SPERRY'S MAGIC TOP . . . Page 66

SCIENTIFIC AMERICAN

AUGUST • 1943

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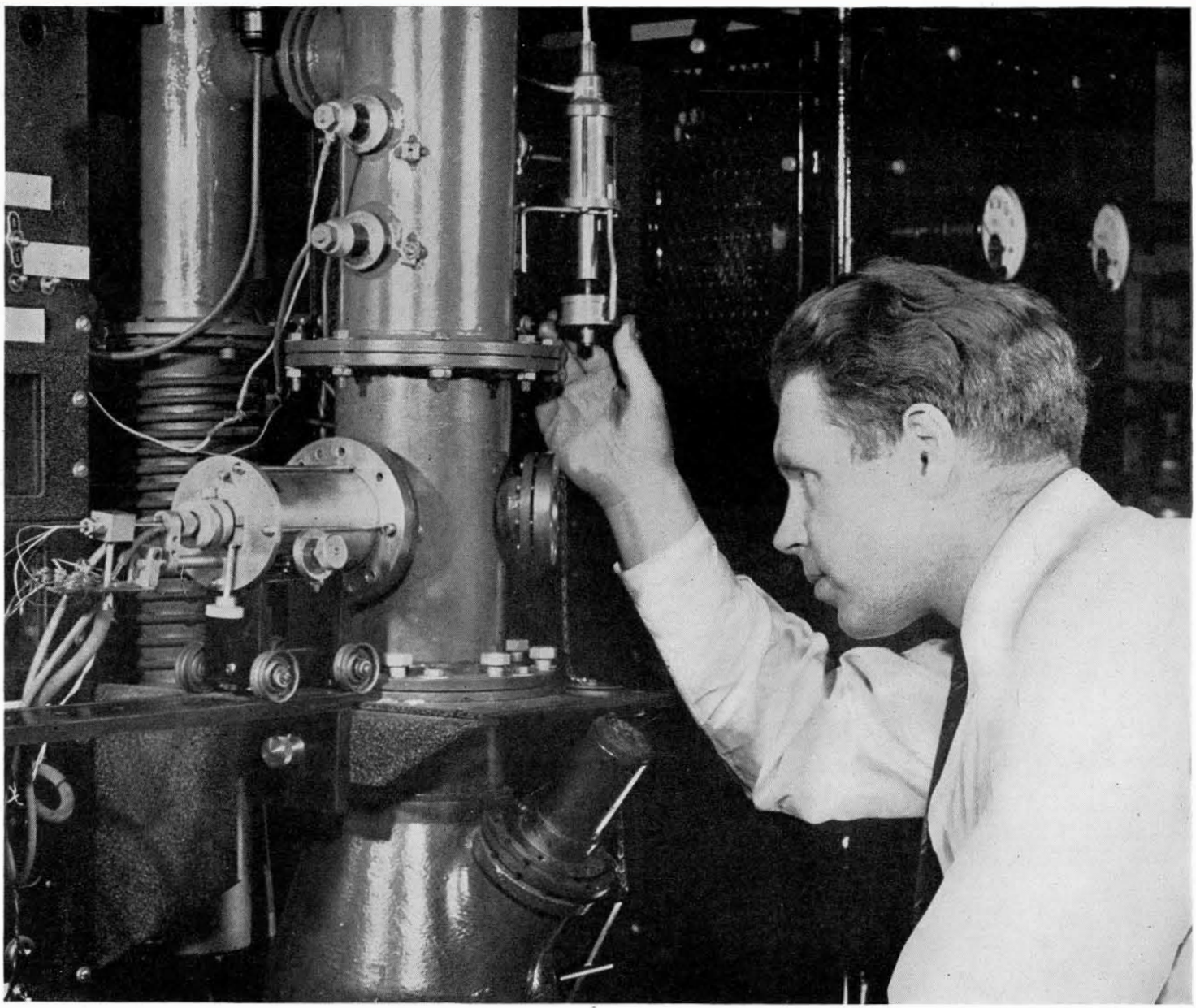


Electron "Bullets" Aid Corrosion Battle . . . See page 78

AN EXPRESSION OF FAITH IN AMERICA

RECENTLY, Goodyear dedicated a new home for its bold and manifold research activities, now concentrated on war products.

Gathered here, in vast array, are the most modern instruments of scientific discovery—not only in the fields of natural rubber, synthetic rubber and its kindred plastics—but in fields also ranging even to aerodynamics and metallurgy.

More than a million dollars went into this building and its equipment. It is, we believe, the finest laboratory for its purpose in the world.

But it is not the completion of the structure which we emphasize here.

It is rather the beginning of a new advance—an advance already launched by the limitless demands of war, which will surely gain momentum with the peace to come.

For Goodyear's growth has stemmed not from the accumulation of properties or from finance—but from fertility of the mind and the serviceability of the products which this fertility brought forth.

From the beginning Goodyear has steadfastly stressed research to advance the usefulness and value of its products.

It was this constant quest for improvement which, in the early days, originated the first straight-side tire.

It brought forth the first pneumatic tire for trucks and farm tractors—the first low pressure tire for airplanes.

It brought cotton, rayon and nylon cord tires to their high perfection.

It produced Pliofilm and Airfoam, twin advances in packaging and cushioning.

It developed the never-equaled Compass transmission belt.

It perfected bullet-puncture-sealing fuel tanks for airplanes.

It enabled America's first *all-synthetic* tire, produced by Goodyear in 1937.

And for 28 years now, it has won popular tribute, expressed in the fact that more people ride on Goodyear tires than on any other kind.

We cannot predict what this laboratory will bring forth in future.

But in the realm of possibilities—from the developments spurred by war—is such a range of products as nailable glass, wafer-thin insulating materials, hundred-mile conveyor belt systems, non-freezable plastic water pipes, metal-wood laminations for car and airplane bodies, mildewproof tents and awnings, static-free radio, all-welded airplane fabrication, crashproof airplane fuel tanks, and many like wonders on which we are now at work.

These will dictate in significant measure "the shape of things to come," forecasting the fullness of life which is ours to conceive and realize when peace returns.

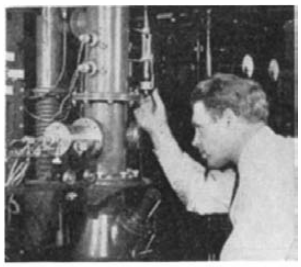
So what we have dedicated is not a building, but the talents which this building is built to serve.

It is our aim to make it forever true of Goodyear, as of life in America, that "the best is yet to come."

Pliofilm, Airfoam, Compass—T. M.'s The Goodyear Tire & Rubber Company

GOODYEAR

THE GREATEST NAME IN RUBBER



ELECTRON "BULLETS" in the electronic diffraction camera are being used in the laboratory to study the problems of rust and corrosion, as told on page 78 of this issue. Dr. Gulbransen, investigator who is conducting this research, is shown in our front cover illustration adjusting a gas pressure valve in the tube where the "bullets" are formed.

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SCIENTIFIC AMERICAN

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NINETY-NINTH YEAR **ORSON D. MUNN, Editor**

AUGUST • 1943

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50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed From Issues of August, 1893)

FIELD 'PHONE—"Some recent experiments abroad by Captain Charollois on the use of a field telephone outfit for military operations indicate that it has great possibilities as a means of communications in the field. . . The small magnetic receivers can be used as the wire is being paid out on the ground, and thus constant communication is kept with the starting point as the line progresses. . . Cavalrymen, or infantry on bicycles, could establish a line with great rapidity."

THEN CAME BUSES—"The perfection of the overhead trolley system has done a great deal to advance rapid transit and render it possible for people with small means to live in the cheap and generally attractive suburbs. . . It is only a question of a few years when the whole State of New Jersey will be gridironed with trolley roads."

ELECTRIC LOCOMOTIVE—"The first electric locomotive of any considerable size in the United States, and what is said to be the first practically operative high speed electric locomotive in the world, adapted to the steam railroad, has recently been completed at the Lynn works of the General Electric Company, and will shortly be exhibited at the World's Fair. . . It is a 30-ton locomotive, designed for a normal speed of 30 miles an hour, primarily intended for operation on elevated railways, and for passenger and light freight traffic on less important steam roads."

OCEAN SPEED—"There are already several ships that can cross the Atlantic at an average speed of over 20 knots or 23 statute miles per hour. The Campania crossed from Sandy Hook to Queenstown, on her first voyage in May last, at an average of 21.3 knots, and during one day she averaged 22.3 knots."

TUNNEL VENTILATION—"In the important matter of ventilation, the method resorted to in the tunnel beneath the Mersey at Liverpool is claimed to present one of the most striking achievements. . . At and near the middle of the tunnel are openings to a smaller side drift or tunnel running alongside of the main tunnel to the shore end, where is fixed a large fan, the result being that air constantly enters at the stations, which are thus swept clear of all foul air."

LENSES—"The use of lenses has been traced to the Chinese moralist Confucius, 748 B.C. A glass case in the Assyrian section of the British Museum contains a piece of rock crystal formed into the shape of a plano-convex lens 1½ inches in diameter and 9/10 inch thick. This was discovered in the ruin called Nimroud. It gives a focus of 4½ inches. . . The date is about 700 B.C."

MEXICAN PROGRESS—"Among the notable industrial enterprises recently inaugurated in Mexico is the electric lighting of the City of Guadalajara. The plant utilizes the famous Juanacatlan waterfalls, which are situated about 18 miles from Guadalajara. The Thomson-Houston generators are actuated by Leffel turbines, the head of water being 58 feet. Three turbines of 550 horse power are used. The dynamos for arc lighting have a capacity each for 50 arc lights of 2,000 candle power."

INCANDESCENTS—"A number of suits have within the past few years been brought by the owners of the Edison electric light patents against opposition companies, to enjoin the manufacture and use of incandescent electric lamps. Recently several decisions have been given by the courts, in which the general consensus . . . was in favor of the Edison patent."

MACHINE GUN—"The long and close competition between rival machine guns has resulted in favor of the Maxim. It has been decided that hereafter, in the offensive equipment of British war vessels, the Maxim gun shall take the place of the five-barrel Nordenfelt and Gardner guns."

RIVER TRAVEL—"The Mississippi River has 600 affluents whose courses are marked upon the map, and a drainage area of 1,257,545 square miles. The traveler embarking upon a steamboat can sail from Pittsburgh, 4,300 miles, to Fort Benton, Mont., and from Minneapolis, 2,200 miles, to Port Eads, on the Gulf of Mexico."

CANAL BRIDGE—"The Manchester Ship Canal was constructed to enable sea-going vessels to reach Manchester, and thus avoid expensive railway transfers of freight at Liverpool. . . . The most important problem connected with the scheme,

next to the cutting of the canal itself, was the providing for the traffic which exists between the two sides of the river Mersey and the Irwell. Four roads cross the canal, one at Barton, one at Warburton, and two at Warrington. In addition to the road bridges, the Bridgewater Canal and five railroad bridges, as well as the famous Runcorn Viaduct, cross the canal. In the final plans, swing bridges were abandoned and high level bridges were substituted. The Warburton Road bridge [illustrated] was designed by Mr. E. Leader Williams, M. Inst. C.E., and is a fine example of a cantilever bridge."

BULLETS—"Experiments made at the Frankford arsenal demonstrate that a nickel-steel covered, unlubricated cartridge is better than the old copper case with lubricated bullet. The velocity of the new 220-grain bullet of 30-caliber is 2,000 feet per second, while the velocity of a 45-caliber, 500-grain bullet is only 1,300 feet. . . . A small caliber bullet of the new type fired at oak timbers placed lengthwise, penetrates 30 inches at 30-yards range, while the present bullet will penetrate only 4 to 5 inches at the same range. Accuracy . . . with the new bullet . . . is remarkable."

PATENT SPEED-UP—"The new Commissioner of Patents, the Hon. John S. Seymour, deserves praise for his recent efforts to bring up to date the work now pending in the United States Patent Office."

A Flag with 46,200 Stars

THE service flag of the Bell System had 46,200 stars on May 1. It has a lot more now. Telephone men and women are serving with the armed forces everywhere.

Those who are right in the middle of the fighting realize especially the importance of the telephone job back home.

"Tell the gang," their letters say, "to keep on plugging.

"We wouldn't have the stuff for fighting if the rest of the Bell System wasn't sticking to the job and pushing through the calls that get things done.

"Takes team-work to win a war — especially a big one like this."

BELL TELEPHONE SYSTEM

★ *Your continued help in making only vital calls to war-busy centers is more and more essential every day.*

"Quotes . . ."

"Don't expect manufacturers to be turning out 'dream models' of the ultra-modern household appliances you may have seen pictured, as soon as the war is over. Eventually, we will be having domestic peace-time appliances such as had not even been thought of before the war, but not immediately." R. C. Cosgrove, Vice President, The Crosley Corporation.

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"It is probable that many types of military aircraft could be converted to inefficient commercial usage. . . . But, despite the appearance of immediate saving in initial cost, the attempt to utilize converted military aircraft on any appreciable scale in this country or on our principal world trade routes would be a gross mistake." Colonel Edgar S. Gorrell, President, Air Transport Association of America.

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"We have been urging our people on the B & O to think of their railroad as a war production industry in the first rank—and of themselves as war workers. . . . We have asked them to exercise care, to work safely to avoid injury to themselves and to others and we ask the older employees to assist the new and the inexperienced." Roy B. White, President, Baltimore and Ohio Railroad Company.

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"I think the time for merely speculative post-war planning has passed. The time for designing is here. Our primary present task is to attend to the preliminaries —the legal and financial phases of public construction, the acquisition of sites and the advance of engineering—so employment will be immediately available when the war ends." Major General Philip B. Fleming, Federal Works Agency.

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"The need for more and better highways and what we term farm-to-market roads is recognized as vital and essential to the continuing progress and growth of our nation. . . . A road-building program, if carried out under the contract system, will in no way detract from or hinder private enterprise." Arkansas Senator John L. McClellan.

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"The public in general seems to believe that we have many new implements of destruction and defense. But have we? Are not the ships, submarines, guns, planes, tanks, and ammunition used in this war the same as those we used in the last great war, except for improvements in design and effectiveness? Our only new weapon is radionics!" Commander E. F. McDonald, Jr., President, Zenith Radio Corporation.

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"Whenever an important discovery or invention is made it has usually been foreseen for 10 or 15 years. This can be proven by a number of instances out of the development of radio. One of these proofs was given a couple of weeks ago by an announcement of Radar made by the Army and the Navy." Dr. E. F. W. Alexanderson, Consulting Engineer, General Electric Company.

99TH YEAR SCIENTIFIC AMERICAN AUGUST 1943

INVASION COMMUNICATIONS

The Jobs of the Signal Corps are Many and Varied

RICHARD L. SIGERSON

MILITARY security prevents revelation of detailed facts concerning the Signal Corps role in invasion of a specific country or area. The following article, based on North African and other operations, therefore represents a composite story with facts taken from a number of Signal Corps operations ascribed to the African invasion in order to portray fully the functions of the Corps without revealing information which would be of value to the enemy.—*The Editor.*

THE GROUP of soldiers moving silently shoreward in the steel-armored invasion launch hours before dawn were tense, absorbed in the thoughts of men enroute to a rendezvous with violence.

Perhaps through the thoughts of some ran the phrase that is both code and slogan in the United States Army Signal Corps: "The difficult we do at once; the impossible may take a little longer." The "difficult" now was to precede an army of Allied soldiers in the invasion of an important North African city. They were to establish and hold communication beach-heads that would complete the nervous system for directing, coördinating, and controlling the invading assault troops scheduled to land in exactly seven hours.

The invasion barge bumped against the sandy beach. Its powerful marine motor, the muffled underwater exhaust burbling softly, continued to drive the screw, holding the blunt prow of the craft firmly aground. Several Signal Corps men leaped into the water and struggled through knee-deep surf to dry land where they spread out to scout the beach and act as sentries. The remainder of the crew swiftly unloaded the barge of its cargo of wooden chests and reels of telephone wire.

For weeks these picked men had studied detail maps of the coastline; while aboard the transport they had rehearsed tirelessly each phase of the work to be done in the next few hours. Now, working in twos and fours, they picked chests and reels out of the small mound of equipment put ashore from the invasion boat, carrying some deeper inland and others along the beach to the right and left. A sergeant and an enlisted technician seized a particular chest from the pile and started inland. The maps listed a small knoll rising up from the beach in this direction, several hundred yards from the shore line. As they approached this point a low voice hailed them. It was one of the Signal Corps scouts.

He led them to a spot he had already picked out. Unslinging shovels, they quickly dug a niche in the embankment large enough to conceal a field telephone switchboard and its operator. The lid of the chest was swung back, a stunted switchboard lifted out and set into place. While the erstwhile sentry removed other articles from the chest, including a 12-pound leather encased portable field telephone, a kit of repair and wire-splicing tools, tape, and wire connectors, the sergeant and private trotted back for more equipment. Presently they returned with a reel of rubber covered telephone wire. Wire ends were connected to the switchboard, a carrying rod inserted through the center of the reel and they trotted off again, stringing wire from the spinning reel toward the harbor.

WHILE these men were setting up the first field switchboards, others were busy in other directions. Some dug foxholes that would later be used for advance observation and gunnery posts, while some strung telephone wire along the ground leading to these foxholes. Still others ran lines far down the beach, working stealthily to avoid prematurely alarming the defending forces. Portable radio transmitters and receivers were set up to complete the semi-circular communications network that extended from the projected spearhead of the attack at the central landing point to embrace outlying flanks on either side. At one point, Signal Corps men stumbled upon a stone building where 75 sleeping enemy troops were quartered. They quietly entered the building, disarmed the men and took them prisoner. A guard was mounted over the captured soldiers who moved them into a nearby railway building, their original quarters being later turned into a Signal Corps message center. The contingency of encountering enemy forces was neither welcome nor unexpected. But it was a contingency that would not be permitted to interfere with setting up, within the alloted time, a communications system by which the main body of assault troops and armored units could be controlled and directed when the battle began.

Tank communication by radio 'phone

As day broke a few hours later, the air screamed with the cataclysmic sounds of bursting shells and heavy cannon, which momentarily receded only to well up again in greater volume when giant ship rifles found the range of new targets. During these lulls the coughing grunts of tanks furrowing tracks across the sandy beach and nosing their way into barricaded city streets mingled with the staccato of machine guns and the sharper spat of infantry light arms. The Signal Corps had fulfilled its initial assignment and the struggle for the African city was on.

These were the noises all present heard. But the air was crowded with other sounds: The shrill notes of radio code and the cryptic clearness of military orders broadcast over close-talking, specially-designed microphones of the Signal Corps. Hundreds of radios, in as many jeeps, tanks, reconnaissance cars, fighter

planes, bombers, and big-bellied transports, loaded with paratroopers, spilled their messages into the tumultuous morning air. Submarines on underwater patrol along the perimeter of the invasion armada added to the radio hubbub. The import of these messages, plus those carried over telephone lines, was translated by message centers, sorted, and sent along to the final destination. That destination might be the commanding general's field headquarters, or a concealed one-man observation post in a section yet to be won from the enemy.

If communications lines make up the nervous system of an army, the message center is the brain controlling the impulses of that nervous system. It is at the message center that all messages, orders, and progress reports between the field and operational headquarters are picked up and relayed to the proper recipient. It is here that priorities and routes are assigned to incoming and outgoing messages. Security and speed of transmission are the two primary considerations. A message center chief, perhaps an enlisted man, may hold up an important order from the commanding officer while clearing telephone lines to handle the message, instead of sending it immediately by radio. Radio transmission is usually rapid, but from the viewpoint of military security, it is less safe then telephony. Enemy monitors may sit behind their own lines and tap any available radio frequency, but to tap telephone wires they must locate the conductors and then tie in their own listening apparatus.

Peep and trailer lay a jungle 'phone line

To avoid overcrowding and confusion on the available wave bands of the radio spectrum, Signal Corps radios are operated on so-called "nets." Assume an attacking Allied force composed of tanks and armored units, artillery, motorized infantry, anti-tank and anti-aircraft batteries, and a squadron of interceptor planes. The radios in one or more of these combat groups would be set on a predetermined frequency, achieving an effect akin to that of a party-line telephone service. There you have a radio net. Unlike the party-line service, radio nets afford facilities for two or more communications simultaneously. A simple illustration of this may be found on a standard home radio receiver by tuning in a station carrying a news broadcast with a background of Morse code. Both are clearly audible to the listener.

In Africa, as in all military land operations, communications lines were geared to keep pace with all units of the Army, and advance observation posts established far out ahead of the foremost troops. As the Allied army threw its armored net around and drove steel columns into the city, the Signal Corps advanced its control network of communications lines, assigned more radio nets as additional forces left the transports to participate in taking the city. Complete radio and telephone message centers, mounted on trucks and manned by trained operators, also came ashore to aid in keeping all units of the indriving Army fluid and immediately responsive to changes in tactics made necessary by the changing tactics of the defenders.

An example of the role of the Signal Corps may be seen from the following messages:

"Post 9 reporting. We are being held up. Enemy forces are strongly entrenched in three concrete buildings fronting our positions. Our firepower is too weak to penetrate their defenses. . . ."

The message is received at field headquarters. Two minutes later a carrier-based observation plane appears and circles above Post 9. In the forward gun turret of a destroyer lying off the harbor, a message from the fire control bridge comes over the gunnery officer's earphones. "Cease firing," he orders. A moment later the range of the new target reaches fire control from the plane, is relayed to the gunnery officer. The forward turret swings five degrees to starboard, the rifles dip a fractional measurement and resume firing. Five minutes later there is a minute change in range, the guns are now pounding the second building of the three that have been holding up Post 9's progress. They then shift to the third building. Meanwhile, the commander of a corps of General Grant tanks is ordered to dispatch a tank to Post 9 to lead an infantry attack on the three buildings when the shelling is finished. Post 10, at the left of Post 9, has been encountering little opposition, is driving in too fast and exposing its flanks. Headquarters orders the 2nd Lieutenant in command to detail a machine-gun crew and 50 men to the aid of Post 9. Post 10 will then dig in and hold until Post 9 can move forward.

Eighteen minutes later Post 9 has cleaned out and is occupying the three buildings, the observation plane is hovering over another part of the city, the destroyer's guns are firing at a target far off on the right flank, and the tank is returning to its corps.

Throughout the day over the entire battle area, similar incidents are repeated and multiplied. Ammunition is rushed from a transport to a howitzer battery. Wounded men are carried to a protected area in the central harbor docks where an invasion barge is waiting to carry them to dressing stations aboard a battleship. A field kitchen grinds off a landing boat with hot soup and food for 600 hungry men in the central sector. The battle is going well. All the Army's parts are operating smoothly and efficiently, due in no small part to the efficiency of the communications system.

