the steel tape can be pulled out and slipped into a slot at the pointed end of the flashlight, thus forming a loop or sling by means of which the flashlight can be suspended around the neck, hung from the shoulder, or hooked around a pipe or beam to direct light conveniently.

QUICK-DRYING

Paints Produced from Domestic Materials

Two new oils have been developed which will make it possible for the paint industry to continue the manufacture of quick-drying paints and varnishes. With imports of tung oil cut off by war in the Far East, the industry, it was feared, would soon be forced to return to the manufacture of slow-drying paints. The new developments, however, will make such a move unnecessary. It is even felt that they may permanently replace China-wood oil in this country.

Developed by Spencer Kelloff & Sons, the new oils are known as Kellin and Kellsoy. Basically they are made from linseed oil and soybean oil to which quick, hard-drying qualities have been imparted by a secret process. Commercial production is getting under way, and the company plans to increase output substantially.

Most of the principal raw materials, flaxseed and soybeans, are grown in large quantities in this country. More than 50 percent of all the flaxseed used in this country is domestically grown, with the balance imported from Argentina. All of the soybeans consumed in the United States are grown here. A satisfactory hard-drying oil has been made from castor oil by chemical reconstruction of its composition. However, the raw material, castor bean, has to be imported from Brazil.—*Chemical and Engineering News.*

Cargo Planes of the Future

Special Equipment Will be Needed for this Branch of Air Transportation When it Starts its Growth

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

SEVERAL airlines this year so far have received revenues of over half a million dollars from transportation of express and freight, and mail cargo revenues over a number of lines total several million dollars annually. Yet commercial transportation of cargo by air in the United States is still in its very early stages.

So far no really special equipment for cargo work has been available. Therefore a paper by Charles P. Graddick, of United Air Lines, presented at the Annual Meeting of the Institute of the Aeronautical Sciences, which discusses operating requirements for air cargo equipment, is very welcome.

Not only must we have special aircraft, according to Mr. Graddick, but other facilities will be required as well. For example, in some of the largest cities special cargo airports should be constructed and at most ordinary airports space should be provided for freight warehouse facilities. Warehouses will be needed for temporary storage of goods awaiting transfer from one airline to another. Space will be needed for railway express agencies and for freight forwarders. Our ordinary hangars may have to be modified to include movable platforms, storage space, hoists, derricks, tractors, and so on. The general ground handling of goods must be given far greater thought than hitherto.

What will be air cargo schedules? There will be, Mr. Graddick says, air cargo ships operating on regular transcontinental cargo schedules between large centers of population. There will also, of course, be feeder planes and feeder routes.

What will be the cost? Undoubtedly rates will be a large factor in determining the volume of air cargo. There is a limit to what shippers can and will pay for speed. At the present time, air express rates are from four to seven times rail express rates and correspondingly higher than rail freight rates. A great effort, therefore, will be necessary to reduce ton-mile operating costs of air cargo planes. This can be attained only by intense study of the airplane, which is being conducted both by United Air Lines and by Air Cargo, Inc., the instrument of all carriers.

Speed of air cargo ships will have to be great but there will also have to be low operating cost which can be attained only by somewhat lower speeds than for passenger craft and greater simplicity of construction. It may be possible to work out movable bulkheads and folding seats which would make possible changes in seating capacity and cargo space by shifting the position of the bulkhead, folding it away into the floor. Some heating will be needed and also some refrigeration will have to be provided for fresh meat products, fruits, and so on. On certain local operations, single motor planes of special cargo carrying type might be utilized. It has even been suggested that gliders might be practical for regular day-by-day all-weather operations. The glider would bear the same relationship to the airplane that the car bears to the locomotive of a train.

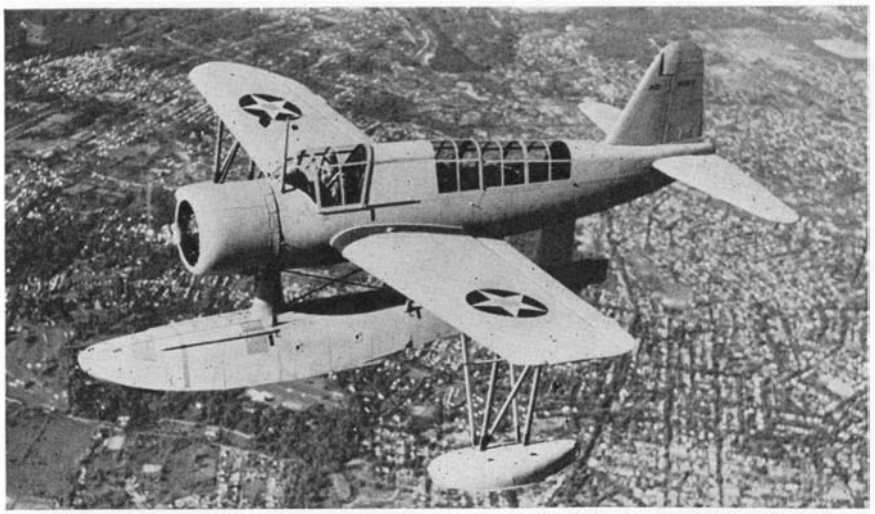
A decided advantage of cargo operation will be that it will provide a splendid training service. A pilot will have served as co-pilot in a cargo plane before advancing to Captain. Before a Captain on a cargo plane is transferred to passenger runs, he will be a well seasoned pilot who will have much more weather and flying experience than would have been possible had he gained his experience merely at school.

Mr. Graddick concludes with such factors as airports, warehouses, schedules, rates, pick up and delivery service and other factors which will have to be carefully studied before our cargo picture becomes satisfactory—yet there is no doubt in his mind that such difficulties will be readily overcome.

RAIDERS

Our Navy Comments on Fighting Planes

A GREAT deal of secrecy must, of course, shroud our aircraft operations



Like the Kingfisher, whose name it bears, the OS2U preys on underwater lurkers

against the Japanese and it is only rarely that the Navy lifts the veil a little and praise is given to the factories which are producing fighting American aircraft.

Recently, however, Secretary Knox and Rear Admiral John H. Towers have informed Douglas Aircraft Company that the "Dauntless" dive bombers and the "Devastator" torpedo planes have distinguished themselves in recent raids. They also stated that in a recent engagement between Japanese land-based aircraft and Grumman "Wildcat" carrier-based fighters a total of ten Japanese fighters and three bombers were destroyed without a single loss to our fighters.