Two tested wheel-horses of the Signal Corps are the teletypewriter, which operates over telephone wires, and the photo-electric radio transmitter. In the case of the teletypewriter, an operator sits at a keyboard only slightly different from that of a typewriter. As he types, a narrow paper tape feeds through a perforating attachment which punches tiny holes in the tape. When the message is ready to send, the tape is merely fed into a transmitter and impulses are transmitted along telephone wires to other printers which duplicate the perforations in the original tape, or type out the message on rolls of paper, as desired. If required, an operator may send by "direct keyboard." In this the tape is not used, but electrical impulses set up when the operator strikes the letter keys are transmitted to receiving machines, causing these to type out the message.

With photo-electric sending, the sound pattern of a telegrapher's manually-operated "bug" is inked, rather than punched, on a tape like that used in the teletype. Tapes may be prepared prior to sending by operators working at normal or subnormal speeds. When these tapes are transmitted—photo-cells picking up the inked images and translating them into electrical impulses—the sending speed may be stepped up to well over a hundred words per minute, making it impossible to distinguish individual Morse symbols by ear. Recorded by a receiver, which operates a high-speed inking device to re-establish on a paper ribbon the pattern of the original tape, the messages are automatically wound up on reels and then slowly unwound before code operators who transcribe the inked pattern into "a-b-c" characters on typewriters.

Although often mounted in mobile message center trucks, photo-electric and teletypewriter sets are used largely in primary message centers set up behind the front lines in battle areas. It was through the primary message centers that close contact was maintained between all Allied units participating in the invasion of Africa, from those attacking at Casablanca, Oran, and Algiers to the British army pursuing Rommel's Afrika Korps along the Mediterranean coast toward

Tobruk. Primary message centers also link the expeditionary forces with the General Staff in Washington, enabling it to balance the needs of one war theater against those of another, and to plan over-all strategy as well as area tactics.

Hundreds of radio stations, thousands of miles of telegraphic and telephonic submarine cable and wire are manned by the Signal Corps to bring the most far-flung tank corps, infantry battalion, or battleship within voice range of Commander-in-Chief Roosevelt at his White House desk.

THE COMPLEX, carefully-wrought Signal Corps with its tremendous responsibility to the Armed Forces has what is probably the highest concentration of specialized talent in the U. S. war machine. Not only must Signal Corps men be soldiers, they must also be able to install, operate, maintain, and, often, build the innumerable electronic and signal devices required in their service to the land forces of the Army and the Air Forces.

One of its many tasks is that of installing and operating secret equipment used in aircraft warning centers.

Military personnel are at the filter and operations boards plotting, on the basis of the reports coming in over their earphones, the course of converging enemy planes. Signal Corps linguists working in relays sit at powerful radios day and night sweeping the entire frequency spectrum to intercept military transmission of the enemy.

One classification of experts in the Corps is concerned solely with supplying the Army Ground and Service Forces with photographic personnel. With their movie and still cameras they perform a variety of important chores. In one instance this may be locating, by camera, camouflaged Axis gun emplacements which cannot be picked out by eye alone. In another, it might be the preparation of training films which are an important aid in training new men in many branches of the armed forces.

While the Signal Corps man is ubiquitous where Americans are fighting or training, he has no monopoly on the use of the instruments of his trade. Often as not the lone soldier picking his way cautiously toward enemy positions with a five pound "handie-talkie" midget radio will be an infantryman.

First ashore—a field switchboard

Most popular Signal Corps instrument in the Army in this handie-talkie. Originally designed for paratroopers, the handie-talkie is now in large demand by the infantry. Its light weight and simple operation contribute to its popularity. The 36-inch antenna collapses into the chassis, automatically turns the set on when extended; slight pressure on the grip permits two-way conversation. The handie-talkie may be easily pre-set on any one of two dozen frequencies. Operated in nets, interchangeable frequencies permit innumerable sets to be used within range of each other by different units, such as reconnaissance, artillery, and paratroopers, without jamming or causing confusion.

Similar to the handie-talkie, but weighing 26 pounds and affording a much greater sending range, the "walkie-talkie"

Handie-talkie, weight five pounds

is the next step up in portable field radios. Carried on shoulder straps like a pack, the walkie-talkie is really a grown-up radio and, when used in conjunction with a hand generator, transmits signals an impressive distance.

Wire and cable, for both telephone and telegraph circuits, however, are still the bone structure of the Signal Corps. These channels provide the greatest security for confidential transmission and are least subject to enemy interference.

Signal Corps wires are now laid, usually by jeeps and trucks, at high speeds. A most interesting wire is the new rubber-covered cable called the "Spiral-4." Spiral-4, developed by Western Electric Company and Bell Telephone Laboratories, consists of four spiraling wires that accommodate three telephone and four telegraph circuits for simultaneous transmission. Manufactured in quarter-mile lengths, the ends of each are fitted with weather-proof connectors to give the desired length of unbroken cable.

The teletypewriter moves by truck

The new connectors speed up the laying of wires as they eliminate splicing.

Prominent military feature of the Spiral-4 is the greater degree of security it offers. The seven telephone and telegraph messages cannot be piped directly into the cable. If this were done they would become hopelessly garbled. Instead, an electronic instrument at either end of the line first generates "carrier" currents. These currents, cousins to the familiar radio wave, retain their identity while intermingling freely in an electrical circuit. The individual messages are superimposed on the carrier currents by the terminal mechanism and ride through the cable pickaback. At the receiving end, the electronic device tosses the carrier current into the discard and guides each signal into its own pair of telephone wires.

Even if the enemy located Spiral-4 military lines and tapped them, he would get nothing for his dangerous efforts but an unintelligible mixture of squeaks and squeals in his headphones.

Mentionable duties and the apparatus for fulfilling those duties in the Signal Corps convey only a fraction of its wartime story. The "unmentionables" make up the most thrilling chapters in its current service record, a record which will be generally known and fully appreciated only after the Signal Corps has circled the globe with its network of communications lines and established primary message centers in Tokyo and Berlin.

●

PRESENT perfection of equipment used by the United States Signal Corps is a triumph of technical research, often performed under pressure of immediate demand, but likewise often with a solid background of long useage under field conditions. An example of such long useage is found in the field telephone, mentioned in the first paragraph on the "50 Years Ago. . . ." page in this issue. As far back as half a century ago, the military forces were experimenting with this means of communication and were developing methods of laying telephone cables at high speed.—The Editor.

Industrial Blasting

Technological Progress Reveals New Uses for Dynamite as Well as New Dynamites that are Safe, Controllable

FRANK J. BYRNE
E. I. du Pont de Nemours and Company

AFTER this war is over the production of industrial explosives—as differentiated from military explosives—in the United States will probably be pointed to as one of the great fundamental accomplishments responsible for the crushing superiority in battle materials which made the victory possible. The output of these explosives this year will likely reach more than 500,000,000 pounds, which is a record. They are the force behind the enormous production of coal and metals. Without them, mining could never deliver vital products in the quantities required. They add a factor of speed and efficiency in providing the materials for building roads, cantonments, air fields, and other projects.

For example: Steel, considered the index of business in this country because next to farming it is our greatest single industry, is dependent upon explosives for the production of its finished product. In the extensive pit mines of the Mesaba Range in northern Minnesota, explosives are used to loosen up the iron ore so that it can be handled by the steam shovels. In the bituminous mines of western Pennsylvania, explosives are used to break down the coal to be made into coke for the reduction of this iron ore. In the big quarries of the lower Michigan Peninsula, explosives are used to blast out solid limestone, which is subsequently crushed and shipped to the furnaces where it is used for a flux with the coke and the ore for the manufacture of iron and steel.

The ships and cars which convey these raw materials to the steel mill are moved by the energy in the coal blasted down by explosives. Not only are railroad trains and tracks, ships and engines, bridges and highways, buildings and automobiles, constructed from the metals or the stone produced by the aid of explosives, but many familiar articles of everyday life also are dependent at some stage on explosives for their economical production.

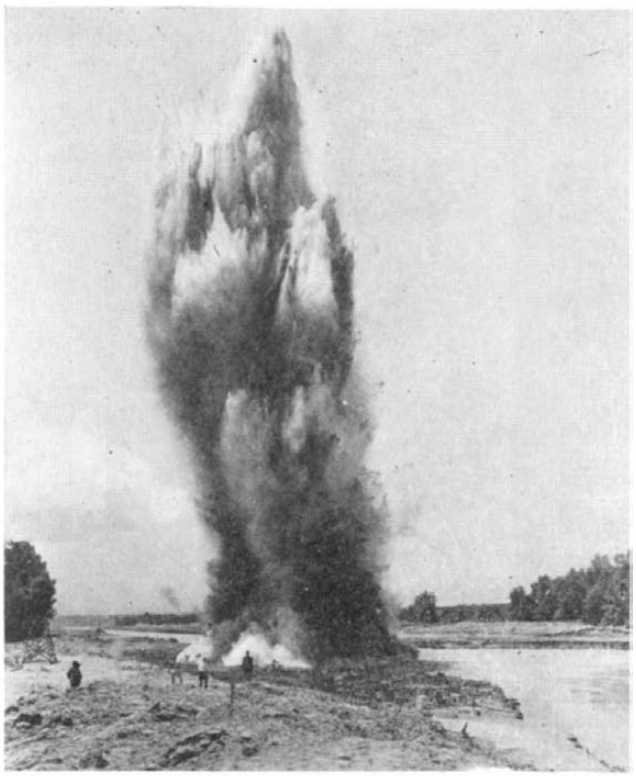
The United States normally uses more industrial explosives than all Europe combined. In an ordinary year about 350,000,000 pounds of various kinds of dynamite and 60,000,000 pounds of black powder are employed for commercial purposes in the United States, whereas only about one tenth as much is used in Great Britain.

With the country at war, and victory hanging on our efforts to turn out metals for the tanks, cannon, bombs, airplanes, ships, guns of all kinds, and other implements of battle, it is a matter of supreme importance that there be no shortage of industrial explosives. Some idea of what is being accomplished with them can be had by a reference to the production of the great iron ranges in the Middle West, mentioned above. In a year of normal business, 55,000,000 tons of iron ore are produced in the United States. In 1929, 67,000,000 tons were produced in the ranges of Michigan and Minnesota. In 1942, the total was 91,000,000 tons. It is expected that 97,000,000 tons will be taken out of those ranges this year. An important point in connection with this is that less explosives were required to mine the 91,000,000 tons in 1942 than to mine the 67,000,000 tons in 1929. This was due not only to improved earth-moving machinery and changes in overburden, but also to more efficient explosives made possible by technological advances.

And in coal, explosives experts expect to see more than 660,000,000 tons mined as against the 400,000,000 tons in a normal year.

Construction work has always employed important quantities of industrial explosives. The building of Boulder Dam required more than 10,000,000 pounds of dynamite. Not long ago, the construction of a water tunnel for New York City used 25,000,000 pounds. Canals, highways, tunnels, and railroads employ large amounts. In building new concrete roads, approximately 1000 pounds of dynamite are employed for each mile in clearing the right-of-way and in supplying stone and cement.

Explosives experts have always used dynamite for operations where no other agent could be so quickly or efficiently applied. Ice jams threatening towns and water works have been broken, ditches have been dug in the South where it was impossible to employ any other product because the right-of-way ran through swamps where logs, stumps, and other debris formed obstacles too great for mechanical shovels. In those cases, the explosives man crawling through the underbrush has put down dynamite cartridges a certain distance apart and blasted out a ditch with one shot, sending the logs, rock, stumps and other impediments flying into the air.



Dynamite blasts a new channel for a stream

THIS "pinch hitting" is being done now also to help along the war effort. Recently, at a strategic airport, it was found that the great landing field was likely to be menaced by floods. Explosives experts used dynamite to blast what is known as a rim canal, 40 feet wide and eight feet deep, all around the field. Lateral ditches were also blasted so that the running water could be carried away. Today, at a saving of many man-hours and hand work, the landing field is able to operate efficiently. In this job, 350,000 pounds of dynamite were employed.

In another case, a landing area for a seaplane base was vitally needed on one of the coasts. Dredges could not get out the rock. Dynamite experts drilled hundreds of holes, brought into play their knowledge of underwater blasting and in a short time had cleared the bottom.

Because of the need of improving navigation for heavy ocean going ships, harbors are being deepened, reefs and obstructions blasted out, and adequate channels being constructed. On one of these jobs alone, 500,000 pounds of dynamite are being employed.

In one of the western states, the army wished to demolish a bridge over a river. The explosives experts placed small

charges all throughout the structure and detonated them at one time. The great bridge fell as if cut with a giant knife.

The speed with which the "Big Inch" can be laid depends in large part on explosives. Something like 750,000 pounds of dynamite are being used to loosen up the right-of-way and lay this, the longest and largest pipe line ever constructed, from a point in the Midwest to its Eastern terminus. This large pipe line is crossing 13 rivers. It will go over mountain ranges and through valleys. It is estimated that about 1000 pounds of explosives will be used for every mile where the rock and stone prevent shovels from scooping out the earth.

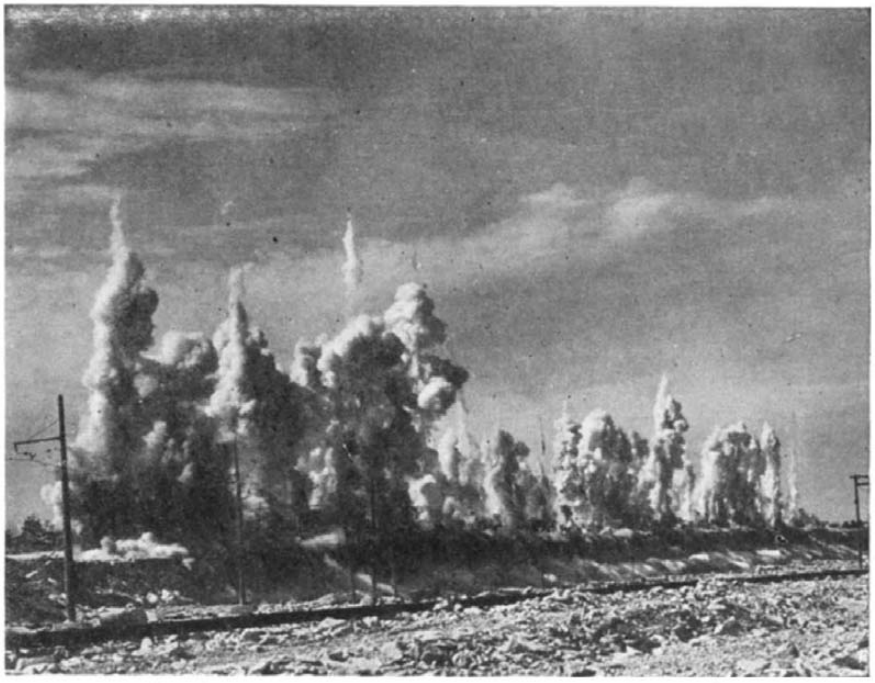
A highly interesting part of the job is laying the pipe line across rivers. Explosives experts are blasting trenches in the bottoms of those rivers. This is one of the time-saving and expert techniques developed by explosives specialists. With the help of boats, barges, drills, dredges and other paraphernalia, holes are drilled in the right-of-way across the stream. Gelatin dynamite which works efficiently under water is loaded into the holes. The equipment is moved out of the way when everything is ready, and the blast fired. The pipe is ready to be lowered as soon as the curtain of water and the debris which has been hurled into the air have dropped. Section by section, the river is thus crossed in a fraction of the time possible by any other method.

Industrial explosives and military explosives are entirely different materials, although often they are confused in the layman's mind. Military explosives are mainly propellants, such as smokeless powder, and disruptives such as TNT for shell bursting charges, mines, and bombs. Industrial explosives include dynamite and blasting powder, neither of prime importance for military purposes as such.

BLACK powder is not used as a propellant in modern warfare, as the smoke produced on firing would disclose the location of the gun. Dynamite cannot be used as a propellant as its speed of detonation is so great that it would shatter the gun. It cannot be used as a bursting charge in shells as the shock of shooting the shell from the gun would also set off the bursting charge and wreck the gun. On the other hand, military explosives such as smokeless powder and TNT are not adapted for use in mines and quarries.

Not only is it impossible to use dynamite as a propellant or for shell-bursting charges, but dynamite manufacturing plants cannot be converted into smokeless powder plants in time of war. The only ingredients common to both are nitric and sulfuric acid. The dynamite manufacturing apparatus is entirely different, the processes and chemical composition totally unlike that of military explosives, and it takes a considerable period of time to train the personnel of both dynamite and smokeless powder plants in their specialties.

Organized research in dynamite has been going on for more than 40 years. Workers have studied the needs of the various consuming industries and as a result have provided a multiplicity of types and grades to satisfy them. They have developed methods for measuring the power of an explosive; methods for determining quickly and accurately its shattering and pulverizing power, its water resistance, its safety characteristics when exposed to shock and flame, the composition of the gases produced on explosion, and other phenomena.



Nitramon blasts out limestone in a quarry

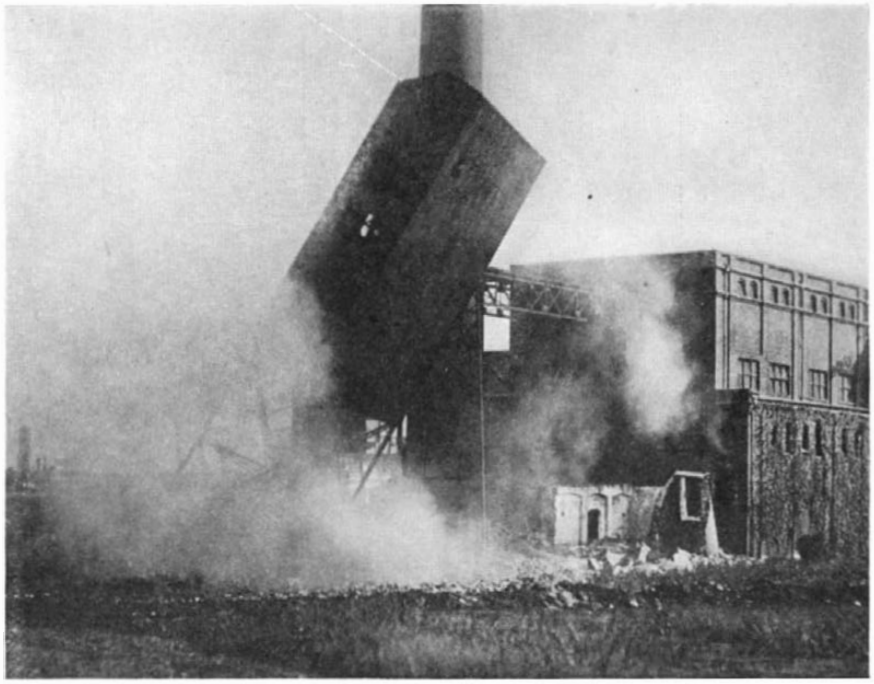
With the methods developed, as a result of prolonged study of the influence of various factors on the properties of dynamite, it has become possible on short notice to design a dynamite combining the qualities best suited for practically any blasting or mining condition.

Many problems have been solved and great progress has been made as the result of this research work. One serious problem that confronted the explosives industry in the early days was that of frozen dynamite. Nitroglycerin, the liquid ingredient of most dynamites, has a relatively high freezing point, around 52 degrees, Fahrenheit. Since many blasters have to work in wintry weather at temperatures far below that freezing point, it was not uncommon for them to encounter frozen dynamite, which was not only unsatisfactory, but also hazardous to use. It could be thawed safely by careful, trained workers, but the miners and quarrymen often used short-cut methods, with fatal consequences.

How to solve this problem was not an easy task, although it was known that the freezing points of liquids could be lowered by dissolving other materials in them. The chief difficulty was in finding a compound that could be added in a relatively high percentage without seriously affecting other essential properties of the dynamite, particularly its propagating power at low temperatures. Research and experimental work were carried on for a number of years, and many diverse freezing-point depressants, such as TNT, nitrated sugars, and nitrated polymerized glycerin, were used with some success. Although reasonably satisfactory low-freezing dynamites were developed in the laboratory as early as 1912, the most satisfactory solution of the problem came in 1925 with the use of ethylene glycol dinitrate as an anti-freeze. This material is not added to nitroglycerin, but when a mixture of ethylene glycol and glycerin is nitrated, the resulting product has a very low freezing point. Frozen dynamites have thus ceased to be a problem to explosives users even in locations where temperatures range as low as 40 to 50 degrees below zero. Anti-freeze protection for dynamite—and for automobile radiators, too—is achieved with ethylene glycol, although it is applied in different ways. The two innovations came practically in the same year.

NEXT to nitroglycerine, the most important explosive ingredient of dynamite is ammonium nitrate. Certain types of dynamite—many of them used in coal mining—contain up to 80 percent of this ingredient. It was discovered that, by varying the size of the grains of ammonium nitrate, the velocity of detonation can be controlled. In other words, by using fine particles, very fast explosives of high shattering power are obtained; conversely, by using coarse grains, the dynamite is much slower and of low shattering power. This was a discovery of great practical significance, since it allowed the production of low-velocity permissibles to bring down coal in large lumps, and high-velocity dynamites for use in hard rock where fine fragmentation was desired.

During the period under review, nitroglycerin has declined in importance as an ingredient of dynamites. It has gradually been replaced by ammonium nitrate, even though, on a weight-for-weight basis, the replacement material has only about 70 percent of the blasting energy of nitroglycerin. But ammonium nitrate is less expensive and much less sensitive. Its use has made possible dynamites that are less



Illustrations courtesy Du Pont Company
Dynamite offers economy in demolishing buildings, stacks, and so on

hazardous to manufacture, handle, and use; moreover, consumers have the benefit of lower cost per unit of energy.

Research development reached a new high point in 1935 with the introduction of "Nitramon" blasting agent, which contains a high percentage of ammonium nitrate; no ingredient of this product is explosive by itself. "Nitramon" is insensitive to the action of a commercial blasting cap, to shock, friction, or the impact of a rifle bullet. To explode it one must employ a booster charge of a more sensitive material. Actually, it is the safest blasting agent available, although it is equal in strength to the most powerful dynamites. It is particularly suited for use in large-scale quarry operations, and a special type, "Nitramon" S, has been introduced successfully for seismic exploration work.

ANOTHER problem of long standing concerns the manufacture of dynamites that will produce a minimum of noxious fumes on explosion. The explosive power of dynamites comes from their almost instantaneous expansion from a solid mass to a very large volume of gases, conceivably a ten-thousand-fold expansion. When charges of dynamite are exploded in confined spaces underground, as in mines or tunnels, it is important that the fumes resulting from the blast shall be as free as possible from poisonous effects on the men as they return to the working faces.

The major portions of dynamite compositions consist of carbon, nitrogen, and oxygen-containing compounds in properly-balanced proportions. Years of research were spent in the laboratory and in mines and tunnels before properly-balanced explosives for underground use were designed and produced commercially. But the results are exemplified by the fact that improved dynamites are being used to drive big-bore tunnels through which water flows from far-distant reservoirs to supply the vital needs of our large cities. It would have been impractical and unduly hazardous to construct such tunnels, if chemical research had not made possible more suitable dynamites for the purpose.

This research work, in addition to the extraordinary manufacturing skill displayed and the wide-flung activities of technical men in the field, examining every possible practical application of industrial explosives, has developed a body of specialists who are today doing the biggest job of their career. Despite huge war demands, explosives in the quantities required are ready for the job. There is no shortage of these vital materials. Moreover, they are being forwarded to users with practically no delay and with the minimum use of priorities.

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VEST-POCKET AUTOMOBILES

Future Cars to be Small and Light

POST-WAR automobiles will be small, light-weight editions fueled by high-octane, heavily-taxed gasolines now available only for military aircraft and motorized equipment. Post-war manufacture of 100-plus octane gasolines will force engineers to design Diesel engines which will get the utmost out of low-cetane fuels for railroad, marine, long-distance and air cargo, and construction service.

These predictions for the post-war petroleum fuels situation were recently placed before the Diesel Engine and Fuels and Lubricants Meeting of the Society of Automotive Engineers by Dr. C. M. Larson, chief consulting engineer, Sinclair Refining Company. He reported that high-octane aviation gasolines, explosives, synthetic rubbers, plastics, anesthetics, and other essential war products now are being made in petroleum refineries at the expense of the kerosenes and distillates from which Diesel fuels are derived. He expressed the opinion that Diesel fuels will be on the critical list by 1944 and said that even after the war the extremes between octanes for gasoline engines and cetanes for Diesel engines will broaden in favor of high octanes to the detriment of Diesel fuel ignition quality.

Dr. Larson's post-war picture indicated that premium grade gasolines will be 87- to 90-octane, regular grades 80-octane, and third grades 72- to 75-octane. Tractor or distillate fuels of 50-octane, 40-cetane, will be available, but in many regions tractor distillate fuels will have to be used with 37-40 cetane, or cetane additive agents will be employed to maintain the 50-cetane minimum called for by manufacturers of high-speed Diesel engines.

He warned that the current demand for distillate fuels by the armed forces, particularly the Navy, will reduce the potential of Diesel fuels and heating oils. He estimated the 1945 production ratio of gasoline to distillate fuel at seven to one as compared with three to one at the start of World War II.

GLUE "WELDING"

Spots are Quickly Set By Radio-Thermics

INGENIOUS as modern lumber cutting methods are, no one has yet devised a way to square off a round log without getting a lot of miscellaneous narrow waste stock in the cut. At the present time particularly, when great quantities of logs are being cut for structural framing to replace steel, and increasingly smaller logs are being cut for ordinary lumber purposes, there is a tremendous amount of narrow stock piling up in lumber yards, and the need for an outlet for this material is rapidly becoming acute.

Even before the present emergency, however, this surplus of narrow boards was a special headache to both lumber manufacturers and timber conservationists. Extensive research has been carried on over a period of many years in efforts to find commercial uses for this narrow material.

The most successful development so far—that of gluing narrow lumber together to make wider usable stocks—has been for the most part a slow and uneconomic procedure complicated by hand methods or by expensive and involved machinery.

Now, however, industrial glue research offers a solution that may prove revolutionary. A new gluing process has been developed by I. F. Laucks, Inc., manufacturing chemists, by which boards are joined together edge to edge by means of "spot welding" or the setting of the glue only in spots along the joint. This method employs momentary pressure and eliminates clamping and also does away with the expensive necessity of heating the whole glue line in order to set it. The welded "spots," which are spaced

about 18 inches apart, hold the boards rigidly together until the glue lines in between are also set. This general setting of the glue takes place after the boards are stacked, thereby cutting down the time the boards must be in the gluing machine.

The present apparatus uses high-frequency radio waves to set the spots. However, the efficiency of the process is not impaired by the use of other heat sources. The glue used is of a special cold-setting type and is particularly amenable to quick setting when heat application by means of the high-frequency method is employed.

Due to the urgent demand for radio and electro-thermal equipment, the availability of this high-frequency equipment is limited by approval of the priority division of the WPB, dependent upon its use.

SANDLESS GLASS

New Optical Glass Omits the Familiar Silica

A RADICALLY new type of optical glass whose unique light-bending properties will make superior lenses for seeing, taking pictures, and studying microbes, has been developed after ten years of research, according to Dr. E. D. Tillyer, research director of the American Optical Company.

The new glass is further revolutionary because it contains no sand as an ingredient. Omission of the sand is primarily responsible for the exceptional optical properties.

Tillyer (right) and Moulton—glass

By varying the composition, two glasses of the same type but having different properties have been discovered. Laboratory developments, they will not be available for some time to come.

Dr. Tillyer revealed that one of the new sandless glasses is made of several common, available chemicals—the first time this has been done successfully. These chemicals are boric acid, zinc oxide, and aluminum hydroxide or beryllium oxide.

The second sandless glass is made by substituting cadmium oxide for the zinc oxide. Dr. Tillyer disclosed that never before has the chemical element cadmium been used as a major ingredient in glass.

In comparison with previous glasses containing sand, the new ones have a much higher index of refraction, or light-bending power, and a lower dispersion, or separation of light into its different colored rays due to their different refractive capabilities.

Because of their composition, the new glasses compress the spectrum. As a result, there is relatively little difference in the light-bending power for light of different colors, and color effects, often noticeable in previous glasses containing sand and lead, are eliminated.

Other properties of the new glasses include low melting point, freedom from color, and stability to weathering and corrosion. The new compositions produce beautiful sparkling glasses which are resistant to chemical attack and almost good enough to be cut into gems.

A basic study in glass technology, the new stabilized glass containing the zinc oxide was developed by Dr. Tillyer, H. R. Moulton, and T. M. Gunn, and the one with the cadium oxide was invented by Mr. Moulton. These glasses will be used in lenses for spectacles, comeras, and scientific instruments.

BALL POWDER

Smokeless Propellant Now Made Under Water

AXIS soldiers won't ask for a second helping of the "black caviar" now in quantity production at a famous ammunition plant in Illinois. The "caviar" is ball powder, a smokeless gunpowder in the shape of minute spherical pellets made by a new process five times faster than those formerly used, according to an announcement by John M. Olin of the Western Cartridge Company.

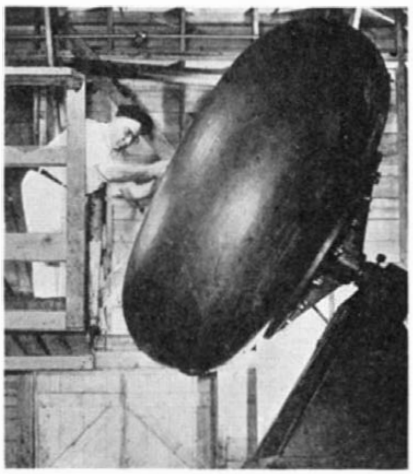
Ball powder, Mr. Olin points out, is manufactured chemically under water by a patented technique which reduces to a minimum the hazard in the making of smokeless powder. Although experimental lots of ball powder were manufactured by the Western Cartridge Company several years ago, its existence has been one of the ammunition industry's most closely guarded trade secrets. Unknown to them, many American peacetime shooters have been using ball powder in Western shot shells and other ammunition for some time past.

When America began its rearmament program, Western Cartridge immediately offered its ball powder patents to the War Department, which authorized the Company to use the new process in all ammunition for which it is suitable. Since then, ammunition loaded with ball powder has been widely used by the Allied troops.

Where the manufacture of ordinary smokeless powder requires fifteen days, ball powder is being produced in quantity in only three days. Where other powder is handled dry in large quantities, ball powder is manufactured in ten times its bulk in water, and when it is finished, is handled dry in small quantities only a fraction of the usual time.

The base of smokeless powder is nitrocellulose, which is made by soaking cotton or wood fibers in nitric and sulfuric acids. Until the invention of ball powder, smokeless powder was handled dry during many of its manufacturing processes, and was reduced to pellets mechanically, by forcing the nitrocellulose "dough" through a "macaroni" machine and chopping the strands into grains of the desired sizes.

In the manufacture of ball powder, nitrocellulose is produced in the conventional way. While immersed in ten times its bulk in water, the nitrocellulose is reduced to a pure liquid form by various chemicals, including ethyl acetate, a substance used in women's nail polish.



Coating ball powder for easy flow

By stirring the mixture, the nitrocellulose lacquer acts in water very much as olive oil does in vinegar, and forms into globules—the tiny ball powder pellets. Other chemicals are added to the mixture to prevent the balls from reuniting with each other when the stirring is stopped. By controlling the speed of stirring, the powder balls can be made in a great variety of sizes suitable for a wide range of ammunition sizes.

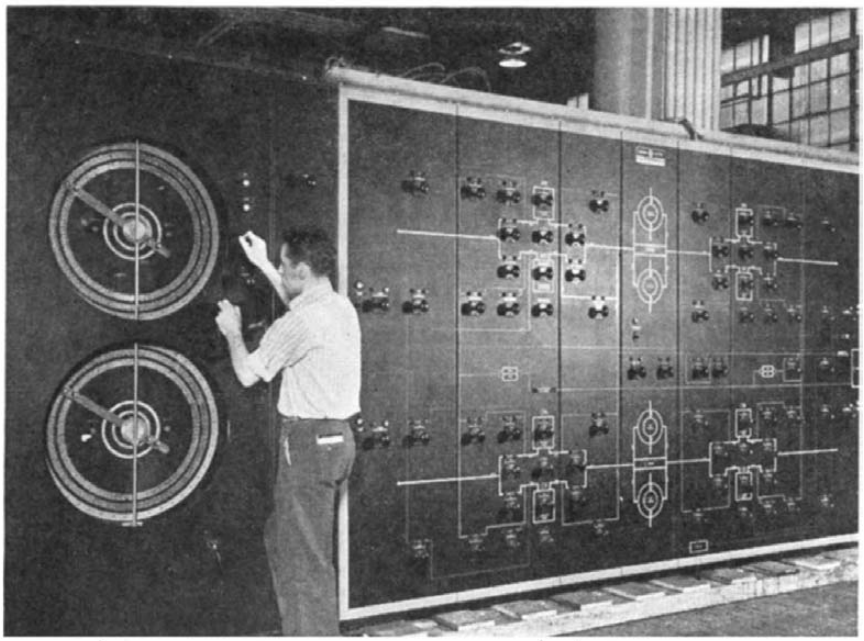
"ROBOT" CONTROL

Opens and Closes Valves Quickly, Automatically

A "ROBOT" which opens and closes dozens of valves with split-second timing now controls processing in many of the nation's plants producing aviation gasoline, butadiene for synthetic rubber, and toluene for explosives, according to B. M. Mills, of the petroleum and chemical section of General Electric's industrial engineering department.

In such plants steam, air, and hot gases flow intermittently through a complex system of piping and tanks. These gases must follow each other at predetermined intervals, and any error in timing or route of flow would slow up production not only through loss of materials but through possible damage to equipment.

The "robot" control performs the same functions in some parts of gasoline, butadiene, and toluene plants as dispatchers and switchmen do in a railroad system. In many of these plants, even if the required numbers of skilled operators were



Testing the operator's section of a typical industrial "robot" control

available, it would be humanly impossible for them to open and close the numerous valves with the precise timing provided by the "robot" control, consisting of automatic cycle-timers and valve control.

The "robot" controls the flow with machine-like precision, minimizing the possibility of human error. If something goes wrong, such as a valve sticking open or shut, the control even voices a warning —it summons an operator by blowing a horn, or ringing a bell.

Before the war this type of equipment was developed principally to produce high-octane gasoline for planes and cars. Because the same methods may be used in producing butadiene and toluene, the robot is now widely used in these two types of plants as well. Plans for extension to other types of plants requiring precise timing or valve control are under way

READERS desiring further information on new products, or research and development work reported in these pages, will be referred to manufacturers or additional sources upon request. Address our Research Department, giving specific references, incluing date of issue and page number.— ***The Editor.***

CHEMURGIC RUBBER
Can Be Used Alone
Or As Extender

A NEW type chemurgic rubber, developed from vegetable oils, is already being used by rubber-goods manufacturers for many essential applications.

This rubberlike material, called Witcogum, is comparable to rubber in many of its properties and requires neither critical materials nor critical equipment for its manufacture. Standard rubber mills and mixers do its milling and mixing. Calendering, extrusion, and vulcanizing are similar to that of rubber.

Witcogum contains an accelerator of the guanidine type and sufficient sulfur to give a cure in 30 minutes at 40 pounds steam pressure (287 degrees, Fahrenheit). Furthermore, all the necessary vulcanizing ingredients are already in the chemurgic rubber.

Used independently or as an extender blended with natural rubber, reclaim, or synthetic rubber, the proper compounding of Witcogum with such pigments as carbon black or clay or a combination of both will result in higher tensile strength. Tests have proved that tensile as high as 450 pounds per square inch, elongation as high as 150 percent, and tear of 45-50 pounds per inch can be obtained.

Water, alcohol, and lubricating oils have no apparent effect on this newest synthetic rubber, nor do antioxidants upon accelerated aging tests. Generally speaking, its reactions to solvents and chemicals are similar to that of rubber.

Manufacturers have found many uses for Witcogum, thus alleviating the pressure on the small reserve of natural, reclaimed, and synthetic rubber. It is going into hose and tubing, wire insulation and gaskets, shims, brake linings and foot comfort pads, hospital sheeting, jar rings, and extruded channels, to mention only a few of its applications.

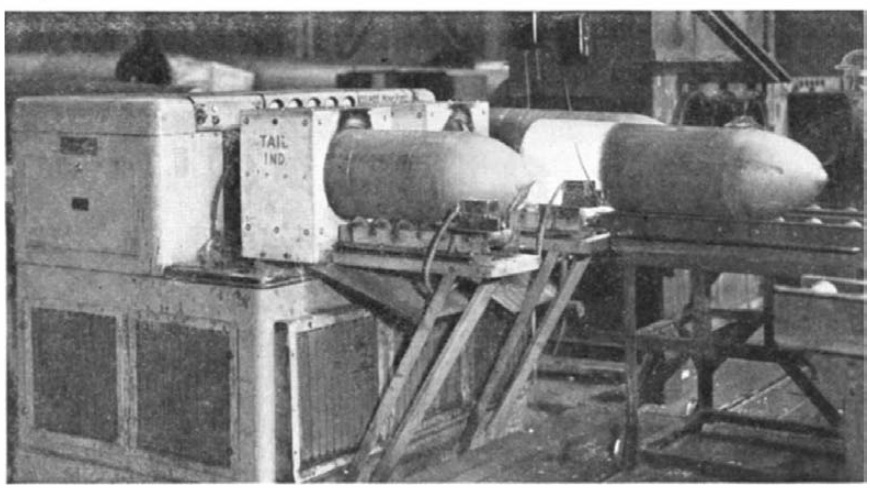
BOMB CASINGS
Made Faster With
Induction Heating

COMBINATION of an automatically controlled spinner and induction heating now is enabling the Wheeling Steel Corporation to shape large one-piece 250 and 500 pound high-explosive bomb casings in just two operations. This is in contrast to other methods which require upwards of ten steps with reheats before the final shape of the bomb is achieved.

In a battery of 200 kilowatt, 3000 cycle induction machines equipped with inductors designed for this vital ordnance work by The Ohio Crankshaft Company, the casings that have been cut from heavy steel pipe are heated first for the shaping of the nose and then for the tail. Spinning follows each heating. Elapsed time for these two operations on the 500 pound bomb does not exceed 14 minutes, while the smaller bomb is finished considerably faster.

Automatic control of the spinning has proved highly successful in speeding the shaping process, and induction heat has been a large factor in achieving this result. Because the Tocco machines could be placed close to the spinners it was possible to establish production-line procedure. Casings are manually withdrawn from the large multiturn inductor coils onto a roller conveyor which slides the heated pipe to the spinner.

After nosing, the casing is lifted to a gravity conveyor, down which it passes to the next unit for tailing operations. En route the pipe goes through a cooling compartment. Then the tail is heated and spun into a truncated cone with open end—and a new bomb case is ready for the next operation. Because high heat is confined to the specified area on the pipe, casings can be handled by operators from inductor to spinner without tongs. Inductor coils are water cooled and have a diameter sufficient to give ½-inch clearance between metal and coil.



Bomb casings being induction heated prior to tail spinning

INDUSTRIAL TRENDS

LET THE LABORATORY DECIDE

In all fields of industrial endeavor there are today, more than ever before, demands for new ideas, new ways of doing things, new materials for new and old uses. All too often, however, these ideas die aborning, killed by the very thing that should warrant investigation—their apparent "wildness." No manufacturer can afford to throw overboard any idea that pertains directly to his business without a thorough investigation. Only after an idea has been subjected to the acid test of laboratory or other expert examination can it be branded as good or bad. And even experts must occasionally be cautioned not to jump at conclusions.

Often the trend of an industry will be directly influenced by an idea that, on the surface, appears to be too hare-brained to merit consideration. Laboratory investigation, in such cases, will save the day, bringing out unforeseen facts and eliminating the "bugs" that stand in the way of success. Thus, industries that depend on new ideas for successful operation in war or peace—and what industry does not fall in this category?—will do well to let the laboratory have the final word, rather than to depend on intuition or some other unreliable "sixth sense" for final decision on new ideas.

PLYWOOD PLUS

A METAL-LINED plywood box for smokeless powder that is airtight and water proof, strong yet light and inexpensive, points the way to a new chapter in the intriguing story of plywood developments. Outstanding factor that made possible this box is a synthetic glue for bonding metal and plywood into a unit that resists action of water and temperature changes. From this development may well come such things as kitchen sinks and bath-tubs, industrial containers of many kinds, vats and tanks, made of a plywood base to which is cemented, in a never-to-be-parted bond, a lining of thin, light sheet metal of a type adapted to the use desired.

MANAGEMENT'S RESPONSIBILITY

ENCOURAGEMENT of better co-operation between employer and employee is a trend of the present, despite strikes and labor troubles that dot the daily papers. Through such co-operation management learns much, can profit if it will only take heed of the obvious.

When one large organization, as part of its co-operative operations, recently polled its employees in an effort to get a better understanding of what the employees were thinking about, they found, significantly, that the question uppermost in the employees' minds was: "Will I have a job when the war is over?"

Here is provided a basis on which to build better employee morale, to solidify worker-management good-will. Other companies would find equally interesting facts upon investigation, facts that could be readily applied to influence trends.

TURBINES FOR TRANSPORTATION

DREAM of engineers for many a decade has been the elimination of reciprocating parts in prime movers. In locomotives and gasoline propelled vehicles, for example, these parts transmit power from the source to the wheels, but, because they reciprocate, they wear more rapidly and have a greater tendency to vibrate than do smoothly rotating parts. Thus it is not unlikely that the turbine, now available in refined form and being even more perfected by the requirements of certain war-time developments, will find its place in the transportation scheme of the future.

The turbine—an excellent example is found in the turbine-driven supercharger used on airplanes—derives its power from the continuous expansion of gas which is utilized to produce rotary motion directly. Turbine locomotives have been built experimentally in the past; another type is approaching the manufacturing stage now and may point the way toward new power for railroads. Not unlikely, also, is development of the turbine for powering aircraft and surface vehicles, as well as a great expansion of turbine use on the oceans of the world.

TOOLS THAT MAKE TOOLS

EARLY in World War II the cry was for machine tools—more and more of them. So well was this demand met that, it is reported, machine-tool builders have anticipated at least ten years of their post-war markets. By doing so, however, they have learned many things about tool design and manufacture: So much, in fact, that the machine tools of tomorrow will be far more productive than the tools of yesterday and today. Through such improvements the machine-tool manufacturers will make possible better consumer goods, while at the same time recapturing markets that they have worked themselves out of by reason of manufacturing speed-up.

X-RAYS FOR INSPECTION

STANDARD method of inspecting many products has been, for years, the process of testing to destruction. Slow, laborious, costly, this method is, at best, not too reliable. The X-ray, however, offers a means of inspecting products ranging from rubber heels and smaller to motor-block castings and larger, and doing its job without in the least influencing or affecting the part being inspected. Not only that, but the X-ray, as now developed, can be placed right in a production line and used with a rapidity which equals that of the line itself.

Bulk of equipment was long a deterrent to the use of the X-ray in industry. Now, however, due largely to new means of insulating the power supply and to refinements in the design of the X-ray tubes themselves, the size of the necessary machinery has been reduced to a small fraction of the former requirements. Such X-ray generators are doing excellent work on war production lines. They will do even more for all industry when restrictions are lifted and they can be made in quantities.

LIGNIN LOOKS LIKELY

LIGNIN, that part of wood which is left after the cellulose has been extracted, is a chemically stubborn stuff that is rather difficult to deal with. Despite this somewhat discouraging definition, however, lignin holds promise of a bright future that may be second only to that other glamorous child of the chemist—dirty, smelly coal tar.

Combined with certain organic acids, lignin is now becoming the base of a number of compounds having a wide range of properties. Some of these compounds are hard solids, others are firm waxes, and they have an equally varying range of solubilities and melting points. Already these lignin compounds are being tested by the plastic industry, by paint manufacturers, and for possible use in the making of inks.

One good thing about lignin is its, at present, almost unlimited supply. Here is real meat for the chemical industry to sink its teeth into.

—*A. P. Peck*

[*References to sources from which additional information may be gleaned on any of the subjects reported or predicted on this page will be gladly furnished on request to the author, addressed in care of Scientific American.*]

Galactic Gas Clouds

A Complex System of Enormous Rarefied Clouds of Gas Moving at High Velocity Has Been Discovered

HENRY NORRIS RUSSELL, Ph.D.

Head of the Department of Astronomy and Director of the Observatory at Princeton University. Research Associate at the Mount Wilson Observatory of the Carnegie Institution of Washington

IT HAS been known for a good while that there are a few lines in the spectra of the stars which are not produced, like the rest, by absorption in the atmospheres of the stars themselves, but arise from absorption of light by the atoms of an exceedingly tenuous gas which occupies interstellar space. These lines can usually be distinguished at a glance by their extreme sharpness and narrowness. In the relatively dense atmosphere of a star, even though it may be only a ten-thousandth part as dense as ordinary air, there are various physical causes at work which tend to widen the spectral lines. But in interstellar space, the atoms and molecules are so far apart that they are substantially undisturbed, and the inherent sharpness of these lines is more nearly (though not completely) exhibited.