A letter to Vought-Sikorsky said that the "Kingfisher" (OS2U), a cruiser- and battleship-based observation-scout, has been very effective in combatting the submarine menace and has also made successful attacks against the enemy.

The "Kingfisher," as can be seen from our photograph, has excellent vision, owing to the liberal use of transparent plastic material. It is a trim, mid-wing mono-powered plane with an air-cooled engine. A single main float is employed which can be readily replaced by a landing gear. — *A. K.*

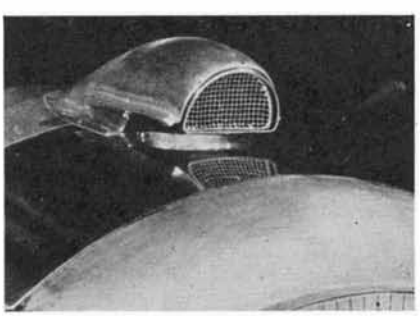
ICING

Another Airline Safety Problem Solved

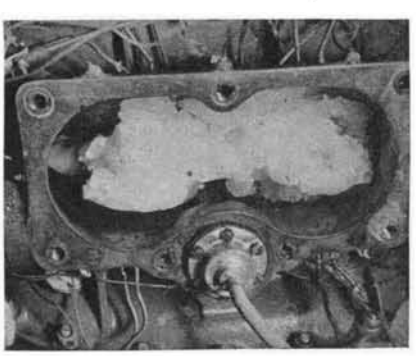
ALTHOUGH the airlines have flown more than 287 million miles during the last three years, they are still concerned about the difficult problem of icing of the carburetor intake, and it remained for Victor J. Skoglund of the United Aircraft Corporation to carry through laboratory tests in a comprehensive research into this important problem.

Special refrigerated tunnels had to be employed and a great many runs were made with scoop and carburetor subjected to high air stream and icing conditions. One of our photographs shows an assembly of carburetor air scoop and a portion of the engine cowling as it appeared before installation in the tunnel. Another picture shows ice formation practically blocking the air induction system below the carburetor — an occurrence prevalent when moist air is cooled by fuel evaporation.

As a result of his experiments, Mr.



Above: Air scoop. Below: An ice-blocked carburetor intake system



Skoglund made radical changes in the design of the air scoop; he developed a scoop with heated air valve and also a new type of fuel discharge nozzle in which the hazard from ice formation by evaporation of fuel is eliminated.

—*A. K.*

Industrial Growth

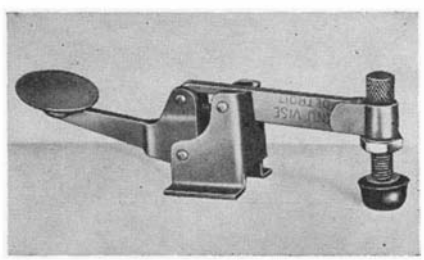
New Products and Processes That Reflect Applications of Research to Industrial Production

TOGGLE CLAMP

Exerts Pressure of 500 Pounds

For holding small parts when riveting, drilling, or reaming, a toggle clamp recently announced by Knu-Vise, Inc., takes the place of the many makeshift devices which are often used for these purposes.

The clamp, illustrated in one of our photographs, is screwed or bolted to a base. The screw at the holding end is



Speeds up hold-down operations

then turned down to the proper adjustment for the work in hand. By pressing on the opposite end of the clamp, a holding power of 500 pounds per square inch is applied to the rubber capped screw, the clamp automatically locking in place. Unclamping is accomplished by simply lifting up on the pressure end of the lever.

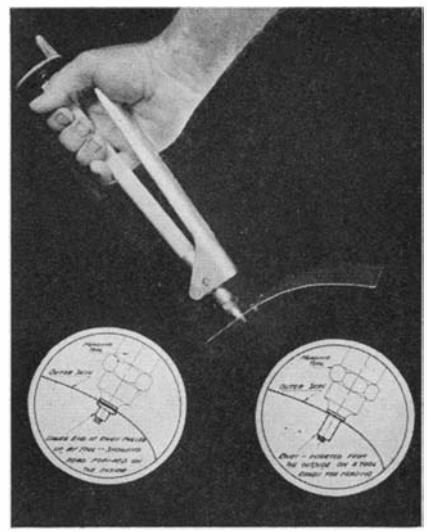
RIVET

Set Blind, Can Also Serve as Anchor

Set with a plier-type hand tool, or more rapidly with a pneumatic power tool, a new type of blind rivet, known as Rivnut, can be employed for blind rivet assembly of sheet metal or to provide a screw anchor on sheet-metal surfaces, or both.

As shown in one of our illustrations, this Rivnut, manufactured by the B. F. Goodrich Company, has a hollow shank which is threaded to provide a means for driving and also to act as a screw anchor if this is desired in the finished job.

In application, the rivet is spun on to the threaded mandrel of the applying tool. The rivet is then inserted into a hole in the sheet and the applying tool is activated. This movement



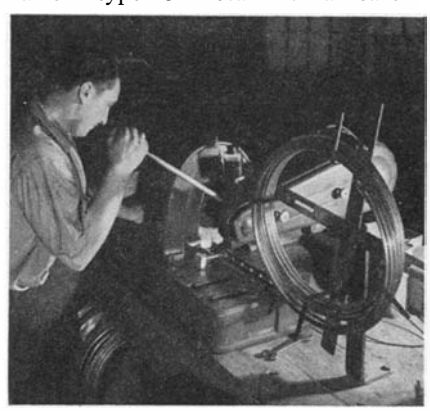
How new blind rivet is applied

pulls the mandrel of the tool back against the anvil, setting up compression in the rivet shank that causes the shank to bulge and form a ring-type head back of the sheets. The tool is then removed by backing it out of the threaded shank, the threads being unharmed in the driving operation and thus suitable for use in anchoring equipment. If anchorage is not desired, the hole can be plugged by application of a headed or headless screw.

CUT-OFF

Tool Uses Abrasive Wheel or Blade

A powerful and accurate unit has recently been made available for use where it is desired to cut lengths of various types of metal with a reason-



Cutting to precision lengths

able degree of accuracy and on a production basis. This unit, known as the Delta Cut-Off Machine, can be applied to any operations now performed by costlier machines or being done uneconomically by hand.

The unit is available in two models, with an abrasive cut-off wheel and with a special cutting blade for use on non-ferrous metals. Rapid cuts to exact lengths can be made on such materials as aluminum, brass, steel, Bakelite and all plastic materials, wire rope, brake linings, tile, hard rubber, and so on.

SANDER

Can Be Used Horizontally Or Vertically

FOR finishing operations on wood, metal, plastics, ceramics, and so on, a new floor-mounting belt sanding machine recently developed can be used in either vertical or horizontal positions.

This unit, shown in use in the horizontal position in one of our photographs, is manufactured by the Porter-

Uses standard belts

Cable Machine Company. Operated by a three-quarter horsepower enclosed motor, the belt is driven at a surface speed of 3400 feet per minute. Standard 4 inch by 45 inch dry abrasive belts or resin-bonded belts run with water or coolant may be used with this machine. The flat backing plate for the belt is four inches wide and ten inches long and the rest table is adjustable to 45 degrees.

CLEANER

Works Quickly on Sheets or Castings

A NEW cleaner for aluminum and magnesium, known as Matawan AL cleaner, is designed for cleaning either sheets or castings. Used at a concentration of four ounces per gallon at 160 degrees, Fahrenheit, it does not produce any etch or weight loss on aluminum after two hours immersion. Machined and polished magnesium shows no weight loss or etching in 15 minutes or more. At this concentration the new cleaner, developed by the Hanson-Van Winkle-Munning Company, has cleaned a mixture of equal parts of kerosene and heavy oil in 20 seconds. In a number of tests on production castings, the time required was from ½ minute to 4 minutes for thorough cleaning, depending upon the type of work and amount of shop grease present.

FILLER

For Plastics Made from Wastes

EXTENSION of the supply of certain plastics now curtailed because of scarcity of raw materials is seen in a new plastic filler material that can readily be manufactured from waste cellulose materials such as sawdust, scrap wood, cotton, or other plant fibers. Not a plastic itself, the new filler material, known as hydrolyzed lignocellulose, can be combined with synthetic resins of the phenol-formaldehyde and phenolfurfural types in proportions of three parts filler to one part resin. This gives a plastic comparable to that obtained from one part filler to one part resin when ordinary fillers are used, it is claimed. Thus it is possible during the present emergency to increase greatly the total amount of plastics which can be made from the limited supplies of phenolic resins now available. Both phenol and formaldehyde, the two most important resin raw materials, have been curtailed for ordinary use as a result of the large requirements of the munitions program.

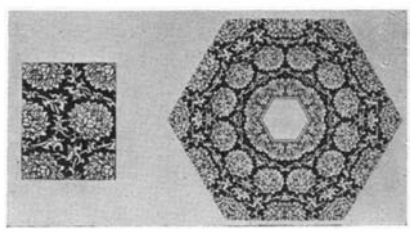
The filler has been developed with the realization that standard procedures in the plastics industry must be adhered to as closely as possible. As a result, the techniques of compounding and molding continuously-hydrolyzed lignocellulose-filled phenolic plastics have been developed so that there is no major deviation from current practice, except for *an acceleration* of both operations—a result which is highly desirable. Particularly important is the reduction in the time required for molding cure, where a decrease by approximately one half greatly increases the productive capacity of the expensive molding machinery and thus reduces the number of units necessary for a given output.

CAMERA ANGLES

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

Camera Multiplies Images

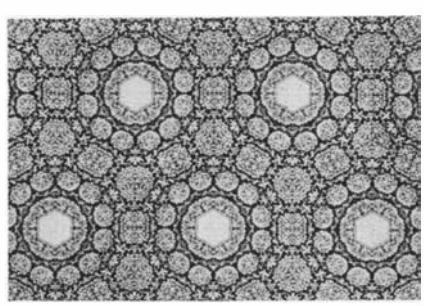
A SPECIAL camera, designed by W. H. Wallace, is so constructed that a single flat object, such as a simple drawing, a bit of lace, a trademark design, and so on, can be photographed by the camera to record five images of the same subject with one exposure. The basis of the camera, which is called the Kaleidograph, is the familiar phenomenon of two mirrors so placed that they meet at one end, forming a variable V. An object placed in the center is reflected in both mirrors; the narrower the angle formed by the mirrors, the greater the number of images, which for practical reasons is held to a maximum of five in the Kaleidograph.



Right: Original. Left: Multiple

The pattern photographed by the camera is made possible by the fact that duplication of the subject is achieved by reflections of reflections, the image being reversed each time it is reflected.

The camera itself is an ordinary 5 by 7 view outfit supplied with a special set of two mirrors so installed that they may be varied as to angle at the will of the operator, depending on the number of images desired or found feasible for a particular purpose. All the images are sharp, clear, and flat, without any noticeable distortion. Mr. Wallace uses a lens of the Dagor type, although any other lens, provided it is sharp-cutting, such as the process or Tessar lenses, may also be employed. Mr. Wallace uses Eastman Process Panchromatic film because, while full-color reproduction is not necessary in this work since the subjects are usually white, or black and white, the film is more sensitive to the red when used in artificial light and therefore permits quicker exposures than process ortho film would. This is important because very small stops must be used; even then, the exposure runs 15 to 20 seconds.



The re-photographed pattern

The object to be photographed is placed under heavy glass to make sure it stays perfectly flat during the exposure. The procedure involves three steps in all: photographing the object; pasting up the desired number of prints; and then re-photographing the pasteup.

Mr. Wallace says only line drawings and similar subjects are suitable. The camera can be used for halftone subjects as well as three-dimensional material, but the results are of doubtful value, according to Mr. Wallace.

Flashing a Crowd

WHAT would you do if you had to photograph a huge crowd assembled in a large square at night? Well, you wouldn't. Neither would we. But when you have to and it's your bread and butter, you find a way. That's what happened in the case of Pringle & Booth, Ltd., of Toronto, Canada, when they were assigned to photograph a crowd "estimated at over 60,000."

"Three 8 by 10 view cameras, loaded with Afga Superpan Press film, were set up side by side, with their Goerz 8½-inch lenses stopped down to *f*/16," they write. "The open-flash-shut exposure method was used, with 40 G.E. Mazda No. 75 photo-flash lamps in special reflectors. These were fired by dry cell batteries. We estimate the amounts of light at approximately 400 c.p. per square foot, or 750,000,000 lumens."

Baby Arrives!

THE amateur photographer does not exist who has not racked his brain on the arrival of the newborn to think up an original gag to announce the fact to the world—photographically. The results are not always happy ones—to the recipients, at any rate—though the sender's enthusiasm and genuine sentiment is fully appreciated. Once in a while, however, a really good idea comes through, an example of which is a card we received the other day from Maurice Lehv,

Posing pins

in which the father arranged a table-top affair showing a milk bottle and woolen booties, with the announcement, "Michael is Here!!" followed by the name of his wife and himself, all neatly spelled out in safety pins!