Though this peculiarity helps to identify these lines, it makes it hard to observe them. Every spectroscope (like any other optical instrument) has a limited resolving power. The very properties of light waves compel the image of a sharp line to be a streak of perceptible width, fading off gradually at the edges, so that a close pair of lines can be resolved only with a powerful instrument. One might suppose, however, that this limitation would not hinder the observation of an isolated line. This is very nearly true for a bright line on a dark background. No light is lost (and of course none gained) by widening it into a streak; and, if the background is practically black, it can be seen or photographed about as well as ever.

But a narrow dark line on a bright background is quite another affair. Not only is it smeared out into a streak, but the light from each side of it is—so to speak—smeared into this streak, so that it loses contrast. With a narrow enough line, or a wide enough smearing, the remaining contrast is imperceptible, and nothing can be detected.

The stronger interstellar lines are observable with spectrographs of moderate power; but the faintest, such as those of iron, recently discovered, can be brought out only with the highest available resolving power. They can be observed, too, only in very distant stars whose light has had to traverse the interstellar gas for a thousand light-years or more. For obvious reasons, such stars do not look very bright. Hence, to get good photographs even with long exposures, the great spectroscope must be fed by a correspondingly great telescope.

Much the most powerful combination in existence is composed of the 100-inch telescope at Mount Wilson, well known to everyone, and an equally notable spectrograph which is not so familiar to the general reader. In this instrument the spectrum is produced by a diffraction grating, and focused by a concave mirror 114 inches (almost ten feet) in focal length. This mirror performs a double duty. It converts the divergent beam of light from the slit into a parallel beam falling on the grating (which works properly only for parallel light). The grating sends back parallel beams of light of different wavelengths in different directions. These fall on the same mirror, and are brought by it each to its own sharp focus on the plate. The principle of operation is very similar to that of the Schmidt camera; but the beam of light of any particular color is so narrow that the mirror alone gives a practically perfect focus, and no correcting plate is needed. The spectrograph, like the telescope, operates wholly by reflection. It is perfectly achromatic, so that the whole spectrum (from the infra-red to the ultra-violet) is in focus at once. Moreover, the light of the star reaches the plate without having to pass through any glass at all; hence the ultra-violet light is not weakened.

With this equipment, Dr. Adams has obtained hundreds of spectra of various stars, showing interstellar lines. The results, which he reported at the Astrophysical Congress in Mexico last year and has now published, are remarkable.

Dr. C. S. Beals, of the Dominion Astrophysical Observatory at Victoria, discovered seven years ago that, in a few stars, the interstellar H and K lines of calcium were close doubles. To follow up this discovery demanded greater resolving power than was then available. With the equipment just described Adams has found that in about 80 percent of the stars which he has observed these lines are complex—double or triple, and occasionally quadruple.

Typical examples are shown in the illustration (from Adams' paper). The K line is shown on the left, and the H line on the right, exhibiting practically identical patterns, which prove the reality of the phenomena. The uppermost star shows a fairly wide pair; the next a triple, with the middle component faint; the third, a close pair; the fourth, a strong line and two faint companions; the fifth shows four components on the original plates, the strongest of which run together in the cut. The wide fuzzy lines are produced in the stars' atmospheres.

There is only one explanation known to physics for such shifts of these sharp lines—namely, motion of the absorbing atoms in the line of sight. Between us and one of these stars there must be, not a continuous thin stratum of gas, but two, three, or four separate clouds of gas at different distances, each changing its distance from us at a different rate, and doubtless moving at a different speed and in a different direction in space. The sharpness of the lines suggests that most of the calcium atoms between us and the stars belong to these separate clouds, with relatively few in the empty spaces between.

The velocities of the clouds are sometimes surprisingly high. The two faint components in the lowest spectrum have shifts corresponding to velocities of 41 and 60 kilometers per second—relative to the general average of the stars near the Sun, after allowance for the solar motion. (This is a sixth magnitude star in Cygnus, No. 199478 in the Henry Draper Catalogue.)

One might expect that stars near together in the sky would be behind the same clouds, and show the same line pattern, and this often happens; for example, the stars μ and 15 Sagittarii, which are less than half a degree apart, both reveal three clouds, with volocities of 4, 22, and 40 kilometers per second (λ Sag is shown in the next line to the bottom in the illustration.) Many other examples of clouds with smaller velocities are evident in Adams' list.

In certain regions of the sky, such as Perseus and Scorpius, the lines are usually single, indicating the presence of but one cloud, while in Orion, Sagittarius, and Cygnus they are usually complex.

Fainter interstellar lines of other origin have been observed in many of these stars. By measuring their exact positions, and deriving the radial velocities, Adams finds that the atoms or molecules which produce these are usually moving with the cloud which produces the strongest calcium lines. In one star, χ Aurigae (third from the top in the illustration) which shows two calcium lines of nearly equal strength, neutral calcium, cyanogen, and neutral CH appear to belong to one cloud, and ionized CH to be present in both. This, by itself, is hardly evidence enough for differences of composition between different clouds; but Adams has obtained additional evidence that cannot be doubted. For example, the hydrocarbon lines are strong in some stars in which those of calcium are relatively weak, and absent in others where the latter are very strong.

The most recent observations with the great spectrograph include eight stars of the Pleiades. The distance of this compact cluster is known to be not far from 500 light-years. This is small from the

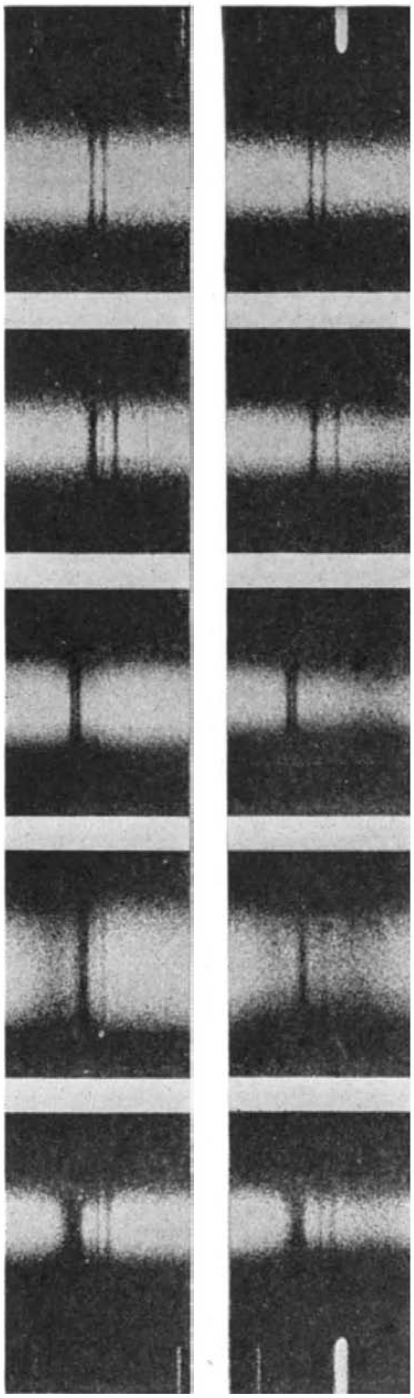
present standpoint, and the interstellar lines are faint; but the powerful instrument has revealed them in eight of the nine brightest stars of the group. The stellar lines in these spectra are very wide; the interstellar lines, in Adams' phrase, "are somewhat broad and may be complex," though separate components cannot be seen. The velocity of the interstellar cloud (or the average, if it is really complex) is 16 km/sec, receding, and nearly the same in all cases. This differs by 10 km/sec from that of the stars in the cluster, proving that the cloud has no connection with them.

So far, it looks as if we had to deal with a single cloud; but, if so, its composition is not uniform. Lines of the ionized calcium atom and the ionized hydrocarbon molecule (CH+) have been observed; but three of the stars show only calcium, two hydrocarbon, and three both together. As all the lines are faint this should not be taken to mean that one component or the other is entirely absent from parts of the cloud. But the relative proportions must at least be decidedly different—and this within a region of the sky only about two degrees square! This cloud beyond doubt is very patchy.

For one star in the Pleiades, Pleione, the interstellar lines cannot be observed for the reason that, a few years ago, its spectrum underwent a remarkable change. Previously, like the rest, it had shown broad hazy lines. While this spectrum persisted, an additional set of strong and much sharper lines, of hydrogen and ionized metals, appeared and still persists. The sharpness of these lines shows that they are produced in a region of much lower density than the original atmosphere; yet many lines, such as the hydrogen series, are present which we know would not be absorbed in a gas so exceedingly rarefied as are the interstellar clouds. To make a long story short, it is generally believed, on good and detailed evidence, that these lines are absorbed in a gaseous envelope a few times larger in diameter than the star itself, which was, in some way not yet fully understood, expelled from it. In Merrill's apt phrase, they are *circumstellar* lines produced close around the star, but not at its surface. The calcium lines are present in this spectrum and strong enough to swamp the interstellar lines completely.

Adams' important observations show that the interstellar gas is a far more complicated affair than was at first supposed, and is a complex system of individual clouds, rather than a roughly homogeneous medium. This ought to surprise no one, for the interstellar obscuring clouds (probably composed of fine dust) which stand out as dark markings in front of the Milky Way are exceedingly irregular both in outline and density.

In principle, one might hope that by spectral observations, upon enough stars, well scattered over the sky, the forms and limits of these gaseous clouds, as well as their motion, might be mapped. But in practice this would be exceedingly difficult. Only stars visible to the naked eye are bright enough to be observed for this purpose, even with the 100-inch telescope,



Courtesy "The Astrophysical Journal"
Complex lines (see the text)

and only the hotter stars, whose spectra are free from strong lines at the critical positions, furnish suitable backgrounds for observing the interstellar lines. The whole number of stars in the sky which satisfy both conditions is small, and they are too sparsely scattered in the heavens to permit a detailed mapping of the clouds. It is not yet certain what connection, if any, there is between the dust-clouds and gas-clouds; this is a problem for the future.

One cannot quite resist the temptation to speculate a little about these gas-clouds in space. They must be of enormous size —dozens of light-years in thickness—and are certainly of exceedingly low density.

How they got there is useless to ask, when we are still in perfect ignorance how anything else "got there"—for example, why the Galaxy and the spiral nebulae are in rotation. But there is some sense in inquiring: How can they continue to be there?—that is, as the fairly definite clouds of gas which they appear to be?

The diameters of such clouds must be relatively large in comparison to the distances between them—probably several percent of the latter. It follows that, in random motions through space, two clouds will sometimes collide. Since each of these contains enormously fewer molecules per cubic inch than the best vacuum which can be produced in the laboratory, this seems like talking about a collision between one vacuum and another.

But the word is significant, just the same. We may regard each cloud as a swarm of widely scattered molecules, pursuing practically parallel courses at substantially the same speed. When the outer boundaries of the clouds intersect, the molecules of each will proceed into the empty spaces between those of the other. So long as no collision between those of the two clouds take place, each will pass freely through the other. But each collision will send the molecules involved bouncing off in quite different directions, so that they are lost to the clouds. The fate of the clouds depends, then, upon the mean free path which a molecule is likely to travel before it collides. If this is large, compared with the sizes of the clouds, the two will pass through one another almost unaffected, and come out on the other side, leaving a small proportion of stray molecules behind dispersed by collisions. But if the size of the cloud is large, compared with the mean free path, practically all the molecules will be diverted; they will make further collisions with one another and the two clouds will be merged into one, with molecules flying so fast in all directions that they will dissipate into space and form part of the general interstellar gas.

The relative number of atoms of neutral and ionized calcium in some of these clouds can be found from the intensities of their lines, and hence the number of electrons. It appears from this that, in interstellar space, there is something like one molecule per cubic centimeter. The theory of gases shows that for this density the mean free path of a molecule should be about 100 times the Earth's distance from the Sun.

This is only 1/600 light-year. For a density 1000 times less, the free path would be 1000 times greater, but even this very low density would not permit two clouds to pass through one another; they would be inextricably mingled.

The question how so many separate clouds of gas can have continued to wander about within the Galaxy without becoming dissipated is, therefore, no easy one. The discovery of the clouds is so recent that there has not been time for mathematicians to attack the problem—much less to publish their results. In due time much more will doubtless be known about this fascinating question.—*Manitou Springs, Colorado, May 19, 1943.*

Science Enters The Woods

Research Shows that Good Forestry Practice Can Provide a Permanent Pulp and Paper Supply

C. E. RANDALL
United States Department of Agriculture, Forest Service

We aren't shooting any paper bullets at the enemy these days: We want the bullets we mark for Hitler's and Hirohito's minions made of sterner stuff. Nevertheless, we'd be hard put to fight this war without pulp and paper. A lot of paper work is back of every military action and every war production job. It takes many reams of paper for the necessary blue-prints or maps, specifications, and orders. From the same source —pulp—comes cellulose for textiles, photographic film, medical supplies, plastics, and filters for gas masks. More than two million cords of pulpwood will be needed this year for shipping containers to get supplies to our fighting men overseas. Then, too, the dissemination of war news and other important and vital information in newspapers and magazines can continue only so long as a supply of paper keeps coming along.

It is estimated that no less than 14 million cords of rough wood will satisfy 1943 pulp and paper requirements. And that is only a part of the wartime demand on the forests. Wood is a critical war material; wood is wanted for ships, planes, gunstocks, docks, cantonments, factories, railroad ties and telephone poles, ammunition boxes, and hundreds of other war needs.

In the past, it was considered practically axiomatic that the woodyard of the United States was limitless. On that presumption, axes and saws ravaged forests from one end of the country to the other. Today, large areas of former forest land are no longer productive. It doesn't take an expert to figure out that if you continue to cut off timber without adequate provision for new growth, some day the wood supply will run short.

Scientific woods management, say foresters, is the Aladdin's lamp which will lead to continuous supplies of pulp and paper. Unlike minerals, timber is a renewable resource, and forest lands can be managed to insure continuous crops.

Spruce, which is peculiarly suited for newsprint papers, has long been the dominant pulp timber species. Relatively pure stands of spruce in the Northeast, near large markets and cheap water power, influenced early establishment of mills there. However, as a result of technical developments, many other species are now going into pulp and paper. Jack pine, hemlock, aspen, and other species feed numerous mills in the Lake States. The ability to use western hemlock opened the way to extensive development of the pulp and paper industry on the Pacific Coast. In recent years new plants of huge capacity have sprung up in the pine regions of the South. However, neither cheap power, nearness to markets, nor the industrial genius and push of men behind the industry will be able to maintain it indefinitely unless attention is given the growing of raw material.

How to perpetuate the valuable pulpwood species and increase the timber growth on pulpwood lands are problems of vital concern. Research indicates that in most cases the productivity of pulpwood lands can be increased considerably. Any effort in this direction necessitates intelligent forest management based on scientific forestry.

The techniques vary greatly with different regions and timber types. In the Northeast, extensive pulpwood operations have frequently led to over-cutting of softwoods, resulting in a deterioration of the spruce-fir types, often with low-value hardwoods coming in to dominate the stands. The major problem usually centers around development of practical cutting methods that will guarantee continuance of advance reproduction, and cultural measures designed to protect and develop existing stands of reproduction to full timber crops at maturity.

Prior to actual cutting, it is important that the pulpwood producer classify his lands on the basis of kind, size, and density of the advance reproduction, bearing in mind that much effort may be wasted in attempting to maintain softwoods on sites distinctly favorable for the production of hardwoods. With stands properly classified, the progressive order in which areas are to be cut, based on their maturity and reproduction conditions, can be determined and adhered to insofar as market and logging conditions permit.

Because attaining an advance reproduction of young growth above two feet in height is a highly important factor in successful spruce management, logging may be so organized that cutting on any specific area can be regulated to permit seedlings to attain this height before the protective cover provided by the main stand of mature trees is removed.

Dependence on advance reproduction necessitates extra care in logging to reduce damage to a minimum. Large numbers of thrifty young spruce and fir may be destroyed needlessly on every acre by careless timber fellers. Studies indicate that this damage often ranges from 20 to 40 percent. This destruction, particularly marked in the two- to five-foot height classes of spruce and fir, is unfortunate since it is this height class that responds more vigorously when it is "released" by removal of the older timber and possesses the best prospects of winning out against the fast-growing hardwoods and attaining a permanent position in the new stand.

When adequate reproduction is lacking, foresters recommend removal of one third to one half of the stand so as to open it uniformly and permit the establishment of additional reproduction under shelter of the remaining trees. Ten to fifteen years later, if conditions are normal, sufficient reproduction will have come in, and the remainder of the old stand may be logged.

Southern yellow pines have come into rapidly increasing use since the introduction of the sulfate pulp industry in 1908. The sulfate or kraft process is particularly adapted to the pulping of resinous or pitchy woods.

Farmers produce quite a bit of the pulpwood consumed by pulp mills in the United States—in the South, the figure is as high as 55 percent. Clear-cutting to supply the timber and pulpwood markets,

Although 16 cords per acre were removed from this southern pine forest, 57 percent of the volume of wood was left standing under scientific cutting

particularly on farm woodlands, and recurring fires have, however, made serious inroads on the productive capacity of forest lands in many areas in the South.

Fortunately, old Mother Nature is a persistent forester. In the South, if fire is kept out, Nature will in time usually provide a new stand of trees. Nature works a lot faster, however, if man co-operates, and foresters are therefore continually working to bring science to the "piney woods." Under most conditions, selective cutting is the recommended practice in the South. The larger trees may be removed from a thrifty stand, and another cut will be ready before many years. Selective cutting thus maintains a continuous growing stock, and it provides frequent cuttings and larger returns over a term of years than clear cutting which removes all salable timber.

In harvesting timber crops, pulpwood may be taken out along with poles and sawlogs, yielding several timber products in one operation. In young stands, thinning and improvement cuttings may be used to improve growing conditions and at the same time yield substantial quantities of pulpwood. The important thing is that enough trees be left to maintain a satisfactory rate of growth to the acre.

The advent of new pulp and paper mills in the South increased the danger of too heavy cutting in many woodlands. In the vicinity of some of the older mills the farm woods have been virtually wiped out because of unrestricted cutting in the wake of timber contractors' activities. The region surrounding Monroe, Louisiana, and parts of southern Alabama and western Florida bear notable witness to such devastation.

Often a woodland owner has not known a better way than the traditional one of clear cutting everything merchantable. The idea of regulating cutting for sustained yield from woodlands, with resultant continuous cash returns, is still foreign to many.

A few years ago, for example, farmers in a certain Texas county sold their timber rights to a professional buyer of wood for a Louisiana pulp mill 150 miles away. The buyer made a bargain to cut everything on the farmers' woodlands by paying the almost unbelievably low price of three dollars an acre, and the contracts gave him the right to remove the timber over a period of years. Much of the land had stands ranging from 10 to 20 cords or more to the acre, growing at the rate of about half a cord or so to the acre every year. The farmers got a stumpage price of only 10 to 30 cents a cord, and in addition they continued to pay taxes on the land.

Upper left: **Piling spruce pulpwood. Supervised cutting here assures sustained yield.** *Center:* **Spruce pulpwood, cut into 50-inch sticks, in the harbor at Grand Marais, Minnesota.** *Below:* **A paper company's pulp yard containing 250,000 cords of wood**

Pulp mills in the South have recognized the danger to their industry and the welfare of the community from the common practice of overcutting woodlands, and accordingly are taking steps to encourage adherence to certain forestry standards in cutting timber for pulpwood.

Scientific forestry, however, is still the exception rather than the rule on privately owned lands, not only in the South, but in all forest regions. And from privately owned lands come 90 to 95 percent of the nation's total wood supplies.

Technical foresters don't yet know all the answers. Further research will be necessary to determine the most successful and economical measures for producing maximum timber crops on a sustained yield basis in various forest types and regions. However, it has progressed far enough to indicate the general requirements for keeping forest lands productive.

It takes almost twice as long to cut and peel 100 cubic feet of pulpwood from trees 5 to 8 inches in diameter as it does from trees 11 to 17 inches in diameter. Cutting undersized trees similarly wastes additional time in loading, unloading, and milling. Restricting cutting to trees of mature pulpwood size steps up production from 20 to 30 percent per man day. To tie up men and machinery cutting and processing immature timber is an inexcusable waste of manpower, equipment, and resources in these emergency days.

New developments in pulp and paper are being introduced all the time. Cellophane is an example of a pulp product whose widespread use expanded almost overnight. Wood plastics are growing in importance. A new laminated paper plastic developed by the United States Forest Products Laboratory shows promise for use in aircraft construction and for many peace-time purposes.

Foresters maintain that if scientific woods management practices are universally applied, the forests of America can be made to supply all our wood requirements and more, in perpetuity. An expanding pulp and paper industry backed by a permanent supply of raw materials could benefit social and economic security in the post-war years. It could provide substantial support for rural-industrial communities in several sections of the country; it could help to stabilize agriculture by affording many farmers a year-'round income; and it could help supply the people of this country with an abundance of the material things that make for a high standard of living.

Elmer Sperry and His Magic Top

How an Inspired Inventor with an Ancient Toy Altered the World of Marine and Aerial Navigation

FRANCIS SILL WICKWARE

ON A SUMMER day in Cleveland, 39 years ago, a slight, blue-eyed man named Elmer Ambrose Sperry bought a toy top and carried it home to his children. He spun it on the living room floor, and one of the children asked:—"Daddy, why does a top stand up when it spins?"

It was an old, old question. Mathematicians had written tomes about "gyroscopic inertia." But no one had ever found a way to utilize this strange physical force.

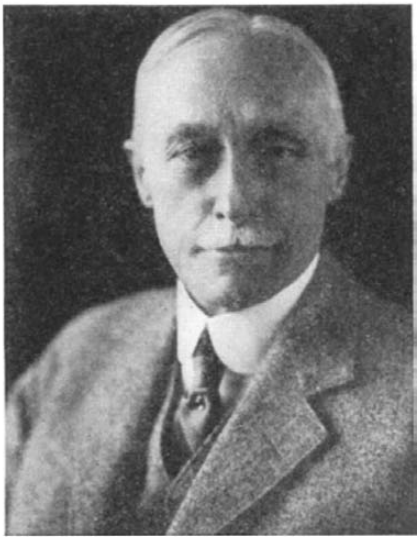
Sperry—then aged 44, and already famous as the inventor of an arc light, a new system of electric propulsion for trolley cars, and a long list of other things—pondered the top. It was his first step on the long road toward his invention of the gyro-compass that bears his name. This invention changed the world. The gyro-compass revolutionized marine navigation and, without it, long-range aviation as we know it could not exist. Transatlantic flights and 2000-mile hops between pin-point islands in the Pacific would be out of the question. Precision bombing would be impossible. For the gyroscope was the forerunner of the directional gyro (for direction keeping and for showing the amount of turns), the artificial horizon (which shows the pilot whether he is in level flight), and the turn and bank indicator (which shows the rate at which the plane is turning). Gyroscopes are an integral part of the Sperry and Norden bomb sights, while the Sperry automatic pilot—which automatically flies the heaviest plane through any kind of weather—is essential in determining the proper course during the crucial moments before the bombs are released.