Prints Direct from Kodachrome

BLACK-AND-WHITE enlargements or contact prints from Kodachromes, lantern slides, and other positive transparencies, can now be made directly on Kodak Autopositive Paper. Available in two sizes, 3¼ by 4½ inches and 5 by 7 inches, the paper is a direct reversal medium producing a positive print from the positive transparency, automatically eliminating the intermediate negative. The paper is orthochromatic and must therefore be handled under a Series I Safelight. Claimed for it are ample speed, a rich black tone, and a simple method of processing very similar to that used in making ordinary black-and-white prints, though the borders are black instead of the familiar white. These, however, can be made white by masking the image and flashing the borders before the print is processed.

Retouching Medium

INTRODUCED by Willoughby's as the latest and reportedly one of the simplest methods available for spotting and retouching, Spotone is described as a "combination spotting, tone-building, and retouching medium developed on the stain principle." Blue-black, sepia, and natural black—the three colors supplied—may be intermixed in various proportions "to produce the greatest number of retouching colors to match the largest variety of print emulsions." Spotone may be used for paper negatives and film negatives, producing grainless tone values on the latter.

Prize Winner Tells All

WANT to know how prizes are won? Listen, please, to what Nathaniel Field has to say about his prize-winning picture, "Topnotchers," which took first place in this year's Kalart Flash Contest, in addition to having won honors elsewhere in contests and pictorial salons. Interviewed exclusively for this department, Mr. Field said:

"'Topnotchers' was taken on Decoration Day at the Ringling Brothers, Barnum & Bailey Circus grounds in Newark, New Jersey. The day was exceptionally bright, with brilliant sunshine and crystal blue skies, without a sign of a cloud. I was able to obtain the co-operation of the performers, Mr. and Mrs. Hubert Castle, in a rehearsal of their act, which was performed outdoors for me.

"In planning the composition of this picture, I decided that for two reasons a low angle would be most effective:

"1. From a low angle the picture would be more impressive.

"2. Since the background was made up of circus tents and wagons, including them in the picture would create a distraction from the principal subject. However, by taking this picture from a very low angle, all of the distracting background could be eliminated.

"Topnotchers"

"To give dramatic quality, a red filter was used to darken the blue sky. For added punch, I used a Wabash Press 40 bulb in a Kalart synchronizer at the camera, with an exposure setting of f/5.6, 1/500 of a second. With this exposure, it was possible to get the performers at the top of their act without sacrificing the dramatic quality desired. The camera was an Automatic Rolleiflex, the film Eastman Super XX developed in DK-20. The print was made on Velour Black paper, developed in D-72, and toned with Tuma toner to give the print a richer quality."

Deferment for Trainees

THE School of Modern Photography, New York City, advises that, due to the need for military photographers, draft boards throughout the metropolitan area are deferring selective service draftees until they can finish their courses at photographic schools. Fifteen men have had their army induction dates postponed from two weeks to as long as six months, they report, to give the students an opportunity to graduate from the school. The Navy, they add, is doing the same.

Kodacolor With Flash

YES, you can use flash with Kodacolor. A bulletin, No. 301, just issued by Wabash, says so. It lists data and exposure tables on the flashing of Kodacolor with one bulb mounted at the camera, or two bulbs flashed in tandem. However, you must use only the daylight blue flash, as this has the higher 6000-degree Kelvin temperature that comes nearest the required lighting conditions of bright summer sunshine.

While on Kodacolor, we hear that Eastman has published a Kodacolor Exposure Guide as the newest guide in its series of Kodak Handy Pocket Exposure Calculators. It gives full data for finding correct exposure with Kodacolor under various daylight conditions.

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.

MACHINE TOOLS AT WORK

By Charles O. Herb

SPECIAL book for advanced machinists and shop executives who seek a broad knowledge of the most advanced methods of equipping for and performing the more unusual operations on many different types of the latest, most modern machine tools. Author is associate editor of *Machinery*. The illustrations were secured from many of the most progressive plants in the nation, doing most exacting work such as airplane engines and ordnance. A crutch book for less advanced plants that are now struggling to catch up or keep up in the war-order race. (552 pages, 5½ by 9 inches, 410 illustrations.)—$4.10 postpaid. —*A. G. I.*

YOUTH MUST FLY

By E. F. McDonald, Jr.

AN EXCELLENT over-all case for gliding as a basis upon which to build a truly air-minded nation which, in turn, can create an all-powerful air-transport system and a military air force second to none. Filled with an unbounded faith in American youth, the author would train these youngsters, from the early 'teens, to get the feel of the air through safe, relatively inexpensive instruction in gliders and sailplanes. From first-hand experience, Commander McDonald knows what the "ham" operators did for radio during the 1920's. He has seen these amateurs out-do the "professionals" at every turn; he has seen them accomplish the impossible, largely because they refused to be hidebound by tradition. The present generation of youngsters, he holds, can do for aviation what the "hams" have done—and are still doing—for radio. Give them the opportunity to glide, to soar with the birds, and there will be created a vast pool of sound material from which to draw the pilots and technicians of the near future. If the war lasts very long, these youngsters will be available for rapid training in the armed forces; they will have been pre-selected by their work with gliders. When peace comes, they will be as ready to further the development of air transportation as were the "hams" in the field of radio. All this and much more is forcefully developed in the pages of this book. The first three chapters, especially, give such a build-up to the sport of gliding that the reader will be completely lacking in imagination if he is not mentally carried out of his easy chair into the quiet realms of the birds. Definitely recommended reading for everyone with the least interest in aviation. (Incidentally, Major Al Williams, who as early as 1923 proposed the use of dive-bombing tactics which have since been widely used by the air forces of the world, has publicly and vigorously advocated the use of gliders for preliminary training of airmen. Commander McDonald presents Major Williams' arguments in concise form.) Covers gliding fundamentals, gliders in defense and as military weapons, a bit of history, and a glimpse of the future. Appendices deal with licenses and regulations, gliding organizations, schools and clubs, and gliders manufactured in the U.S.A. (222 pages, 5¾ by 8¾ inches, 61 photographs, drawings of manufactured gliders.)—$2.60 postpaid.—*O. D. M.*

ELEMENTS OF SPHERICAL TRIGONOMETRY

By James E. Thompson

SPHERICAL "trig" is usually presented as a sort of brief tail in plane trig texts, but here the tail is expanded into a separate and longer, more detailed book intended as a class-room text and for self-study, especially by students of geodetic surveying and nautical astronomy. However, this book avoids the greater length and detail of the complete theoretical treatise. The presentation is rather formal. (144 pages, 5½ by 7¾ inches, 30 figures.)—$1.75 postpaid.—*A. G. I.*

PLANE TRIGONOMETRY MADE PLAIN

By Albert B. Carson

ORDINARY textbooks of mathematics traditionally present only the bare bones of their subjects, usually in the most frigid, formal, conventional form. Here, however, is an author, instructor of mathematics at Louisiana State University, who departs from the "keep 'em mystified" tradition and discusses "trig" in greater detail than most authors. Not only that, but the book reads just as if the author had a heart and actually dared let the fact show through that he cared whether trig could be implanted with less than maximum suffering. This is not to say that this book makes trig easy; the student still must himself supply about 99.44 percent of the horsepower and probably always will. But the sympathetic feeling evident in this book

should act as a stimulant, especially to home users. Emphasis is on practical applications more than on mental gymnastics for mere torture's sake. Logarithms are explained lucidly. The student should once have studied algebra, including quadratics, and plane geometry. Despite its five-syllable name trig isn't formidable—not as hard as geometry when geometry is first tackled. (389 pages, 5½ by 8¼ inches, 197 figures, log and trig tables.)—$2.85 postpaid. —*A. G. I.*

THE ELECTRON MICROSCOPE

By Burton and Kohl

HERETOFORE, literature on the electron microscope has consisted only of (1) articles in professional journals, difficult of access to the average reader, also abstruse and incomplete; (2) popular articles, too brief to cover the full technical details. This new work, the first coverage of the subject in book form, is scientific—enough so to satisfy the average technical man up to the level of professional physicist, but with each technicality explained as it is brought up so that readers who have studied (and perhaps partly forgotten) high-school science and mathematics can in each instance make the approach. In other words, such a book as would, for example, satisfy engineers and equals as being solid and substantial, and not fluffy. Not a "popular" account in the average sense: more meaty. Authors are respectively a physicist who has specialized in electron microscopy and a radio engineer. (233 pages, 6 by 9 inches, 134 illustrations.)—$3.95 postpaid.—*A. G. I.*

PHOTOMICROGRAPHY

By R. M. Allen

TREATISE for the microscopist who wishes to enter this advanced phase of his work. Fundamental principles, equipment, homemade equipment, technique, special processes, microphotography, photographic processes, materials and equipment, illustrative photomicrographs —these indicate the scope of this solid work which is not superficial or sketchy but rather technical, and which is recommended to those who already know something of the art of microscopy. It is a sequel to the author's "The Microscope." (365 pages, 6 by 9 inches, 225 illustrations.)—$5.60 postpaid.—*A. G. I.*

WOOD TECHNOLOGY

By Harry Donald Tiemann, M.E., M.F.

UNIQUE—there's no other book like this in the English language. It digs more deeply into the subject of wood, and covers that subject from more aspects, than any other available work. The author is Senior Wood Physicist at the United States Forest Products Laboratory. Content: what wood is; life of a tree; structure of wood; wood identification; cell wall structure; chemical utilization of cellulosic fibers and synthetic substitutes; paper and pulp; shrinkage and swelling; wood compared

——OUR BOOK CORNER——

with other materials; cause of collapse; reduction of shrinkage; kiln-drying and stresses; electrical methods of drying and gluing; mechanical properties of wood; density and absorption of liquids; effect of various periods of different temperatures and humidities; biological destructive agencies and preservation measures; wood identification classifications. No significant feature pertaining to wood has been omitted, and much of the information presented is new. Few will be the instances in which the owner and student of this compact, meaty, technical —but not abstrusely technical—work will not be able to deepen his scientific insight into wood considerably more than that of those around him. (316 pages, 6 by 9 inches, 85 illustrations.)—$3.60 postpaid.—*A. G. I.*

STORM

By George Stewart

LITERARY luminaries acclaimed this book because, as a novel, it was unique: the story's hero is a cyclonic storm. Scientists acclaim it because its hero performs according to the science of meteorology. The author is a professor of English, and he has used the progress of a typical cyclonic whirl roaring across these United States as a skeleton on which to hang a long series of narratives of the storm's effects on the lives of ordinary people in the course of its path. Readable, essentially, as a vivid, stirring story having authentic scientific background checked by meteorologists. (349 pages, 5¼ by 8 inches, unillustrated.)—$2.60 postpaid.—*A. G. I.*

LANGUAGE IN ACTION

By S. I. Hayakawa

A CANADIAN-AMERICAN, assistant professor of English at the Illinois Institute of Technology, is the author of this "guide to accurate thinking." It is an easy, elementary treatise on semantics, the science of the meaning of words, which in recent years has become a subject of much interest and attention. Half our life's troubles can be traced to basic misunderstanding of words, the conventional intermediaries by which thoughts are conveyed from one brain to another, if they don't become altered in sense en route. A study of this little book should greatly help to clear one's thought processes—also to facilitate the proper evaluation of propaganda and faulty argument. (245 pages, 5 by 7½ inches, unillustrated.)—$2.10 postpaid.—*A. G. I.*

In a review of the book "Nostradamus Sees All," by Andre Lamont, published in this department in the May number, the statement was inadvertently made that the astrologer Nostradamus foretold World War I, Nazism and other specific recent events. The intention was to state instead that the astrologer *allegedly* foretold these events.—*Eds.*

CURRENT BULLETIN BRIEFS

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

THE SECOND MILE, by William E. Wickenden, is an eight-page reprint from *Electrical Engineering* which will serve to clarify the goal to be set before young engineers and to give a better understanding on their part of the opportunities, obligations, and ethics of engineering. It gives an enlarged professional understanding and consciousness of this unfortunately little-understood group. *Engineers' Council For Professional Development, Engineering Societies Building, 29 West 39th Street, New York, New York.—10 cents per copy, $3.00 per hundred.*

AN INTRODUCTION TO SHIPBUILDING is a a 70-page text originally compiled by Bethlehem Steel Company to familiarize new shipyard workers with all phases of shipbuilding from blueprints to fitting out of crews' quarters. Its plans, its glossary of terms, and illustrative diagrams for each are now available in lively, understandable style to a ship-conscious nation through joint sponsorship of the WPB and Bethlehem Steel Company. *Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.—20 cents.*