But that day in Cleveland, Sperry foresaw none of these things. He was aware only that the child's question nagged him.

Sperry first waded through the technical literature then borrowed an electrically driven gyroscope from a scientific school. It was a simple instrument—a solid steel wheel on an axle, mounted within gimbal rings so that it could be turned in any direction. That is, it could be turned when the wheel was at rest. But when the motor spun the axle at 3000 revolutions per minute it became difficult to budge the wheel out of its plane of rotation. The frame could be turned in any direction—the wheel held steady. Sperry pointed the whirling axle toward the sun, and watched how it stubbornly held its direction. The spinning wheel *seemed* to turn over within its frame once every 24 hours. But actually it steadily pointed at the sun. The sun doesn't move, and neither did the spinning wheel. *The world revolved around the gyroscope.*

For months Elmer Sperry was obsessed with the spinning wheel. At such times he had to be reminded to eat, and invariably forgot to take any money with him when he went out of the house, with the result that he ran into embarrassing situations on street cars and in restaurants.

Sperry first proposed building a gyroscopic stabilizer to keep the top-heavy old-fashioned automobile on an even keel on the high-crowned roads of the day. This was not feasible. A little while later he took a trip to Europe. In a storm at sea he was thrown out of his berth and wrenched his knee. He was indignant—why should man be at the mercy of the ocean?—and immediately decided to do something about it. Couldn't the gyroscope be used to stabilize a ship and prevent it from rolling in rough weather? He believed it could. Might not a gyroscopic stabilizer improve naval gunnery by keeping ships steady during the firing?



Above: **Elmer Sperry—almost 400 patents.** ***Right:*** **Sperry's modest birthplace in Cincinnatus (population 800) in central New York State. He was a student at the Cornell University for two years**

The Navy showed cautious interest. After three years of tests and deliberations, Sperry built a full-sized stabilizer for the destroyer *Worden,* a notoriously unsteady craft. The stabilizer made the *Worden* ride like a canoe on a mill pond. But cost and weight of stabilizers were a drawback—and as a matter of practice the ship's roll is useful to naval gunners, who thereby get increased gun elevation and range.

However, Sperry gyro-stabilizers were installed in many large private yachts, and years later the Italian liner *Conte di Savoia* was fitted with three 80-ton gyros at a cost of over $1,000,000. There was so much publicity about this installation that the Italian company had to stop advertising it. People insisted on traveling on that one ship alone.

Steam had replaced sail long ago, and steel had driven the wooden ship from the seas. But nothing had been done to improve the compass, an ancient Chinese invention which never deserved its reputation for accuracy. For one thing, the needle did not point to true north but to "magnetic north," a broad, uncertain area in northern Canada. Steel hulls threw the compass needle off the beam. Steel superstructure also deflected it. Any metallic cargo added further uncertainty. In certain parts of the world—notably the Great Lakes—iron-ore deposits made the compass particularly wild. In submarines it was entirely useless. Often it took days to adjust compasses before a ship could sail.

Elmer Sperry felt sure that his gyroscope was the answer. Once fixed on true north it would stay fixed. It could be placed anywhere on the ship, and would not be distracted in the slightest by magnetic influences. The problem was to couple the spinning wheel to a compass card, and to mount it so that it would not be thrown off by the ship's motion, or by the terrific shock of a broadside fired in battle.

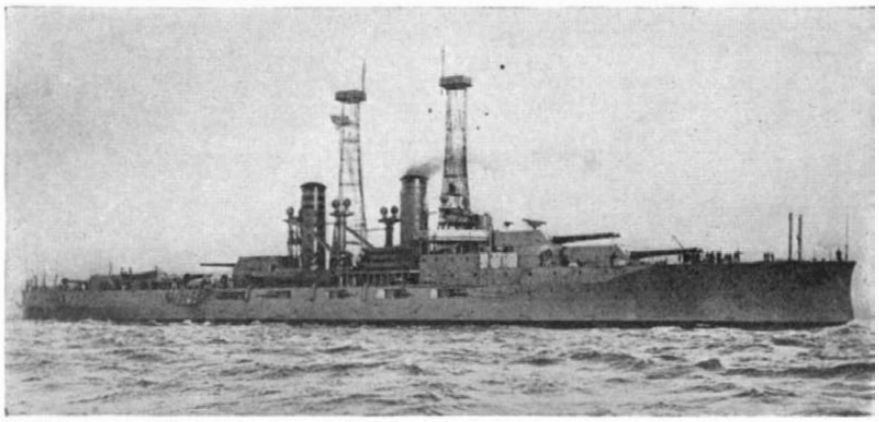
Sperry worked slowly, with great labor. Finally, in 1908, he triumphantly announced that he had perfected the gyro-compass—simple, sturdy, foolproof, and efficient.

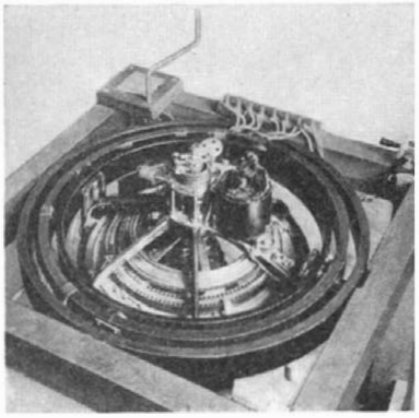
This news caused a great stir in the Navy. The gyro-compass was taken out for final trials in the *Delaware,* then our newest and finest battleship. The compass was set up in the base of the conning tower, with repeater compasses on the bridge, and the decisive test came when the *Delaware's* guns thundered a salvo that smashed lights and crockery and sent men reeling against the bulkhead.

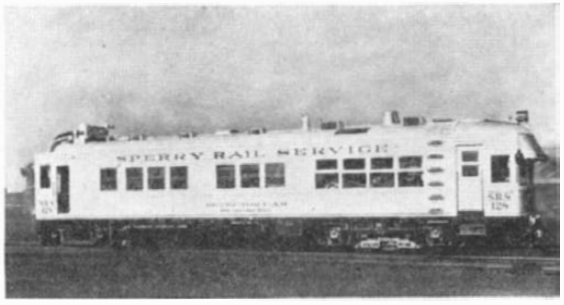
At this moment a ditty box which a sailor had carelessly stowed on a platform halfway up the conning tower came tumbling down and thudded squarely on the compass, scattering handkerchiefs, photographs, and assorted personal belongings among the outraged officials. Elmer Sperry just fainted. When he revived the compass still pointed serenely toward true north, and all was well. Reminiscing later about the compass tests, Sperry said: "On such occasions there comes over me a welling up from within, a sort of elation, and life takes on a new and exalted aspect. That is living!"

The Navy at once started equipping all ships with the gyro-compass, and orders arrived from the British, French, Russian, Italian, and Japanese navies. The last skeptics were convinced when a gyro-compass guided the British submarine E-11 through the nets, mine fields, and swirling currents of the Dardanelles to the harbor of Constantinople, where it destroyed much shipping.

Today all submarines depend absolutely on the gyro-compass, not only for underwater navigation but for accurate firing of torpedoes. The torpedoes themselves are steered by gyroscopes. Practically every first-class ocean-going vessel in the world carries the Sperry compass, despite its minimum cost of $6500. Originally our Victory ships were planned for magnetic compass operation, since there was a scarcity of gyro-compasses. But the demagnetization of the ship that is necessary to neutralize magnetic mines so affects the operation of the magnetic compass that we are now putting gyro-compasses on them.







Top: **The old *Delaware*, first naval vessel to be equipped (1911) with a Sperry gyro-compass.** ***Above:*** **The original compass as installed on the *Delaware*. Some of the parts were built by Sperry himself.** ***Left:*** **A modern Sperry detector car. Within are generators that deliver 4500-ampere currents to test rails**

Most modern merchant ships also are equipped with the Sperry Automatic Pilot, or "Metal Mike," which can steer a ship straight across the ocean with no human helmsman on the bridge. "Metal Mike" is so uncannily accurate that at first superstitious native pilots refused to stay on board with it. They thought the Devil was steering.

Two years ago, the Navy launched the submarine tender *U. S. S. Sperry,* honoring the inventor not only for his contribution to navigation, but for the way the gyroscope transformed naval gunnery. Gun-pointing used to be done visually. But now an officer in the foretop a hundred feet above the deck spots a target over the horizon, superimposes the bearing on a gyro-compass, has it transmitted instantly to all battle stations by repeater compasses, and thus enables gunners to hit distant objectives entirely out of sight. Unaffected by the ship's yawing, the gyro provides for accurate gun-pointing.

Sperry's place in aviation is just as important. Even before World War I, Sperry started adapting the gyro-stabilizer for use in airplanes, mainly to make the air safer for his son Lawrence Sperry, a determined pioneer flier. It was a bitter blow when Lawrence was drowned in the English Channel in 1923, after his plane was forced down by motor trouble. But this only made Sperry more eager to do for planes what he had accomplished for ships. Gradually the basic flight instruments were developed and perfected. Each instrument is a marvel of precision, beside which a watch is coarse and clumsy. The raw materials in the directional gyro are worth only a couple of dollars, but the fine work necessary brings the cost of the finished product to more than $300.

Of all the miracles of modern science, surely one of the greatest is a huge bomber or transport roaring through space at hundreds of miles per hour, buffeted by the winds, cut off from sight of earth by clouds or darkness, yet following a true course, with its every movement controlled automatically by tiny gyroscopes. Elmer Sperry made the miracle possible.

The gyroscope also has uses on land. For example, it is useful in oil-well drilling. Formerly, there was no way of controlling the direction of a drill thousands of feet underground. Bore holes wandered as much as half a mile off course, frequently ending up in territory belonging to someone else. There was no remedy for this until a special gyro developed by Sperry was harnessed as a subterranean direction-finder. Now bore holes can be drilled accurately to any depth.

The gyroscope created a great industry. The Sperry Gyroscope Company is today one of the biggest war plants in the New York area, and one of the most secret, closely guarded factories anywhere in the world. It is a technological wonderland behind closed doors, pouring forth —in addition to gyroscopic equipment— a staggering assortment of instruments which serve as the mechanical eyes, ears, and nerves of modern war. Without these instruments—mostly labeled "confidential"—we scarcely could control our own weapons.

The gyro-compass is not the only reason why engineers and scientists rank Sperry second only to Edison. When he died in 1930 he had nearly 400 patents in his own name, covering inventions which ranged all the way from electric coal-cutting machinery to a chemical process for extracting tin from scrap metal. One of his most important inventions was a searchlight which creates "the brightest continuous light ever made by man." Sperry built the first model for the Navy during the last war. It evolved into the 60-inch searchlight which now is standard equipment in all U. S. anti-aircraft batteries. The eight hundred million candlepower beam actually is as bright as sunlight. It can be seen 200 miles away, and it is easy to read a newspaper in its beam at a distance of several miles. A small model of the lamp is used in motion-picture projectors in thousands of theaters. Without it, clear projection would be impossible in large theaters like the Radio City Music Hall in New York City.

Everyone who rides a train is indebted to Sperry for a vital contribution to railroad safety. For years, one of the chief causes of wrecks was the unpredictable collapse of sections of rail. Rails that looked all right would suddenly give way under the weight of a train. All railroads had tried desperately to find means of detecting the hidden cracks, but without suc-

(*Please turn to page* 84)

The Culprit Is Histamine

A Substance Normally in Our Body Cells Makes Trouble When it Escapes into the Blood Stream

L. W. GIELLERUP

IT WAS one of the hottest days of the year in Rochester, Minnesota, yet at high noon a man limped into the famous Mayo Clinic wearing a heavy overcoat and spats. His ears were tucked under furry ear muffs, and, as it developed later, he was snugly swathed in heavy woolen underwear. The Mayo doctors found the bewrapped gentleman's complaint to be as odd as his dress. It was so simple—he just couldn't keep warm!

Within a year, thousands of miles away in London, England, a man was rescued from the wreckage wrought by a Luftwaffe bomb. Following routine treatment this victim was discharged. For a few days he seemed to be in perfectly normal health. Then he suddenly dropped dead.

These seemingly unrelated events had a curious association. The shivering patient in Rochester, Minnesota, and the air-raid victim in London, England, were brothers under the skin. They were related by blood, in the sense that their veins harbored the same mysterious substance which had brought chronic misery to one and sudden death to the other. They were victims of similar allergies.

These curious cases have played significant roles in one of the most striking medical developments of our times, a triumph of scientific deduction which may well have a vital meaning to countless sufferers from allergies to foods, pollen, ivy poisoning, and some leading types of chronic headaches. Common allergies are universal and costly menaces to human health and happiness. From Aunt Martha's "migraine" to the mysterious behavior of air-raid victims, the allergic keep many a physician playing hide-and-seek with the baffling symptoms inherent in these disorders. Often, these symptoms may resemble those common to a well-known complaint. Yet orthodox treatment fails to bring relief.

The most striking feature of common allergies is the wide divergence of the symptoms. Naturally, it was a real triumph when medical science discovered that the same substance which burdens some people with a lingering lifetime of allergic misery, may also cause the collapse and sudden death of persons suffering from serious shock. Here the culprit is histamine, a substance manufactured by the body itself. The real significance of histamine in common allergies is known only to a relatively small group of medical men. But the British discovery of histamine's lethal powers has stimulated world-wide interest in the subject. Here is how London physicians tracked down the killer.

Victims extricated from bomb-blast wreckage are hospitalized as "crush injuries," meaning that they have been under pressure. The skin of a "crush injury" may show only a few welts, a wheal or two. Usually there is a degree of nervous tension. After routine treatment patients may seem to be normal for a time, but without warning they may suddenly collapse and die. These cases are not to be confused with the well-known phenomenon of soldiers found dead on the battlefield without apparent cause. Here is the difference. The "crush injury" victim of air-raid wreckage suffers from the *secondary* effects of bombing—the debris and its insidious pressure. The seemingly related battlefield fatalities result from the *direct* impact upon the body of high-velocity sound waves. Modern shell-bursts cause serious internal disruptions of the human mechanism. Without creating a single surface wound the action of these waves contributes to shattering the lungs in a thousand places.

The wreckage-bound victim of an air-raid also reacts to pressure but the damage is close to the surface. Though the skin is whole, careful examination will reveal crushed muscle cells due to steady and powerful pressure on the confined parts. Whether the ordeal has lasted a few hours or more than a day, the duration of the "crush" bears no relation to the final outcome. At this point the cases became first-class medical mystery. Painstaking autopsies revealed nothing directly related to the fatal result of the "crush injury" until—well, medical science simply rolled up its mental sleeves and started remembering.

Way back in 1909 there had been experiments by Drs. Baylis and Cannon. The muscles of animals were confined, circulation blocked. When the pressure was removed and normal bloodflow released, shock followed and the animal died. Later, Sir Henry Dale, professor of pharmacology at the University of London, discovered that the "crushed" muscles of such animals contained a something called histamine. This substance was released into the bloodstream from the debris of the crushed muscle cells. Dale's deduction that this histamine substance caused the fatal shock is one of the accepted medical theories today. Well it might be. The same shock, observed in the experiments, was produced by injecting histamine into normal animals!

One notable thing about histamine is its potency. One one-millionth part in the bloodstream can cause intense physical distress. This seems to be true in the direct action of histamine, as in "crush injuries," and in the sensitivy to external substances, as in allergies. It was only natural for medical science to reason that if histamine can set the stage for the death of its sensitive host, what about the non-fatal damage of less though abnormal concentrations? The far-reaching implications of this question and their possible significance to millions of people, easily raises the subject of histamine research to the level of the vitamins and sulfa drugs.

The nature of histamine, how it operates in serious body disturbances, is extremely interesting. Histamine is a protein associated with the everyday food proteins beloved by nutritionists. You may recall that proteins share the spotlight with those other basics in foods, the carbohydrates—proteins the major constituents of meats, carbohydrates the rulers of the "starchy" foods. Histamine is normally in all living body cells, but it gets into the bloodstream when cells are injured. One accepted medical belief is that histamine is set free by destruction of tissue. The action of bacteria, too, can unleash this blight; even exposure of the body to light. Theoretically histamine can act like allergens, body substances which make some of us so sensitive to pollens, dust, poison ivy, and the circumstances producing hives. Allergens may also be connected with the more sinister phenomenon of shock.

To give the devil his due, histamine has its good side. Normally it is a stimulant to many muscles and glands. But when it is itself goaded, the substance inhibits the tiny blood vessels of histamine-sensitive people. These vessels, which regulate the blood supply, lose their function. This is a step toward shock. The removal of a simple tourniquet from an injured limb may bring on shock thought to be due to an increase of histamine in the bloodstream. This is histamine acting directly. The allergic action of histamine is often demonstrated in a homelier way by a condition called dermagraphia, or skin writing. Perhaps you have never met a human writing pad, but such people are not at all uncommon. When the flesh of these individuals is inscribed with a pointed object, the characters appear like magic in red welts. The reason is this: Even light pressure injures the tissue cells. Histamine is released, causing the welts, engorgements of the local blood vessels, wherever the pressure occurs.

It seems a long jump from the pressure of a pencil on the skin, to being buried alive in bomb-blast wreckage, or even to reactions caused by pollens, cold water, or poisonous plants. But, medically speaking, unfavorable reactions to these experiences may simply represent different levels of allergy. This demonstrates better than any funeral cortege that the real importance of histamine research is in its application to the many who may be sensitive to the substance in different but extremely vital degree.

Medical research is increasingly con-

cerned with the millions who suffer at some disturbing level from chronic ailments due to obscure causes such as allergies. Science is speeding important research on the relation of histamine to such mysteries as hay fever, migraine headaches, the common cold. The principal conclusion of science on this subject to date is that it takes histamine, or related substances, to fight a histamine susceptibility. The modern principle in the treatment of allergies mirrors the homeopathic doctor's ancient dream—to cure the disease with its cause. Doctors know that histamine susceptibles must be handled with elaborate caution. Desensitization to the substance must proceed from infinitely tiny doses through almost imperceptible increases. The physician must have the patience of Job to avoid an overdose and the resulting shock. To patients, the relief from the misery of histamine sensitivities is well worth the strain of the treatment. Take ivy-poisoning susceptibles, for example.

There is glad news for millions of such sufferers in a scientific report tucked away in America's leading medical journal. Dr. Joseph Moss, of Durham, North Carolina, theorized that allergy to poison ivy might in some way be related to histamine sensitivity. For a laboratory he chose a summer camp infested with poisonous ivy growths. Eight persons were used as subjects. All were known susceptibles to ivy poisoning. Four were given daily doses of a drug in the histamine family. The other four subjects served as "controls." All eight were exposed continuously to poison ivy for ten days. Result: None of the subjects who had taken the desensitizing drug developed ivy poisoning. Two of these four, who had been poisoned during the preceding summer, survived deliberate attempts to contract the ailment. Two of the four "controls" who went drugless contracted ivy-poisoning, "one rather extensively."

Later a group of 35 campers took the test. Nine who had been poisoned by ivy the summer before were given the drug for 25 days. The other 26 persons were "controls." One of the nine subjects dropped out. Result: Ivy-poisoning struck 13 of the 26 "controls." But only one of the eight taking the drug came down, and the attack was confined to a mere patch on the knee. Four of these subjects, all allergic to the weed, actually *rubbed* it on their skins!

Dramatic, too, is a feat of research by Dr. B. J. Horton, a Mayo clinic allergy expert. For intuitive and courageous procedure, Dr. Horton earns a medical palm. Recognizing that headache, a supposedly simple, everyday ill, causes tremendous physical misery and economic loss to millions of people, Dr. Horton has long applied his skill to the relief of this widespread ailment. His experience gives an excellent preview of what histamine therapy may mean to the world to come. Actually it is much easier for a physician to diagnose and remove an infected appendix than to pin down the causes of many types of chronic headache. During an extended clinic Dr. Horton catalogued many headache symptoms. From careful records he discerned definite patterns. One that recurred frequently was an excruciatingly painful condition centering in the victim's eye. Patients described it as the sensation of "a knife being driven through the head."

With the strange consistency of some human ailments, the attacks came with deadly regularity at the victim's bedtime. Sleep could be had only by sitting up in a chair. Most patients confessed to suicidal thoughts. Some had resorted to serious operations. Marshalling his knowledge of histamine, Dr. Horton decided to try an experiment. He injected the patients with pure histamine. Upon such intuitive decisions of physicians depends much of the world's good health. To Dr. Horton's own surprise the injections consistently produced attacks of the ailment. The conclusion was obvious. The sufferers were allergic to their own histamine, which, in mysterious concentration, struck savagely in the area of the eyes. Why the eyes? Dr. Horton does not know to this day. A series of desensitizing "vaccinations" with histamine relieved 76 of 78 serious cases.

Dr. Horton christened the disease "histaminic cephalgia." *The Journal of the American Medical Association* carried his statement that histamine is as specific in this ill as insulin is in diabetes!

Score another triumph for the belief that many allergies may stem from the individual's own histamine. Dr. Miles Atkinson, of New York City, reports on the histamine treatment of sufferers from "Ménière's syndrome," which, roughly speaking, is to the ears what migraine is to the head. Dr. Atkinson writes that injections of histamine are successful in relieving patients who are hyper-sensitive to the substance.

Another striking application of histamine therapy is the research of Dr. Horace Hill, Medical Superintendent, Laverstock House Mental Home, Salisbury, England. In the "shock treatment" found beneficial for dread schizophrenia (split personality) and manic depressive (heavily brooding) psychosis, Dr. Hill injects patients with histamine and insulin. The benefits, Dr. Hill believes, come not from the shock, but "from some chemical body as histamine." Physicians in America have used this technique with greater benefits than the crude "shock therapy" of suddenly dropping the patient through a trap-door, or placing him in a rapidly whirling chair.

Astonishing 30-day cures of long established hives cases resulted from oral administration of a drug which neutralizes histamine. The same drug relieved the histamine-sensitive of skin eruptions and acid stomach. Even rheumatoid arthritis and swelling of the legs and arms have been benefited. Dr. Louis E. Prickman, of the University of Minnesota, believes that histamine therapy offers great possibilities in the correction of food allergies due to histamine sensitivity.

However, it must be remembered that only the histamine-sensitive can hope for such miraculous results. It is quite likely that a great deal of the world's minor and major ailments could be cleared up by a general "vaccination" of all persons against possible histamine sensitivity. But that is mere day-dreaming. The cost would be fantastic, the organization of general densensitization incredibly involved. Unfortunately, "vaccination" against histamine sensitivity is apt to be a long drawn-out affair. It is true that the poison ivy experiments accomplished apparent immunization in periods of 10 and 25 days. But, even so, this can hardly be compared to the low cost and minor inconvenience of the single shot-in-the-arm techniques widely used against the better-known diseases.

It seems pretty obvious that any moves on the histamine front are bound to be private affairs. The individual, if sufficiently interested, will have to take the time and trouble to consult a physician qualified to determine by test his or her reaction to history-making histamine.

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CHILD CANCER
Cancer is Not Confined to Middle and Old Age

EVEN CHILDREN may have cancer—in fact, infants sometimes are born with it. In the professional journal *Radiology*, statistics on child cancer, on the basis of the census, indicate that approximately 150,000 persons died of cancer in the United States in 1939, and approximately 1100 of these were less than 15 years of age, or 0.7 percent. Taking vital statistics of Massachusetts for the same year, it is shown that the death rate from cancer in childhood was greater than for pulmonary tuberculosis, measles, diabetes, scarlet fever, or typhoid.

Thus the rather common tendency to smile incredulously when cancer in children is mentioned is not justified by the facts. It can happen here.

WHOSE FAULT?
Nobody's—And Certainly Not the Mother's

IF A *pater familias* ever harbored a secret (or expressed) grudge against his spouse for "delivering him," as the old expression went, daughter after daughter without any sons, it is now his time to retire from the argument as softly as possible before the lady finds out, as she ultimately is likely to do, that human sex "is determined," as *The Journal of the American Medical Association* states it, "by the presence or absence of a particular gene or set of genes of the father rather than by the mother."

This astounding fact is based on research performed by the geneticists and is actually experimental, not merely theoretical. Genetics is today one of the soundest branches of biological science.

In the next phase of popular knowledge of the remarkable fact just stated, the long-suffering mothers are likely to turn the tables by demanding that the husbands themselves do something about it. But there is nothing they can do for the matter is entirely out of human hands.

OUR *Point* OF VIEW

HOW EASY IS HINDSIGHT!

IN A combative, newly-published book, "The Wright Brothers, a Biography Authorized by Orville Wright," Fred C. Kelly demonstrates what is incontestably true—that it took the editor of Scientific American a long time to come to the point of believing that claims for the early Wright flights were truthful. Nearly three years elapsed between the Wright's first powered flight and this magazine's full acknowledgement, in the number for December 15, 1906, of "their epoch-making invention of the first successful flying machine."

In the light of what everybody now knows, such a delay seems difficult to explain—difficult, in fact, to comprehend—especially when three more years are added, as they must be, for the Wrights' previous gliding experiments, those of 1900, 1901, and 1902 at Kitty Hawk. Does it not seem strange, especially to readers who were not yet living at the time, that Scientific American did not currently describe and closely follow the long annual series of experiments from the outset? What, then, was wrong?

The chief thing that was wrong is one that still is "wrong," namely, that in human affairs there is no known formula for dead-sure prescience. From the vantage point of what we know today the early Wright experiments stand out like a beacon light. When they were being made they remained as obscure as a light under a bushel. In all the history of science and invention there scarcely ever was an instance so strange in this one respect: That public awareness of events which it seems today should have spread like a forest fire, and which could not by the utmost caution have been kept secret, actually kept themselves almost secret and spread only by the most slow, gradual smouldering. In an age of publicity writers this will be difficult to grasp. Let us go back.

In 1900 the Wrights sought a location where winds were steady over flat open country. Weather Bureau data showed that Kitty Hawk, North Carolina, was suitable. The Wrights had not sought a secret place, yet had they done so they could scarce have found one more likely to afford that commodity.

Three autumns at Kitty Hawk—those of 1900, 1901, and 1902—taught them enough knowledge of glider control to tackle powered flight. They still were without publicity. They did not deliberately seek it but they did not fight it. And if at the end of the second year's work Wilbur Wright could say that not within a thousand years would man fly, how can we today expect that people of even less faith then would feel otherwise, strongly enough to bring them to Kitty Hawk to report the events going on there? The Wrights were not regarded as crackpots; simply they went rather unnoticed.

The first power flights took place at Kitty Hawk late in December, 1903. Orville Wright, the one now living, flew for 59 seconds. It seems probable that if the world had learned to be as receptive of new inventions and discoveries as it is today the Wrights would at that point have sprung into a limelight that never would have diminished. But the world's psychology was unready. A nearby newspaper, the Norfolk *Virginia-Pilot,* treated the news of the 59-second flight as important but only five of 21 big-city papers ordered the story when it was offered them; two of these did not print it. The news was still a match that hadn't enough body of flame to it to ignite a log, and after its brief moment it went out.

Kelly, the author, divides editors of the period into two groups of disbelievers: Those who didn't believe the flights had taken place at all and those who saw no importance in them. For had not the distinguished scientist Simon Newcomb only two months previously proved by mathematical logic that heavier-than-air flight was impossible for man, and had not Professor Langley once more failed in an attempt to fly only two weeks before that?

If Kitty Hawk was so remote as to be a factor in the seeming unreality of the asserted flights, was a field only eight miles from Dayton, Ohio, so remote as to have a similar damping effect of remoteness on public credulity—especially as two highways and an interurban car line passing it permitted full view of the Wrights' powered flights of 1904 and 1905? Scarcely so, yet the suburban farm might almost have been at remote Kitty Hawk. The Wrights prepared for a powered flight, sent written invitations to Dayton and Cincinnati papers—and only 35 persons turned up, 12 of them reporters. When motor trouble prevented the plane from lifting, most of the reporters *knew,* as they *had all along,* that it was a hoax; and when the next day more motor trouble cut the flight to 60 feet, the rest went home to stay and forget it.

"During all their experiments that year and the next," Kelly states, "the Wrights had all the privacy they needed." The match again hadn't ignited the log or the forest.

The Wrights flew and flew and flew on that field in 1904 and 1905, in plain sight of a sightless world. They had plenty of troubles but worked up to five-minute flights, 18-minute flights, 25-minute flights, 38-minute flights, but it still wasn't news! You could draw a circle around that field, beyond which nobody saw or apparently cared. Even Fred Kelly, the author of the new book, reporting for a nearby Dayton daily, was sure it was all nonsense—yet in the same book he "pans" Scientific American for paying no attention when the publisher of a magazine on *bee culture* wrote an eye-witness account of the Wright flights and sent the editor of this magazine a marked copy!

Thus it was that, a year later, the Wrights were still a forgotten secret because Dayton newspapers were waiting for them to "do something unusual" before risking in their columns space that might be used for more profitable purposes such as local society notes. And instead of making the most significant event of the century known to the outside world, Scientific American was publishing in its issue for January 13, 1906, a statement of its disbelief in the alleged Wright flights: "If such sensational and tremendously important experiments are being conducted in a not very remote part of the country, on a subject in which almost everybody feels the most profound interest, is it possible to believe that the enterprising American reporter, who, it is well known, comes down the chimney when the door is locked in his face—even if he has to scale a fifteen-story skyscraper to do so—would not have ascertained all about them and published them broadcast long ago?"

Scientific American's mistake—and it made one—lay just there: The enterprising Dayton reporters obviously weren't so enterprising as our trusting editors believed. It was they, primarily, who kept the Wrights' big news in a vacuum. And Fred Kelly at the time—so says his own book—was a reporter dwelling only 11 miles from the Wrights' experiments!

It is not as if Scientific American had always ignored or belittled the Wrights' flights. Eighteen months before the editorial comment quoted above was written it had stated (in the number for June 11, 1904) that "the flying machine invented by Orville and Wilbur Wright, which made a successful flight at Kitty Hawk, N. C., last December, had another trial near Dayton, O., on May 26, which the brothers say was successful." What transpired in the next 18 months to cause the editors temporarily to become doubters we today know not.

Kelly tells how in 1940 Dan Kumler, who was city editor of *The Dayton Daily News* during the years in question, parried embarrassing questions and then gave in. Asked why there was nothing in his paper, he replied, "We just didn't believe it. Of course, you must remember that the Wrights at that time were terribly secretive." "You mean they were secretive about the fact that they were flying over an open field?" "I guess," said Kumler grinning, "the truth is that we were just plain dumb."—*A.G.I.*

Oil From Canadian Sands

Billions of Barrels of Oil, but Not for Lubrication, May be Drawn from Northeastern Alberta

LEONARD BOURNE

IN THE widespread search for new and undeveloped sources of vital materials needed for the successful prosecution of the war, an area of some 10,000 square miles of mineral-rich oil sands in the northeastern regions of Alberta may prove to be an invaluable aid and to provide much weight to the eventual knock-out punch to Axis dreams of world conquest.

At McMurray, a few hundred miles north of the capital at Edmonton, is real wealth in oil—huge quantities of it, estimated to be enough to supply the world's needs for the next hundred years or more; oil with an amazingly high ductility that may help solve the problem of supplying synthetic rubber to the armed forces of the United Nations, as well as for civilian requirements. This oil is also producing an asphalt of excellent quality in sufficient quantities to surface the entire length of the recently completed Alaska Highway.

High octane gasoline, tractor fuel, Diesel fuel, coke, and asphalt are the immediate products in view from the Alberta oil sands and quantities of each have already been recovered from this "black gold." So important is the area considered that plans have been under advisement for the construction of a $20,000,000 plant that will add considerably to the United Nations' oil reserves. Already a half-million dollars have been appropriated by the Dominion Government for the development of existing plant equipment and for research directed toward the solving of some of the still present problems in the extraction of oil from the extensive sand deposits. The potential importance of these oil sands to the Allied military plans is great indeed, for this vast region lies within reach of America's newly built lifeline to Alaska. With Russia's vast Caucasus oil fields endangered earlier by Nazi advances toward Stalingrad, these deposits in Alberta take on vital significance. Produced here in great quantities, fuel oil and high-octane aviation gasoline will facilitate the supply problem to our northern outposts and the Pacific.

How much oil is there in this fabulous region?

Nobody really knows, but American and Canadian geologists say that a hundred billion barrels are within the realm of possibility and that even 250 billion barrels are not too high a guess. Then remember that the present known oil resources of the world are perhaps 35 to 40 billion barrels and the extent of the potential development of the oil sands begins to take on astronomical proportions.

The fact that the Alaska Highway was completed ahead of schedule, opening a direct supply line to defense posts in Alaska and the Pacific, has speeded up other aspects of the drive for raw materials.

Blasting out sub-surface oil deposits

Results of investigations made last summer have not been fully revealed but recent action by the Canadian Government strengthens the belief that no opportunity to increase supplies of natural wealth is being overlooked. The Canadian budget estimates, recently made public, include provisions for income tax deductions by prospectors, mine operators, and oil operators. Pre-production expenses, according to the altered income tax schedules, may be written off against the income from new oil-well production or the production of vital base minerals. Other concessions, too, are included in the new tax program to encourage and stimulate interest in prospecting for these needed materials.

Specific plans with regard to increasing production at the McMurray oil sands region are still not complete, however. One of the principal considerations includes the building of a pipeline from McMurray to Edmonton, but the problem of securing material for such a pipeline at this time may be found insurmountable. Other means of transportation, however, are not only feasible but are now being employed despite temporary difficulties and a resulting reduction in the facility with which oil can be moved.

These Athabaska oil sands of Alberta are not newly discovered; they have been known for many years, but because of their inaccessibility, little was done to develop production on a commercial scale. White men first heard of this strange vast resource in 1719, when an Indian brought samples of "gum or pitch that flows out of the banks of rivers" to a fur trader on Hudson Bay. Peter Pond and Alexander Mackenzie, two of the revered names in Canadian exploration, left long and glowing accounts of these river banks where Indians dug out pitch to mend their canoes.

THE SANDS are an ancient delta or estuary deposit, washed into a shallow sea many million years ago and later buried beneath accumulations of sediments. In time, these were consolidated into sandstones and shales. At some time and in some manner about which there is still much speculation, the sand became saturated with heavy oil. More recently, the Athabaska River and some of its tributaries have cut valleys through the overlying rocks and through the oil sands, leaving benches or shelves in the oil sands, some of them of large extent, along the valley walls.

It is probable that no other mineral deposit has been the subject of research over so long a period of time. Much of the pioneer exploration was conducted by S. C. Ells (F.R.G.S., F.G.S. of London) of the Dominion Mines Branch of Ottawa, who revealed the potential resources of the vast area. In 1913 the first tests were made in an area then largely unsurveyed and known only to trappers and northern natives. Core drilling, sampling, a study of mining methods in conjunction with the excavation of tons of these bituminous sands, and exhaustive laboratory studies contributed toward the actual operations that materialized only recently.

It remained for Max W. Ball, one time member of the U. S. Bureau of Mines and for many years a successful geologist, to develop a method of "mining" the sands successfully. The oil is found at depths of from eight to perhaps two hundred feet below the surface, hence open pit extraction is possible. Light blasting followed by power shoveling is used to ex-

cavate the oil-bearing sand; in fact, the blasting actually starts the separation of the sand grains from the surrounding oil film. Conveyor belts carry the sand to the separation plant where, by means of flotation, the oil is completely separated from the sand.

This is the method employed at the Abasand Oils Ltd., plant at McMurray where Mr. Ball's experiments over a period of 12 years now make it possible to recover oil from the sand deposits in a matter of minutes.

Actually, commercial production has become a problem in economics rather than engineering. Production costs are pretty well established, but transportation costs, the extent of a stable and assured market, and problems of expansion are important factors.

Original estimates revealed the oil sand deposits to average 15 to 17 percent oil content. Operations now are limited to more than 4000 acres in the Athabaska River region around McMurray, for which the mining rights have been issued, and except for two or three small tracts, present leases cover all the known mineable deposits within 45 miles of the present railhead at Waterways. These sites have been selected as being most suitable for the open pit mining methods now in practice and it is highly probable that only these deposits will be worked for another generation or so.

Plant operations now reveal a steady production rate of 300 barrels of oil daily from the processing of 400 tons of oil sands. On this basis, and with the required plant expansion envisioned, production of 10,000 to 20,000 barrels of oil

So rich in oil are some of the sands that oil can be squeezed out by hand

per day is quite feasible. Carrying these estimates further, officials anticipate production of 100,000 barrels of oil to the acre of these valuable deposits.

Assuming that oil from the sand deposits is exact and steady, at 10,000 barrels daily, it could be laid down at the refinery for 75 cents now and two years later it would still be produced at the same basic cost.

It is estimated that it costs 83 cents to produce the average barrel of oil at

A general view of the open-pit mining area at the McMurray, Alberta, pilot plant, where oil-sand deposits are found at a depth of 15 feet below the surface

American wells; taking it to refineries averages perhaps another 25 cents, or a total of $1.08, which figure could conceivably fluctuate but still be higher than the Alberta estimate. Most oil fields decline from their peak production; as the fields grow older, pumping and other production costs increase. But the open pit mining methods at McMurray made possible by the accessibility of the oil deposits at depths close to the surface, eliminate any fluctuation in production costs.

Present production is more than adequately covered by the market demands. Gasoline, Diesel fuel, and fuel oils produced from the Alberta deposits are already being shipped to the North. A heavy freight rate advantage over products from competing refineries is explained by the fact that the McMurray deposits are 500 miles nearer to their markets; hence, transportation costs are lowered.

The principal markets for asphalt products, aside from the anticipated use in surfacing the Alaska Highway, are to the south of the McMurray plant. Small sections of Alberta roadways surfaced with this native asphalt have proved extremely economical and substantiate the belief that, even produced in large quantities, the demand might well exceed the supply. There are roadway sections in Edmonton built of this McMurray oil sand asphalt which have never required major repairs in more than 20 years. Pavements of other refinery asphalt require repair almost every year and in some cases must be completely replaced every five or six years.

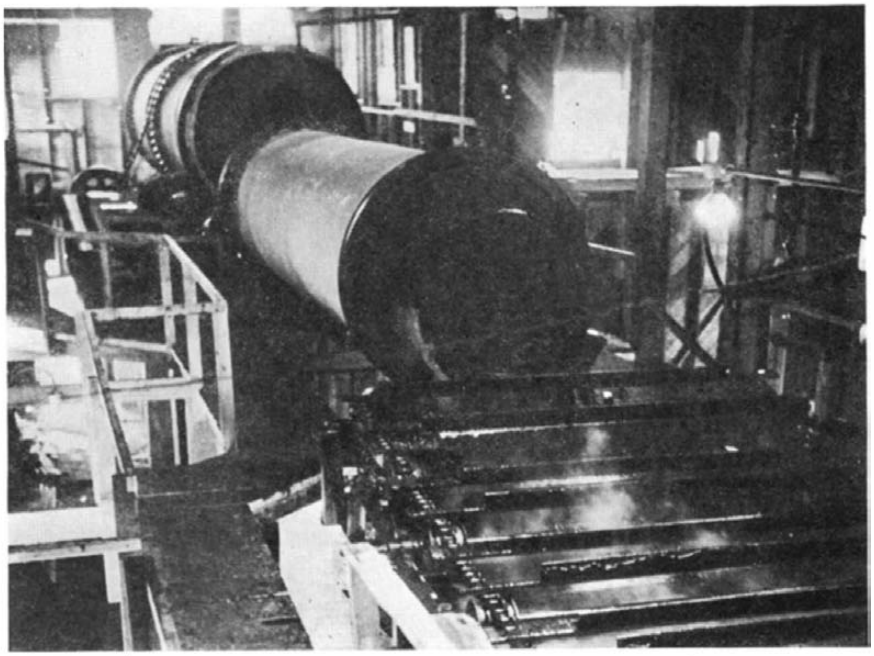
Alberta's native oil sands have been weathered for more than 100 million years, learning the hard way to contract and expand in temperatures ranging from 90 above to 56 below. Consequently, the asphalt product is peculiarly adapted to the surfacing of public roads throughout the northwest and will solve one of the major problems in year-'round maintenance of the Alaska Highway. Weathered by nature and possessing qualities of persistency that make frequent repairs unnecessary, the Alberta oil sands product eliminates the repair cost factor.

Asphalts from McMurray, for example, can be delivered for about 10½ cents per gallon, F.O.B. Edmonton, in tank car lots. This is the same price for which asphalt can be delivered from Calgary, Alberta, refineries as a by-product of the Turner Valley oil fields. Even with tankage scarce, it could be shipped in barrels at a slightly higher cost, but the superior quality of the McMurray product would more than offset the increase.

THE VERY quality which makes for perfect asphalt also renders the crude useless for the manufacture of lubricating oil. It has never been exposed to the tremendous pressures to which deep-well crudes have been subjected. It is very susceptible to heat and therefore it cracks down at relatively low temperatures. On the other hand, this quality makes possible the manufacture of all types of fuel which require low flash point.

The lighter products—gasoline, Diesel fuel, and fuel oils—are already fueling the steamers, tugs, and other river craft which ply the Athabaska, the Slave, and the Mackenzie Rivers. It likewise fuels the Diesel engines, gasoline motors, boilers and heating appliances of the mining camps in the far north. Everything from bunker oil, including the kerosene categories, to the highest octane ratings, can be produced.

All contemplation of future developments of this area are allied with the Alaska Highway. Canadian and American authorities see this road not merely as a wartime emergency lifeline to de-



Oil-bearing sand is fed into the large drum in the background where hot water accomplishes the separation by flotation. The separated oil is then carried into the tanks

fense outposts, but as a postwar route opening the doors to almost unbelievable expansion and development of the northwest and its natural wealth and resources. These will, of course, be urgently needed in the reconstruction and stabilization period following the end of hostilities.

In this postwar development, the McMurray oil sands will play a vital part, even if they should not, for one unseen reason or another, become directly harnessed to the present war effort.

Larger deposits farther down the Athabaska River from present operations are estimated to contain 300,000,000 barrels of oil. To work them successfully requires a plant to produce and digest an average of 10,000 barrels a day, to connect this plant by pipeline with the railhead at Waterways, and to erect a complete refinery at Edmonton at a total cost of about eight million dollars. Such expansion would assure production of 10,000 barrels a day for 20 years before the plant need be moved; this figure could be stepped up to even 30,000 barrels a day, with no further burden such as is involved in drilling additional wells.

Construction of a 300-mile pipeline from plant to refinery, no matter what it costs, is considered economically desirable. Since the supply of oil is unlimited, the amortization on this pipeline could be extended over a period of 30 to 40 years instead of the usual ten-year period as in the case of most oil lines.

Probably of greatest significance in considering the future of this vast mineral wealth is the matter of a permanent supply of basic materials for the manufacture of synthetic rubber. Because of its high ductility, Athabaska oil sands are considered a likely source of butadiene, an important basis for the manufacture of synthetics. Once the ultimate development is launched and butadiene is produced in large quantities from this source, a national economy independent of supplies of raw natural rubber can be established.

• • •

Orphan Agar

But Poorly Known to the General Public, Agar is One of the Nation's Most Critical War Materials

HAROLD KEEN

Add to the nation's critical war materials, alongside rubber and many metals, a white, semi-transparent, tasteless, odorless, gelatin-like mass—agar. Without it our military machine might well bog down in a complication of hygienic problems, and our public health and sanitation systems might be seriously disrupted.

In laboratories where bacteria in the military or civilian supply of water, milk, and food must be constantly checked to prevent wholesale contamination, agar is an irreplaceable bacteriological culture medium which, unfortunately, the United States has long depended on Japan to provide.

When the Japs attacked Pearl Harbor, agar automatically became a scarce commodity within the United Nations. Since a Japanese peasant three centuries ago accidentally discovered nature's alchemy which mysteriously transformed gelidium, a small dark-red seaweed, into a jelly-like substance of gastronomic attraction, energetic Nippon had built a world monopoly from the harvest at its shores.

Amputation of the Japanese supply left us with an agar stockpile of about 200,000 pounds—sufficient for only one year's maintenance of healthful food, milk, and water standards.

Thus agar came under the whiplash of the War Production Board, which issued a conservation order "freezing" the material and prohibiting its employment anywhere except in bacteriological laboratories. Much of the 600,000 pounds imported annually by the United States had met a wider variety of consumer uses—for jelled desserts, as a stiffening medium in candy, ice cream, and pastries, as a coagulant for clearing beverages, as a sizing agent in cloth, for dental impressions, and in combination with laxatives and mineral oils to overcome constipation.