POSSIBLE ALTERNATES FOR NICKEL, CHROMIUM AND CHROMIUM-NICKEL CONSTRUCTIONAL ALLOY STEELS is a 144-page bulletin describing four completely new series of alloy steels designed to make the nation's limited reserves of strategic metals go further and help build more materiel of war. *American Iron and Steel Institute, 350 Fifth Avenue, New York, New York.—50 cents.*

APPLE VARIETIES is a bulletin describing the important climatic and topographic features of the main apple-producing sections of the United States; insect and disease conditions; and characteristics of leading varieties. Bulletin FB1883. *Office of Information, United States Department of Agriculture, Washington, D. C.—Gratis.*

HERE'S HOW TO HANDLE IT is a 16-page illustrated bulletin describing a wide range of belt conveyors for handling bulk materials in industry and on engineering projects. Bulletin No. 410. *Chain Belt Company of Milwaukee, Milwaukee, Wisconsin.—Gratis.*

FIREPROOFING is a copy of a report presented to the American Wood Preservers Association for the benefit of engineers, architects and others interested in fireproofing methods for wood. *Mr. H. L. Dawson, 1427 Eye Street, N. W., Washington, D. C.—Gratis.*

PLATING CONVEYOR BULLETIN gives illustrations and detailed descriptions of the construction and improved features of these conveyors. It describes various types of drives, a wide range of carriers, methods of agitation and ventilation, and the operation of machines. Profusely illustrated. Request Bulletin SA-101. *Hanson-Van Winkle-Munning Company, Matawan, New Jersey.—Gratis.*

FRACTIONS, WHY THEY ARE DIFFICULT AND THE REMEDY, is a 19-page pamphlet on the octic system of numeration. *E. M. Tingley, 221 North Cuyler, Oak Park, Illinois.—Gratis.*

REPORT ON EXPERIMENTS WITH COLCHICINE BY LAYMAN SCIENTISTS, by Eigsti and Tenney, contains practical instructions for producing hereditary changes in plants by applying colchicine to the growing portions. *University of Oklahoma Press, Norman, Oklahoma.—35 cents.*

THE NEXT STEP AHEAD IN FLUORESCENT LIGHTING is a folder describing briefly the newest type of cold-cathode fluorescent tubes which start instantaneously when the switch is operated, and which have numerous advantages over the familiar fluorescent tubes which have a time lag in starting. *Fluorescent Lighting Association, 509 Fifth Avenue, New York, New York.—Gratis.*

SAFE INVESTMENTS is a file folder containing loose inserts describing various types of protection equipment for industrial plants. These range from welders' masks, aprons, and capes through hand-protecting gloves to various types of goggles and protective clothing. *Kimbal Safety Products, 7314 Wade Park Avenue, Cleveland, Ohio.—Gratis.*

WE'VE COME A LONG WAY is an elaborately produced brochure tracing the development of the American standard of life and of the part which porcelain enamels have played in this development. Partly "human interest" and partly devoted to excellent illustrations of steps in the process of manufacturing these enamels. *The Hoffman Brothers Company, Charles Street at 22nd, Baltimore, Maryland.—$1.00.*

TAYLOR INSTRUMENTS FOR PRESSURE is a 24-page bulletin illustrating and describing various types of instruments for indicating, recording, and controlling pressures in industrial operations. *Taylor Instrument Companies, Rochester, New York.—Gratis.*

WARTIME EMERGENCY FIRST AID is a single sheet describing various types of first-aid equipment for factories and offices, as well as stretchers, asbestos suits, protective helmets, and other equipment for air raid protection. *E. D. Bullard Company, 275 Eighth Street, San Francisco, California.—Gratis.*

LYCOMING AIRCRAFT ENGINES is a four-page folder presenting flight views of the numerous types of Lycoming-powered training planes as well as illustrations and brief descriptions of five types of engines ranging from 50 to 300 horsepower. *Department B, Lycoming Division, The Aviation Corporation, Williamsport, Pennsylvania.—Gratis.*

TELESCOPTICS

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

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

UNFORTUNATELY, there is no book on amateur spectroscope making — nor even an amateur's book on spectroscope using. Potential market for such a book is probably too limited to make it pay its own way (say 3000 copies sold) but this department will rejoice if any writer ever disproves this theory. Until then the amateur spectroscopist will have to do the best he can with what he has: a few technical works on spectroscopy (cited in these pages, March, 1941), and here and there a description by some amateur who made a spectroscope despite the lack of an ideal, all-around handbook.

Such an amateur is R. M. Watrous, M.D., 1924 Flora Place, Highland Park, Ill., and his account, written by request, follows:

"The concave grating spectrograph is undoubtedly the simplest of all types for the amateur to construct because it has only one optical surface, requires no collimating or objective lenses, and can be constructed to give almost any desired amount of dispersion. The essential optical part can be bought for $4.50 and up; the rest of the instrument for the most part can be made of wood and scrap brass, and does not require elaborate machining. Scientific supply houses, such as the Central Scientific Co., Chicago, list in their catalogues a variety of replica gratings made by taking collodion impressions of famous gratings ruled on glass. These are offered in three grades at three sets of prices, depending on the degree of faithfulness with which the original rulings are reproduced. The medium grade has been found to give amply good performance in the instrument to be described. Replica gratings can be obtained mounted on silvered spherical concave mirrors of various focal lengths, and one of these is the only optical part needed for a concave grating spectrograph.

"The concave grating spectrograph may have various forms, but all are dictated by the optical principle laid down by Rowland, which states that the slit, the grating, and the spectrum must all three lie on the circumference of a circle whose diameter is equal to the radius of curvature of the mirror on which the grating is mounted. The mirror and the spectrum must lie at opposite ends of one diameter of the circle, in order to have images of the slit in focus, so the only possible variations in design must be obtained by changing the location of the slit along the circumference of the circle. In practice, the parts are arranged as shown in Figure 1.