Shoveling seaweed into washing tank for soaking to remove foreign matter

As W.P.B. learned, science has never found a pinch-hitting ersatz for agar. It is the only substance known to have the peculiar properties needed in an effective bacteriological culture medium. Briefly, it withstands sterilizing temperatures of 248 degrees, Fahrenheit, for 20 minutes, and cools into convenient gel form. Unlike animal gelatin, which supports the growth of most kinds of bacteria, very few bacteria digest agar. On the other hand, it holds the peptone, beef extract, and similar nutrients introduced into it to keep the bacteria alive for laboratory analysis—a function discovered 70 years ago by Koch, the German bacteriologist.

Japan became world supplier of this vital commodity, not because it had a corner on gelidium, the plant from which it is obtained, but because its labor costs

In these 1000-gallon autoclaves the weed is pressure-cooked six hours to dissolve out the agar

were low enough to wipe out competition from an American product.

A small group of Americans nevertheless maintained a spark of life in the ill-nourished industry. In San Diego, for two decades, companies have unsuccessfully tried to process agar out of gelidium in the face of Jap underselling.

Hence, southern California, home of the motion pictures and a booming aircraft and shipyard industry, now is serving also as agar storehouse for the Allies. San Diego is almost the geographical center of a great gelidium-bearing region, from Monterey 400 miles on the north to Cedros Island, off the coast of Lower California, 350 miles on the south.

Colossus of United States agar manufacturing today is American Agar and Chemical Company, which a few weeks after the outbreak of war began producing in San Diego the precious material at a rate which has exceeded the 100,000 pound per year mark—roughly half that used annually for bacteriological culture media. The urgency of increased output cannot be overemphasized.

Curiously enough, American Agar and Chemical Company to a large extent owes its strong position to a generous source of supply in foreign waters. Much of its gelidium is harvested off the coast of Lower California, by Mexican divers operating from Punta Banda, near Ensenada, south 300 miles to Cedros Island. The factor which established supremacy of Jap agar in American markets—relative cheapness of labor—is once again being put to practice.

The Agar Company of California, a Los Angeles concern with a plant in nearby Orange, has launched diving operations with an American crew at Newport Beach, swank resort. E. H. Lochridge, manager, estimates that the cost of raw materials obtained in Mexican waters is one half that of domestically procured gelidium. In recent months, American Agar and Chemical Company also has been harvesting gelidium off Newport Beach, but major reliance still is placed on the Mexican supply due to superior weather and water conditions, as well as cheaper labor.

Most important aspect of the agar problem, availability of sufficient seaweed, is a potential bottleneck which the United States Fish and Wildlife Service and the Scripps Institution of Oceanography, at La Jolla, California, a division of the University of California, are attempting to shatter. Marine biological stations and marine botanists have been enlisted in a study to determine the abundance of various types of red algae, and their agar assay, on all our coasts, as well as the Hawaiian Islands, and Caribbean waters off Puerto Rico and Cuba. Simultaneously, experiments on improved methods of extraction have been under way at such research centers as the Scripps Institution, the Marine Laboratory of Duke University, Beaufort, North Carolina, and the United States Fish and Wildlife Service at a laboratory at Bethesda, Maryland.

Of more than 6000 marine algae, about 30 yield agar, but only eight or ten species are extensively used. *Gelidium cartilagenium,* the most common agariferous weed off the California and Lower California coasts, is an habitué of rocky shorelines, clinging in maroon-colored, bushy masses to the tops of rocks lying in water from low tide to about 60 feet depth. Vacationists have collected small sprays of it on California beaches without realizing the lofty place this seaweed occupies in the scientific world.

Harvesting gelidium is strictly hand work. The weed grows, tuft-like, seldom more than one to two feet from the rock. It must be located at close quarters by the diver as he walks along the ocean floor, gathering it by hand into a twine basket. Turbulence of the current, an essential environmental condition for growth of gelidium, further precludes use of machinery for harvesting. Sluggish, brackish waters which allow sediment to form on the rocks are shunned by the temperamental weed.

A gelidium diver, struggling against the surging, swirling inshore current, can be no weakling. He must keep himself in trim physical condition to endure the strain of searching for the red algae. The industrious, wiry Japs were ideal for the task.

For almost 300 years, agar has been produced in much the same manner by Japan. In the summer, the seaweeds are gathered in Japanese waters and bleached on the beaches. Baled like hay, the gelidium is transported to Japan's high mountains, where the winter months are devoted to extraction of the agar in crude equipment operated by many family units.

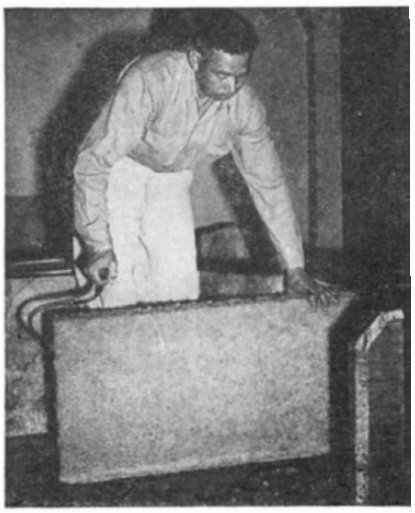
After the weeds are boiled for ten hours, the fluid is filtered and allowed to congeal indoors until it has reached the consistency of soft gelatin, when it is cut into strips or square shapes. These are placed outside on cold nights, and freezing transforms the jelly from a uniform structure to one consisting of filmy cells like that of a beehive. When this is exposed to the sun, the ice crystals melt away, leaving spaghetti-like shreds of trifling weight. In this form, the agar was exported by the Japs, and converted into a jelly merely by placing in a hot water solution.

The manufacturing process in this country, except for mechanical improvements, is essentially the same. The seaweed is gathered, dried, baled, and shipped to the factory, where it is shoveled into a washing tank and cleaned. Next it goes into 1000-gallon pressure cookers and is cooked for six hours. This dissolves out the agar content of the weed to form an agariferous liquor. This liquor is clarified, filtered, and allowed to congeal. Then it is ground into small particles, shaped into 100-pound blocks, and frozen and in that state it is re-ground. After thawing, it is rewashed, chemically treated and dried, ready for shipment and use.

Artificial refrigeration, of course, is employed in balmy Southern California, and the finished product is flaky, instead of stringy. A greater degree of purity is claimed for the domestic agar.

Dr. Marston C. Sargent, of the Scripps Institution, who spent much of 1942 experimenting with methods of obtaining agar from various types of marine algae found off La Jolla, claims that "any enterprising person can make agar out of a surprising variety of seaweeds, using a washtub, a stove, and (in warm weather) a mechanical refrigerator."

"Experience in China, New Zealand, Australia, and Russia," continues Dr. Sargent, "has shown that beachcombers and even school children who have been taught what to look for can gather

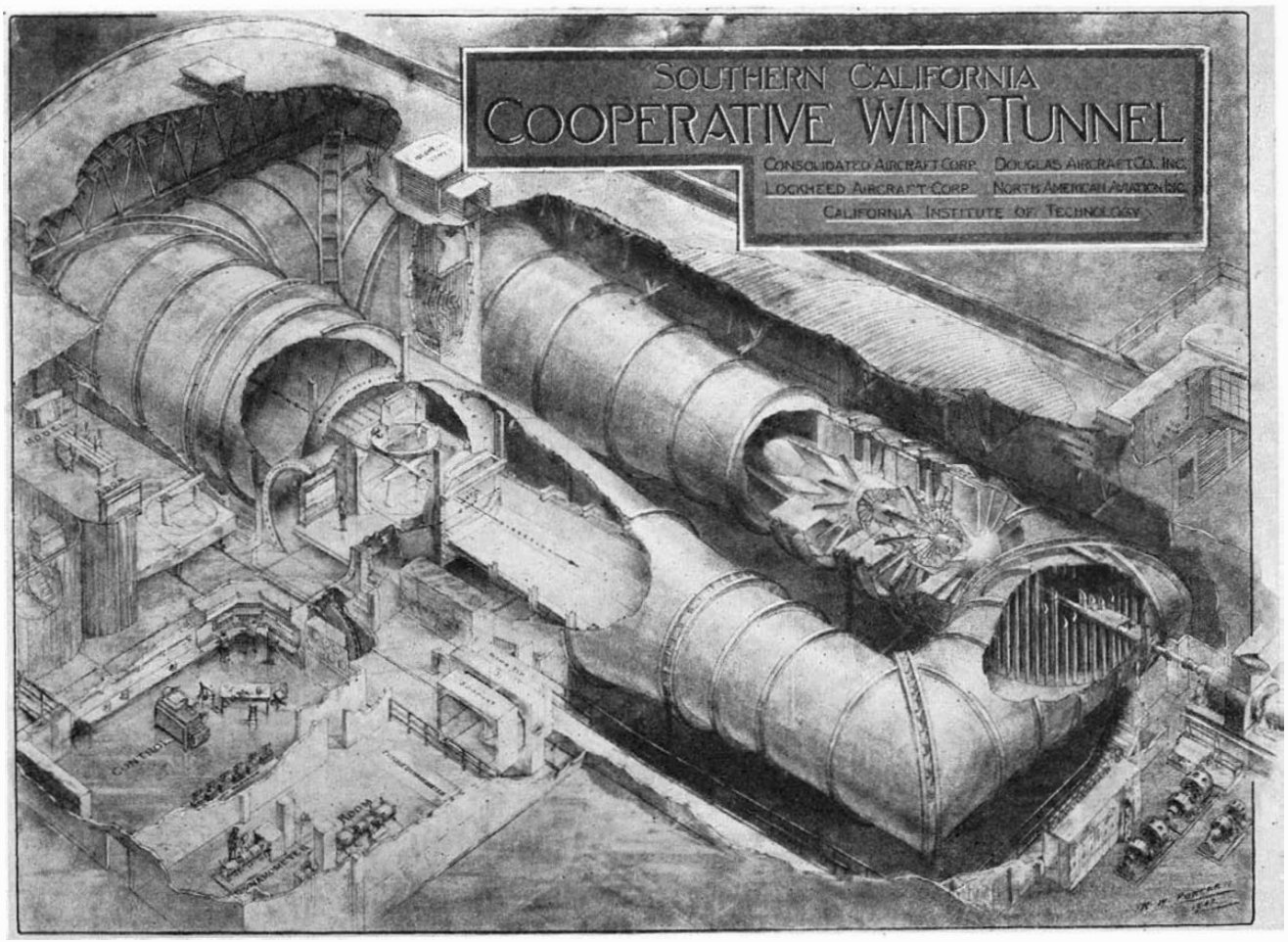


Introducing 100-pound block of frozen agar gel into a chopper which grinds the gel to small particles

enough valuable red seaweed to form an appreciable addition to their country's resources and at the same time earn something ranging from pocket money to a good day's pay.

"The fact that, as late as 1929, 300,000 pounds of dried porphyra, a seaweed used as food in China, was collected each year in California by men, women, and children, shows the possibilities of this kind of work."

Dr. Sargent and an associate, Dr. Robert Tschudy, have produced jellies, on a small scale, which showed three times the geling strength of the present commercial output from weeds found off the Institution's shores. Thus, 0.5 percent of their



Drawing by Russell W. Porter
Important sections of the Co-Operative Wind Tunnel are shown cut-away to reveal interior details

agar in solution provided the same geling potency, for use in bacteriological media, as 1.5 percent solution of the material now used.

Still more significantly, they demonstrated that, besides gelidiums, many other weeds plentiful in the inter-tidal zone are agar producers. Whether these can be employed on a commercial scale remains to be determined.

If the United States is to supply agar to its allies for the duration, it has to contend with some truly staggering figures.

The agar requirement of Russia alone, in 1937, was 1,000,000 pounds, compared with the 100,000 pounds a year production at Odessa, Archangel, and Vladivostok. China's needs have run over 350,000 pounds annually, but the loss of its coastal regions has smashed its agar industry, which produced 150,000 pounds in 1936. England has no agar production, and only a very small industry exists on the island continent of Australia and New Zealand.

Evidently anticipating a pinch, Germany imported huge quantities of agar from Japan, and is believed to have a stock pile of approximately 2,000,000 pounds. Japan's production rate has been as high as 6,000,000 pounds, or 3000 tons, a year.

Thus, Nippon alone need not fear a wartime crippling of her public and military sanitation systems through lack of agar.

FINEST WIND TUNNEL

Will Provide Velocities Close to Speed of Sound

THE most advanced wind-tunnel in the world is nearing completion. The laboratory buildings for the $2,100,000 Southern California Co-operative Wind Tunnel are now completed and the construction of the steel tunnel itself is well under way.

Soon the tunnel will be ready to serve as the world's most advanced testing ground for the developments now making American airplane performance set new records in speed, altitude, armament, and maneuverability.

The tunnel, financed by Consolidated, Douglas, Lockheed, and North American —all Aircraft War Production Council members—is being constructed and will be operated under the supervision of Dr. Clark B. Millikan, by the California Institute of Technology. An identical twin tunnel, in the east—at Buffalo, New York —is being constructed under the supervision of Dr. Norton B. Moore, of Curtiss-Wright.

Design of both tunnels was in process for many months, under the general direction of Drs. Millikan and Moore. Collaborating were engineers of the four southern California companies, Caltech, and Curtiss-Wright.

Importance of the wind tunnel in the development of better aircraft lies in the fact that much of a new plane's flying data (probable top speed, landing speed, rate of climb, stability, controlability, number of required take-off feet) can be accurately determined in the wind tunnel before the proposed plane is built.

Aircraft manufacturers expect to build planes in the next few years that will have diving speeds exceeding 9/10 the speed of sound (approximately 741 miles per hour). Airplanes of the future may be designed to dive at a rate of more than 700 miles an hour. The new tunnel will be equipped to test at such speeds. Most existing tunnels have a maximum testing speed far less than this, and only a few are capable of testing at speeds exceeding 500 miles an hour. In the development of high performance military aircraft, problems requiring immediate wind tunnel testing almost always occur in the design phase and particularly during the flight test period when immediate access to a wind tunnel is of vital importance.

Wind tunnels operate on the principal of the Venturi tube, which was devised in 1800 by Giovanni Venturi, an Italian physicist, for measuring the flow of water through a pipe.

Substituting wind for water, air is moved by a huge propeller in a section of large diameter. From there it is blown into a much smaller section, the "throat." When the wind in the large section of the tunnel reaches the "throat" it gains in speed.

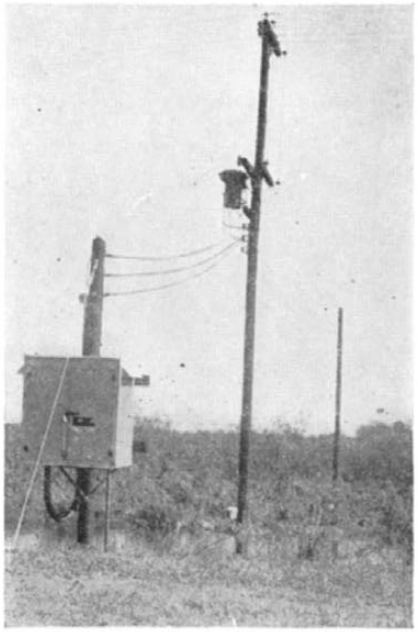
By placing an exact scale model of an airplane in the "throat," tests can be made

which will show what the actual plane will do when it is in the air at similar speeds. Reactions of the model (placed on supports resting on highly sensitive balances) are measured mechanically, electrically, or hydraulically. Readings are taken for every attitude of the model in the tunnel and the recorded information is immediately plotted on a graph. Engineers are then able to list accurate flying characteristics of the future airplane.

ELECTRICAL PROTECTION

Reduces Upkeep Cost of Pipe Lines

PIONEER work on electrical protection of pipe lines is today helping save steel for battleships and bombs. So severe is the corrosive action of salt water on the steel in a net-work of lines near Port



Pipe-line transformer and rectifier

Arthur, Texas, that the stretch of swamp-land has become known to Gulf engineers as "Hell's Half Acre." The actual distance between the refinery and tank farm is only 2½ miles, but there are over 19 miles of pipe lines between the two points, including five 10-inch lines and three 8-inch lines. It was costing the company $15,000 a year to maintain these lines. This was before 1935.

In 1937, at a cost of $17,000, the installation of electrical protection to the pipes in this corrosive salt marsh was made. Since then the frequency of rust holes has been reduced to practically nil. Maintenance costs have been reduced about $10,000 per year. The only direct charge per month is $50 for purchased power.

Electrical protection of pipes is at present restricted to the pipe exterior. A typical circuit involves the use of a source of direct current such as a motor-generator, wind-driven D.C. generator, or rectifier. The positive pole of the direct-current source is connected to a ground bed buried in the earth between 100 and 500 feet from the pipe. The current flows from this ground bed through the earth to the pipe to be protected. The current is picked up by the pipe and flows along it to the negative terminal of the direct current source, thus completing the circuit. The ground bed is usually composed of either junk steel or graphite surrounded by coke.

Corrosion of steel pipe occurs because of differences in electrical potential on the pipe face. It has been found that when the electrical current flows to the pipe from the remote anode, it flows first to the areas having the lowest potential. The hydrogen evolved raises the potential of these cathodic areas to the level of the anodic areas and thus, by eliminating the potential differences, corrosion ceases.

This installation by the Gulf Oil Company, and others, have definitely proved the worth of electrical protection to the oil and gas pipe-line industry. The result is that much lighter pipe, usually coated with enamel and wrapped with asbestos, is now used, saving tons of vital war-needed steel annually.

• • •

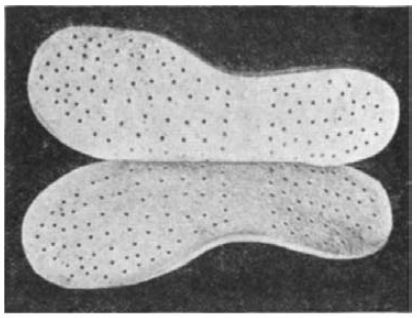
PLATING—Landing gear struts for military airplanes are chromium plated twice as fast by using a tube of "Lucite" methyl methacrylate resin to protect the strut's threaded end during plating.

• • •

WARM INSOLES

New Design for Use in Cold Regions

RECENT research into the foot comfort of military forces in the Arctic regions of Canada, Alaska, and Greenland, has led to the design of a new "ventile" wool felt insole which incorporates several important innovations. This insulating insole has been made to meet the difficulties encountered in various types of footwear tested by hunters and trappers who have lived in the Far North for years, as well as Antarctic explorers, Army Engineers Corps, salvage parties, patrols, airplane pilots, and others of the armed forces. The name "ventile" (generic; not trade) was coined by members of a recent expedition to express the ability of a bodily covering to ventilate by "breathing." This important property permits moisture from perspiration to be exhaled, whereas non-porous coverings retain moisture, which forms ice and becomes an important



Ventilated, hinged, warm

source of discomfort and danger. This is true even when extraordinary precautions are taken to prevent the conduction of heat away from the body.

The new ventile insole differs from the usual type in that it consists of two layers of wool felt totaling one half inch in thickness; these are hinged at one side by a stitched seam. This seam runs for about five inches along the outer edge of the instep and permits the upper and lower layers to "work" under the intermittant pressures of walking.

Both layers are also perforated, having approximately one hundred holes ⅛ of an inch in diameter spaced ⅜ to ½ of an inch apart. This construction has been tested for both ease and warmth, with highly promising results on both counts.

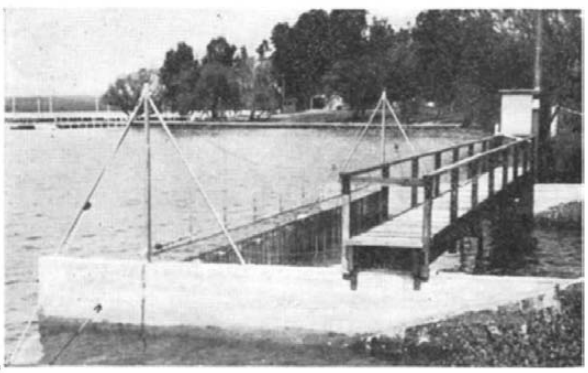
The type of wool employed in the felt for these insoles is selected for its tendency to loft itself when released from pressure, instead of matting down and losing the springy support. It is antiseptic and fungus-proof and will not stretch when washed, if properly handled.

FISH SCREEN

Electrically Operated, Keeps Fish Within Bounds

REPLACING more bulky and less satisfactory mechanical fish screens, a new electrical device has been developed which will fence off sections of a stream, the outlet of a lake, or the entrance to irrigating systems so that fish cannot pass, yet logs, sticks, leaves, and other debris will flow down stream. The screening is achieved through the use of an electric current which is sufficiently powerful to keep fish away from the electrode, yet will not stun or kill them. The current is furnished by an electronic impulse generator conected to electrodes which swing freely in the water.

An electric fish screen installed at one of the outlets of a California lake. The hanging electrodes clear the lake bed by about three inches



Wanted: MORE EXECUTIVES!

To help win the war!...and the peace to follow!

Every great crisis produces new leaders. This war is no exception. It has created as great a crisis for business as for our nation, and new leaders are rising to the top every day.

Right now, companies are searching high and low for men of executive ability and training to manage the different departments in new and expanded plants. The war and its demands for production, and *more* production, has thinned the ranks of executives to the danger point. The country needs men of executive ability just as it needs production workers and men for the armed forces.

Where will it find them? Ordinarily there would be enough "officer material" right in the ranks . . . men who had been learning by experience, slowly but steadily advancing in the companies which employed them. That is one way of doing it—the hard way, the slow way. But now time is pressing. Such men are needed not two years from now, but *today* and *to-*

morrow! Where will they come from? Those men will have to be trained, *and the smart ones will train themselves—now!*

How can they do that? Through the Alexander Hamilton Institute's intensive Course of Executive Training.

This executive training, which is described in a book called "FORGING AHEAD IN BUSINESS," can help you to accomplish in months what would otherwise take years—if you could get it at all. It is valuable to men in different lines of business because it covers the fundamentals of *all* business—production, marketing, finance and accounting. It is equally effective for the college graduate or the business man who only finished grammar school.

More than 400,000 men have enrolled for this training and every day reports come in of their promotions, salary increases, new and better positions. Many of these men have become so famous that you will recog-

nize their names instantly when you see them in this booklet.

Send for "FORGING AHEAD IN BUSINESS"

The facts about this executive training are given in the book "FORGING AHEAD IN BUSINESS." This 64-page book has inspired thousands of men. Many say it started them on the road to real business success.

A word of warning. If you are *not* interested in executive training, don't send for this book. But if you *are* interested in this way to better your position and increase your earning power, then we want you to have a copy of "FORGING AHEAD IN BUSINESS" with our compliments. Simply fill in and mail the coupon, and the book will reach you by return mail.

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Please mail me without cost a copy of the 64-page book—"FORGING AHEAD IN BUSINESS."