"In order to understand how images are formed by a concave grating, it is worth while to imagine the mirror on which the replica is mounted set up facing the observer as for a Foucault test, using a slit at the center of curvature as the source of light. Under such circumstances, the image of the slit will be cast back upon it, and a percentage of the light striking the mirror will be returned. However, the grating will cause some of the light to be diffracted, with the result that varicolored images of the slit will be formed both to the right and to the left of the direct image. Thus there are two first-order spectra. To the right and left of these respectively will be another set of colored images, forming the second-order spectra, and beyond these will be third-, fourth-, and *n*th-order spectra, each fainter and more spread out than the last. If the slit be now moved to one side sufficiently, and also be brought closer to the mirror, to preserve the relationships of Rowland's circle, the direct image of the slit will move in the opposite direction, as will all the spectra, until a position is reached in which the images will lie in the positions shown in the figure. By moving the slit still farther, the second-order spectrum could be brought opposite the mirror. [Detail in extension of this particular paragraph, by Dr. Watrous, may be borrowed from this department on request by readers interested in this type of spectroscope.—*Ed.*]

"Having determined the dimensions required to secure the relationship shown in the figure with any given concave grating, it is necessary only to construct a box to support the parts and exclude light, and one has a spectrograph. A film-holder may be made, to support films at the point where the spectrum comes to focus, or a telescope eyepiece may be supported at this point for direct observation. With such an instrument, clear spectrograms may be obtained 8" long, showing hundreds of details such as Fraunhofer lines. The light obtained by sparking two iron nails across the terminals of a storage battery will give a beautiful line spectrum of iron. Light passed through solutions of hemoglobin, dyes, chlorophyll, and others, will show characteristic absorption bands. Bunsen's famous experiment with the sodium flame can be performed; and so on.

"In choosing a grating, a few facts should be kept in mind. The degree of dispersion (and thus the length of the first-order spectrum) is proportional to the number of lines per inch in the grating and to the focal length of the mirror. The resolving power, however, depends on the area of the grating and the accuracy of the ruling. The spectrograph shown (Figure 2) contains a medium grade grating of about 40" radius of curvature, with 14,500 lines to the inch and a grating area of about 2 x 3 centimeters.

"The box is made of plywood, painted black inside, and with light baffles located at strategic points. The adjustable slit mechanism is on the left. The sliding adjustment for the film-holder is on the right, actuated by the two vertical screws. In Figue 2 the film-holder has been removed and is resting on top of these screws, its slide pulled two thirds of the way out to show how it is loaded. The main body of the camera extends into the background, with a small square porthole in the far end to give access to the adjustments of the grating mount. [In Figure 1 the slit is on the right of the spectrum but it matters not.—*Ed.*]

"The slit of a spectroscope is one of the essential parts, since every detail of the spectrum is actually an image of the slit. Its edges should be as smooth and as parallel as the maker's skill can con-

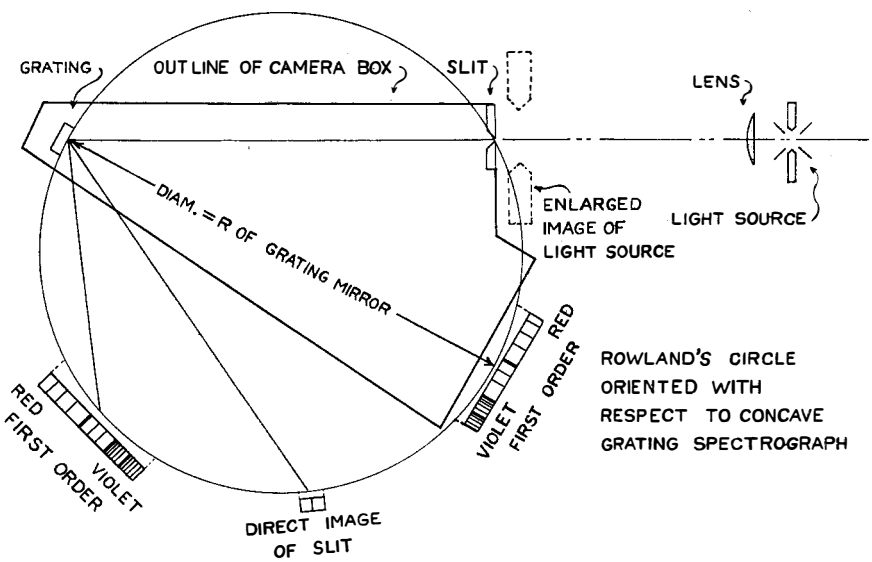


Figure 1: General plan of the concave grating type of spectrograph

trive, and one may lavish as much or as little care on it as he wishes. For ordinary work, a slit 0.002″ to 0.003″ in width is suitable, and there is very little actual use for an adjustable width. Provision should be made for rotating the slit mounting to line it up parallel with the ruling of the grating for best definition, and it should be mounted in a draw-tube so that its distance from the mirror can be varied slightly for focus.

"The jaws of the slit may be made of brass and should be filed to a chisel edge and then sharpened like a chisel on a flat piece of plate glass, using finishing emery. After the edge is sharp, it may be

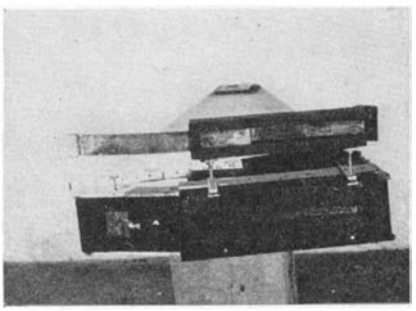


Figure 2: Watrous' instrument

placed on a very clean, smooth piece of plate glass and gently pressed down. This will smooth out the "saw" edge and give a perfectly straight line. The two jaws should then be placed in their channels and closed gently together in front of a strong light. I believe that irregularities of less than .001″ can be detected with this test. The most difficult part of an adjustable slit to make is the parallel channels in which the jaws are to slide. Not having a milling machine, I built these up out of strip brass. [By using a principle to be described next month, this problem is avoided.—*Ed.*]

"Thirty-five millimeter film is very useful for making spectrographs, and a holder may readily be designed to accommodate strips long enough to take in the full length of the spectrum. The film should be held in a curve conforming to Rowland's circle. Though it adds considerably to the problems of construction, a slide which permits the film holder to be moved at right angles to the length of the spectrum in the same plane will prove well worth while, since it allows up to ten spectra to be made on one film, with all the advantages of being lined up for comparison with one another. With such an arrangement, a narrow slit-like mask should be placed just in front of the focal plane so that each spectrum occupies a strip about 2 mm wide running the length of the film.

"The grating mount, as all telescope makers will realize, must be adjustable as to tilt in two dimensions, and it must have an adjustment for rotation about the mirror axis, in order to line up the rulings in a vertical position.

"Light sources are many and varied, but the ordinary incandescent filament lamp gives a disappointing spectrum. Sunlight, with its thousands of Fraunhofer lines, furnishes material for many

hours of study, but one must secure the co-operation of some patient soul to wield a mirror in order to direct the light into the slit, or else make a heliostat. If photographs are made, of course, they can be studied at any time.

"Carbon arcs give fine line spectra, and are excellent for collimating the instrument. Cored projection carbons, 5/16" size, will operate well on ordinary house current if the arc is placed in series with a cheap heating element or electric iron drawing about 500 watts. If the carbons are removed from this circuit and replaced by iron nails, copper wires, aluminum, brass, nickel, or lead rods, light can be produced by making and breaking the contact, which will give beautiful bright-line arc spectra of the metals. These flashes are too fleeting to study visually, but can be recorded on film and the lines can be identified with the aid of a table of wavelengths.

"If the experimenter has a small transformer, such as is used for neon signs, he can obtain spark spectra of metals by causing the spark to jump between electrodes of the proper material. In order to obtain emission of lines, however, a condenser must be placed across the secondary of the transformer. The writer found that a home-made, one-quart Leyden jar served this purpose very well, though a more efficient and less bulky condenser would be preferable.

"The light from neon signs, fluorescent lights, and sodium vapor lamps will furnish interesting material for study and will also challenge the ingenuity of the experimenter to find some way of making it enter the instrument. On one occasion I balanced my spectrograph, which is about the size and shape of a baby's coffin, across the back seat of my car, while my wife sighted it like a rifle at a sodium vapor lamp and I held a condensing lens so as to cast an image on the slit. This was on a busy highway, but fortunately the stunt took place at night!

"Figure 3 shows three contact prints made from portions of negatives obtained in the instrument. They extend from the orange to the violet. Violet is on the right.

Top: Arc and spark spectra of metals; from top to bottom: aluminum arc; 15,000-volt condensed spark between Al electrodes; iron arc; spark between iron electrodes; copper arc; copper spark; nickel arc; nickel spark; spark between platinum electrodes.

"Middle: Series of exposures made with carbon arc for purpose of focusing slit.

"Bottom: Absorption spectra of hemoglobin derivatives: carbon arc; next two, light from incandescent portion of carbon arc passed through hemoglobin solutions; next two, same through methemoglobin solutions; next two, same through carbon-monoxide-hemoglobin (note shifting of the two dark bands to the right); carbon arc.

"The two D lines of sodium are especially prominent in most of the negatives made with light from the carbon arc. They appear near the left margin in the middle set of spectrograms, and serve as convenient landmarks.

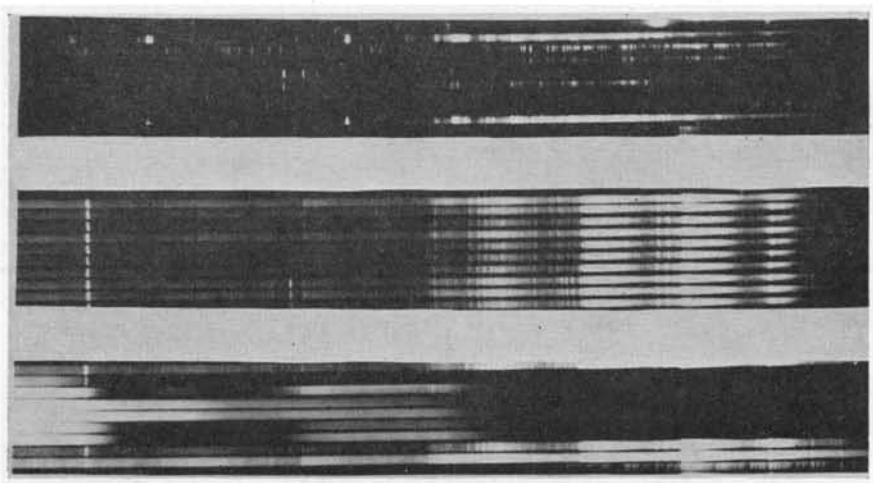


Figure 3: Spectrograms obtained with the Watrous spectrograph (see text)

"Brode's 'Chemical Spectroscopy,' 1939, is a fine technical work with 120-page tables of wavelengths and other things but no information on building spectroscopes. The old maestro of the subject was Baly, whose 3-volume 'Spectroscopy' was published in 1912, but this, too, is pretty technical and is no longer in print."

NEXT month two or three shorter items on amateur spectroscopy will be presented in this department.

STELLAFANE convention of amateur astronomers and telescope makers has been called off this summer. War.

FROM Thomas Hindle, England, son of the noted amateur telescope maker, J. H. Hindle, the following cablegram has been received: "Regret inform you my father John H. Hindle, F.R.A.S., died on 17th May aged 72. He was governing director of Hindle Son and Co., Ltd., and had many engineering inventions to his credit, notably the electric baling press and electric control for wide looms." It is hoped that further detail concerning Mr. Hindle will later be made available for publication in this department.

Printed in the U. S. A. Press of the Wilson H. Lee Company, Orange, Connecticut.

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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ALL OVER AMERICA there are high school seniors . . . boys and girls . . . who have potential scientific ability and budding creative genius of a high order. These talents are latent . . . awaiting the opportunity for further development through higher education.

To provide this opportunity, Science Clubs of America, sponsored by Science Service, is now conducting an *Annual Science Talent Search* . . . made financially possible by Westinghouse. This Talent Search has three major objectives:

1. **To discover and foster the education of boys and girls who possess exceptional scientific skill and ability.**
2. **To focus the attention of large numbers of gifted youth on the need for perfecting their creative and research skill . . . as future contributions to winning the war and the peace to follow.**
3. **To help make the American public aware of the role of science in war and in the post-war reconstruction.**

High school seniors, who enter the Science Talent Search competition, must take special examinations in their local schools to determine their aptitude for science, and must submit essays and school records.

Each year, forty winning contestants are to be given all-expense trips to Washington, D. C., during July where they will meet some of the country's foremost scientists, visit scientific institutions, and take part in scientific programs. While at the Nation's Capital, these embryo scientists will be given additional written and oral tests.

Judges will then select the two most talented youngsters . . . a boy and a girl . . . who will be awarded Westinghouse Grand Science Scholarships of $2400 each. Additional Westinghouse Science Scholarships . . . each valued at $200 . . . will be given to eighteen contestants.

By aiding the education of these gifted boys and girls today, we hope to help develop the scientists of tomorrow who will lead the way in the advancement of research and engineering.

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