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Conservation possibilities, using the Burkey electric fish screen, include confining fish to certain areas; diversion of up-stream migrants to fish ladders or counting devices; segregating sizes and species in hatcheries; protecting bathers by a harmless electrified zone which will effectively keep away sharks, barracuda, and other dangerous fish life; and the solution to other problems which constantly arise in connection with fish culture and control.

CORROSION BATTLE

Being Waged With Electronic Diffraction Camera

ARMED with a vacuum tube "machine gun" that shoots billions of electronic bullets a second, a Pittsburgh research chemist is making a new scientific attack on rust and corrosion. With this new weapon—an electronic diffraction camera—Dr. Earl A. Gulbransen of the Westinghouse Research Laboratories, is investigating the atomic structure of coatings that "grow" on steel, aluminum, and copper when these metals are exposed to air or corrosive chemicals.

Dr. Gulbransen is shown in our cover illustration at his new form of "target practice" which is pointing the way toward longer-wearing bearings and cylinders for airplane and automobile engines, better tin plate in which the tin will cling more tightly to the steel underneath, and cheaper methods of making stainless steel.

"Just as some types of bacteria are beneficial to human beings," Dr. Gulbransen says, "some of these oxide coatings protect the metal underneath them. Others, of course, like rust, are harmful. With this electronic camera, we are testing new theories as to how these coatings are formed."

Electrons are shot down through the three-foot-long vacuum tube and bounced off a highly polished button of metal on which an oxide coating is being built up. The electrons ricochet off the faces of the block-like molecules that form the coating and continue downward at an angle to strike a strip of photographic film.

The electrons trace on the film a pattern of black and white semi-circles which appears when the strip is removed from the camera and developed. This design is formed by the electrons bouncing off the different faces of the molecules in the coating.

The polished metal buttons which Dr. Gulbransen uses as targets are inserted six at a time in a magazine which fits into the side of the vacuum tube. By revolving the magazine he can bring any one of the buttons into the field of electronic fire. Electric resistance wires in the magazine heat the buttons to accelerate the formation of coatings. Dr. Gulbransen can also speed up the growth of the oxide coating by turning valves to admit measured amounts of oxygen into the tube. Another valve pours cleansing hydrogen into the tube. This gas combines with the oxygen in a coating and forms water vapor which is pumped out of the tube before a series of experiments is started.

Just as a pinch of salt can improve a recipe, small amounts of alloy metal can alter the nature of the coating formed on a piston ring, cylinder wall, or motor bearing, Dr. Gulbransen explains. Iron, for example, acquires an "overcoat" of rough iron oxide when exposed to air but when one percent of chrome is added to the iron the coating formed is chromium oxide, a thin, protective layer that hinders the oxidation of the metal.

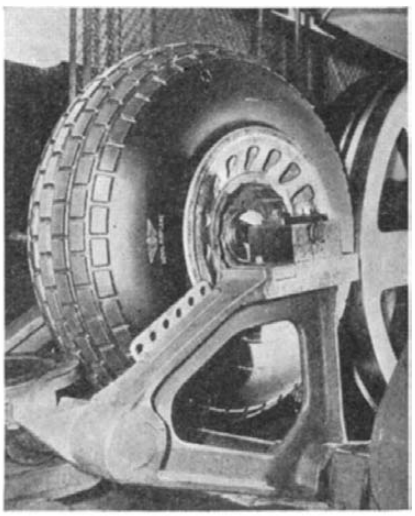
"There are two factors involved in the growth of these coatings," Dr. Gulbransen says. "One is energy. Metal ions, atoms which have lost some of their surrounding electrons, require a certain amount of energy to travel through the oxide layer to combine with oxygen atoms. Free electrons making this same trip also need energy. Sometimes, travel is in the opposite direction, with oxygen ions moving inward to build up the oxide on the surface of the metal. When we heat the metal, we give these particles more energy, they make the trip more easily, and the coating builds up more quickly.

"The second factor is entropy—which means chance or opportunity. Even when ions and electrons have the energy necessary to go over the 'hill' between metal and air, many never complete the trip. They fail to find the proper path and fall back down the hill, thus slowing up the rate of rust or corrosion."

NYLON IN TIRES

Giving Good Service Under Severe Conditions

BOMBER tires, containing strong sinews of nylon beneath their rubber surface, have given a good account of themselves in a year of action in the Pacific War Zone. Placed on planes of a type giving the greatest tire trouble, the performance has been eminently satisfactory.



With tough and supple nylon sinews

The tires have been subjected to punishment beyond anything in the experience of civilian motorists. The huge ships, sometimes weighing 25 tons or more, hit the ground at high speed, 100 miles an hour or more, on front line fields, necessarily small and requiring quick stops. With the landing brakes jammed on, the tread portion of the tire carcass actually buckles and folds back on itself. A tire must be tough to stand this torture. Nylon tires have demonstrated they "can take it."

Although nylon tires still are in an experimental stage, with some problems remaining to be solved, scientists engaged in the work assert they meet the most severe form of the standard bruise test without breaking. This test, made in a tire manufacturer's laboratory, involves pushing a blunt cone-shaped plunger down upon the tread of an inflated tire until the tire bursts. When this test was applied to 9.00 inch tires made of the strongest material in commercial use, they burst when the plunger had sunk six inches. Applied to 9.00 inch nylon tires, inflated to the same pressure, the plunger forced the inside of the tread clear to the rim without breaking the tire; and when the plunger was withdrawn the tire sprang back into shape, without a sign of injury.

RADAR

Background of the War's Greatest Development

THE recent lifting of certain Army-Navy restrictions pertaining to radar has been like the turning of the page of a magic story book. Now is revealed the part played by the American radio industry functioning in co-operation with the United States Navy and Army Signal Corps in the development of the revolutionary wartime science of detecting and ranging by radio. As an epic story of American teamwork between scientists and military-naval men, radar is an outstanding illustration.

Basic research work on apparatus and techniques for the locating of ships and planes by radio was instituted by the Radio Corporation of America as early as 1932, when experimental equipment was constructed. Apparatus completed in 1934 was used for a series of co-operative reflection tests with the Signal Corps. Immediately, the Army indicated an interest in the possibilities of developing apparatus for detection of aircraft and ships.

Encouraged by this response, RCA continued tests to determine what performance toward this end might be expected. With further development and improvement, the early apparatus indicated possibilities of much better performance than the sound locators then in use. By demonstrations and discussions, the Army and Navy were kept in touch with the RCA research. In view of military applications, no publicity was given to this development.

During 1937, operating equipment was completed and tested, indicating the distance and position of reflecting objects, in much the same form as is now used in a large part of modern radar equipment. These developments had so grown in importance to the military services dur-

ing 1937 that RCA was requested to put all of this work on a secret basis. As early as this date RCA is reported to have delivered experimental radar apparatus to the Signal Corps for aircraft location tests. Westinghouse and RCA produced for the Signal Corps portions of its first radar apparatus, such as was in operation at Pearl Harbor, on December 7, 1941. It is a matter of record how radar warned of the approach of Japanese planes on that fateful morning, but the operator's report went unheeded since his superior officer, knowing that a number of American planes were due from the mainland, believed that the radar had spotted them, and therefore took no action.

Like many inventions in radio, radar is attributed to no lone inventor. Since it draws upon many radio devices and circuits, various men of science have contributed to its development. Nevertheless, there are a number of radio men whose work has been directly concerned with putting it together and with the development of components that made it practical. The basic research of Commander A. Hoyt Taylor and Leo C. Young, of the United States Naval Aircraft Radio Laboratory, and Dr. John H. Dellinger of the Bureau of Standards, in studying the Heaviside surface and radio echoes, added much knowledge that helped to open the way to radar. Prominent also has been the work of Dr. Irving Wolff, whose early experiments with radio reflection soon led into radar principles. He has been intimately associated with radar research work, while a staff of research workers have been under his direct supervision.

During 1937, it is claimed that Westinghouse developed the key electronics tube for the first United States Army radar equipment for detecting enemy aircraft by means of invisible beams of radio waves.

Supplementing its present mass production of radar equipment, work on apparatus to "beamcast" radio waves is being conducted in the Westinghouse laboratories by a staff of specially recruited physicists and engineers in cooperation with the National Defense Research Committee, the United States Naval Research Laboratory, and the United States Army Signal Corps.

This research work is a continuation of studies begun nearly 10 years ago when Ilia E. Mouromtseff observed that radio transmission was being interfered with by highway traffic. Every time an automobile passed along the highway between the two buildings where the work was being carried on, the radio signals rebounded.

In September, 1940, it was radar equipment, utilizing the rebounding effect, which enabled the outnumbered Royal Air Force to turn back Adolf Hitler's previously invincible Luftwaffe, according to Lord Beaverbrook. It was also radar units, installed in British fighter planes, which provided, at least in part, their defense against night bombers by enabling them to locate and intercept the enemy in the dark. The British called their device the radiolocator. The American name for the new system is radar, an abbreviation of "Radio-Detection-and Ranging."

Radar beams, traveling at the speed of light, can be aimed at definite, predetermined places instead of fanning out in all directions as do the radio waves transmitted in the ordinary commercial broadcast.

Radar's advantages over the outmoded acoustic detectors, whose large listening horns were once familiar sights in news reels, are speed and range. Sound, picked up by an accoustic detector, travels at around 700 miles an hour, only about twice the speed of a fast bomber. But short waves carry the warning of approaching planes with the speed of light —186,000 miles a second. And they do this highly important war-time job over much greater striking distances.

Radio waves, on striking an obstacle, are reflected somewhat as sound waves are reflected to make an echo. The shorter the wave the clearer the echo or reflections; hence short waves are most successfully employed in radio-locators because their reflection is sharper.

A peacetime application of the echo principle is the absolute altimeter, an airplane safety device using short-wave transmitters and receivers. The transmitter sends earthward very short waves which are reflected into the air after

striking the ground. The receiver picks up the reflected waves and actuates instruments on the panel board of the plane to tell the pilot how far above the earth he is flying.

Radar functions as an absolute altimeter in reverse. The transmitter sends its waves from the earth into the clouds to probe the sky like an invisible beam of a searchlight. On striking the surface of an enemy plane, the beam is reflected earthward, where it is picked up by a radar receiver. These devices accurately indicate not only the position but also the distance of the approaching plane.

SPRAY GUN

For Insects, Has Plastic Parts

WHENEVER a manufacturer of a consumer product is forced to find a wartime substitute for critical metals, the consumer is usually the gainer. A recent case is the insecticide gun shown in the accompanying illustration. If you are used to the old tin and brass kind, you will be pleasantly surprised when you

No metal parts to corrode

bring home one of the newest wartime models. It is lighter, easier to manipulate. It has a squat, broad-based bottle which will not tip over easily. It has no metal parts to rust or corrode.

Standard Container, Inc., in collaboration with Universal Plastics Corporation, developed the new gun. They replaced the old tin barrel with a spiral-wound paper barrel . . . the steel plunger with one of wood and leather. To connect the barrel and the glass bottle, they used molded black cellulose acetate parts. Even the 1/16-inch dispensing tube is made of this plastic material.

WEED KILLER

Permanently Eradicates Certain Pests

POISON ivy and many other noxious weeds can be killed easily with a spray solution of ammonium *sulfamate* (not sulfate), a non-poisonous herbicide which is free from fire hazard and sterilizes the soil for a brief period only. Properly sprayed, weeds are eradicated permanently.

The base of the chemical is sulfamic acid, introduced by Du Pont's Grasselli Chemicals Department as a new industrial chemical less than two years ago. Since then the acid and its salts have been devoted wholly to war uses, but improved manufacturing "know-how" now permits release of substantial quantities for herbicidal purposes. Supplies are available

for applications around farms, factories, orchards, and military establishments and wherever an ivy poisoning hazard exists that may cause lost-time of essential labor.

Weeds killed by spraying with ammonium sulfamate include poison oak, chokecherry, wild black berries, Russian, Canada, and sow thistles. Weed destruction is achieved by absorption of the chemical into the foliage and thence down to the roots. It has permanent effect on many hardy, deep-rooted perennials heretofore difficult to eradicate. The weed killer is non-toxic to animal life when the recommended dilutions are observed.

Poison ivy and oak are particularly obnoxious in orchards in some sections, presenting a serious hazard in the care and harvesting of crops. Field experiments demonstrate that ammonium sulfamate spray causes no damage if it falls on tree trunks. It should be kept from fruit tree leaves, however.

WHITE TRAFFIC LINES

Made Permanent by Use of White Concrete

WHITE-SURFACED pre-cast concrete blocks are being used in several London boroughs for marking traffic lines. The blocks are 9 or 12 inches long by 4½ inches wide, and are generally 3 inches deep. Flat-surfaced blocks may be used, but a rounded or chamfered surface assists visibility; on a block 4½ inches wide a ¼-inch chamfer is enough to improve visibility without being dangerous to cyclists.—*Highway Research Abstracts.*

AMINO ACIDS

Some Essential, Some Not, To Human Beings

How human "guinea pigs" are for the first time revealing the body's needs for amino acids—little-known food elements essential for life and as important as vitamins—was told recently at a meeting at the Nutrition Foundation by Prof. William C. Rose, biochemist and acting head of the University of Illinois chemistry department, who has studied amino acids for 20 years and is an international authority in that field.

The human guinea pigs proved that the 12 amino acids not essential to animals were found likewise non-essential to humans. Eight of the amino acids essential to animals have proved likewise essential in human diets. One amino acid, histidine, which is essential to other mammals, has been found not essential for nitrogen balance in humans. One acid essential to animals remains to be tested to determine whether it is essential in human diets.

All previous experiments with amino acids involved animals. It was with animal subjects that Professor Rose in 1935 discovered the tenth amino acid essential for their normal growth, named by him threonine.

Amino acids are the components of proteins, the principal food constituents of meats, milk, and eggs. Threonine brought to 22 the known number of amino acids, and to 10 the number proved to be essential for normal growth of mammals other than humans.

For the past eight months the amino acid needs of humans have been studied at the University of Illinois by feeding synthetic diets to 12 male graduate students selected from a large number of volunteers. Each of the men continued on the diet for from one month to six weeks at a time.

They eat meals that are substantial though monotonous. Special crackers contain most of the food elements other than protein. The crackers are spread with purified butter to provide fat. In place of proteins the men drink solutions of amino acids in distilled water flavored with lemon juice. They also take cod-liver oil and vitamin pills.

This diet contains all food elements in proper proportions to maintain weight and the nitrogen balances of the body. After a week or more to check and stabilize the diet, one amino acid is omitted for several days while the effect on weight and nitrogen balance is noted. Then it is replaced to check the return to normal conditions.

PERMANENT ANTISEPTIC

Has Uses in Textiles, Packaging, Industrial Processes

ODORLESS, tasteless, colorless, are the sensory characteristics of a newly devised permanent antiseptic which apparently

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READERS desiring further information on new products, or research and development work reported in these pages will be referred to manufacturers or additional sources upon request. Address our Research Department, giving specific references, including date of issue and page number.—*The Editor.*

holds promise of finding wide applications in our industrial and everyday lives. This new material, known as Perm-Aseptic, has a dye-like affinity for fibrous and plastic materials. Once incorporated in such materials it has the advantage of retaining its antiseptic qualities for long periods of time and through repeated washings or cleanings.

Tests have shown that Perm-Aseptic not only kills micro-organisms within its penetration area but also inhibits subsequent growths on treated materials. These same tests have indicated that these antiseptic qualities, in the case of fabrics, are effective even after 40 washings; on tooth brush bristles they have been proved effective after 700 washings. This new antiseptic not only kills bacteria but attacks certain fungi as well, thus making possible the control of growths which, uncontrolled, create tremendous annual losses to textile manufacturers, food processors, and so on.

Possible applications of Perm-Aseptic are in the manufacture of paper, in container materials to inhibit the growth of bacteria and mold, in food preservation, and in the protection of textiles for innumerable purposes.

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FIRE RESISTANCE—In treating wood for high resistance to fire, as much as three and one-half pounds of dry chemical per cubic foot of wood is required.

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MOTOR CONTROL

Regulates Speed Through Use of Electronic Tubes

A NEW team of electronic tubes designed to speed up and increase the usefulness of industrial machinery powered by electric motors has been assembled by engineers of the Westinghouse Electric and Manufacturing Company. Key parts of this new electronic device, called Mot-o-trol, are glass and metal tubes which, working without moving parts and acting many times faster than any mechanical device, will replace electric motor-generator sets or mechanical gadgets now being used to regulate the speed of cutting tools, conveyors, and scores of other industrial machines.

Housed in a cabinet smaller than a floor-model radio, the Mot-o-trol provides wide speed ranges, close speed regulation, and smooth automatic starting of direct current motors, the "work horses" of war industry.

"These motors," says Thomas R. Lawson, electronics engineer for Westinghouse, "must be fed just the right amount of direct-current power at the proper time so they will turn a lathe, drive a conveyor belt, or feed metal into cutting tools at the pace required.

"Most industrial plants are supplied with alternating-current electricity but alternating-current motors are unsuited for such jobs because they have only a few fixed speeds, depending upon the motor's construction and the number of times the current alternates. But a direct

current motor receiving its power through these tubes can operate at many different speeds over a wide range—just as you can drive your automobile at speeds ranging from a walk to 80 or more miles per hour by changing the pressure of your foot on the gas pedal."

At present, Mr. Lawson explains, some industrial plants drive their machine tools and other equipment by hitching an alternating-current motor to a direct-current generator and then using the generated power to drive the direct-current motor. Speed is changed by "throwing away" part of the generated power. Others attach belts and pulleys to an alternating current motor and vary the speed of the machine by altering the size of the pulleys.

The Mot-o-trol converts alternating current from the power line into the required direct current by means of two electronic tubes called thyratrons which allow current to pass in one direction only. "Inside each of these power tubes," the engineer says, "is a grid which is connected to a speed-control dial in front of the operator. Turning this dial varies the electrical 'pressure' on the grid so that it acts as a faucet, opening to let more power pass through the tube to the motor or closing to reduce the stream of power and thus slow down the motor."

The speed control dial moves a metal button which rides on a semi-circle of smooth carbon. It can be turned to any

Direct-current motor speed control

desired point, giving an infinite number of speed variations. On the Mot-o-trol control board there are two of these dials, one for forward and one for reverse speeds. In addition, there are push buttons for forward, reverse, and stop.

Here's a typical application of the new electronic device: On a machine tool cutting a slot in a large piece of steel, the operator can select the best cutting speed by turning the forward speed control dial. This speed depends upon the toughness of the steel, the depth of the cut, and the cutting tool's quality. Then, by turning the reverse speed dial, he can make the tool return to the cutting position at high speed so that there is little non-working time.

Other electronic tubes in the Mot-o-trol stand guard over the motor. If something goes wrong with the machine being driven so that the motor is under heavy load and drawing dangerous amounts of current, these tubes automatically cut off the power supply before the motor is harmed. The unit can be mounted on or built into the machine tool or other equipment for which it "tailors" electric power. Those now being built are designed to furnish power to motors of one horsepower or less but larger ones can be built for machines requiring more power.

FIRE EXTINGUISHER Made with Non-Critical Container

FIBERBOARD tubes in a wooden holder form the basis of a new fire extinguisher made of non-critical materials. Reported to be accepted by the Interstate Commerce Commission for the protection of motor vehicles, and carrying the seal of the Underwriters' Laboratories, the extinguishing material, stored in seven-pound fiberboard tubes, is a free-flowing, water-repellent dry powder that extinguishes fires in gasoline, alcohol, wood, and paper, and can be used on fires in electrical equipment.

Elmer Sperry and His Magic Top

(*Continued from page 67*)

cess. As trains grew heavier and faster, the danger increased.

Sperry's solution was characteristically simple, and effective. He reasoned that any internal flaw in the rail would disturb the flow of electricity. So he built a special testing car called the "flaw detector," with a dynamo to generate current which was shot through the rails, and a device which instantly recorded any variation in the flow. The crowning touch was a pump which automatically squirted white paint on any defective section of rail. At first the railroaders thought it wouldn't work—too simple. But it has worked for almost 20 years and is working today. Just since the start of this war, Sperry Detector Cars operated by Sperry Products, Inc., for the railroads, have tested 140,000 miles of track and discovered more than 113,000 defective rails—each one a potential cause of a wreck.

To accomplish what he did, Elmer Sperry drove himself unmercifully. He was so full of energy that his engineers in the Gyroscope Company sometimes hid behind pillars or filing cabinets at the end of the day when they saw him approaching with his quick, bouncing step and a bright gleam in his eye that probably would mean an all night session. He had a peculiar capacity for juggling several ideas simultaneously, and frequently held multiple conferences, outlining a new project to one man, telling another how to prepare a blueprint, and offering suggestions to a third.

Work to him was the only justification for living, and even when he was supposed to be relaxing he never got far away from his work. He used to enjoy having his wife or his daughter Helen read to him in the evenings, but as often as not he would hand them a technical article on electro-chemistry, or patent specifications detailing a double connecting rod attached to a crank arm. Patiently they would read, until Sperry would jump up and say, "Now I've got it"—and hand them another technical paper.

Sperry started his career at the age of six, when he invented a horseradish grater for his aunt in Cortland. That was in 1866. When he was 12 he invented a multiple, semi-automatic drill that speeded up the work of a wagon shop in his home town. At 18 he built an improved light and so astonished his neighbors that they collected a fund to send him to Chicago, where he got his start—his initial success financially. He remained an inventor even on his deathbed. It was unbearably hot in New York on June 16th, 1930, and the hospital room where Sperry lay in his last illness was stifling. At three in the morning a cake of ice was brought in and placed in a tub, with an electric fan blowing across it. The room temperature dropped a degree or two, and with a great effort the dying man whispered—"Put some water in the tub. It will give more cooling surface."

Those were Elmer Sperry's last words. His inventive mind was busy to the end.

New Products

PLASTIC ADHESIVE AND CLEANER

PROTECTIVE paper used on plastic surfaces such as those on bomber noses and gun turrets, to prevent damage during handling, shipment, and storage, may now be cemented in place by means of a new adhesive developed by E. I. du Pont de Nemours and Company. The adhesive is so compounded as to permit stripping the paper from the plastic without leaving any deposit on the surface.

For similar plastic surfaces which have become covered with grease or other foreign matter a new liquid cleaning material known as Plexi-Glyst has been developed by Turco Products Inc. The material is applied by spraying or by wiping on with a sponge or clean cloth after loose dust that might cause scratching has been flushed off with water.

WRINKLE FINISH

RESTRICTIONS on the use of Chinawood oil have severely restricted the manufacture of standard wrinkle finishes. Recently, however, there has been announced by Mass and Waldstein Company a new line of wrinkle finishes which contain no Chinawood oil yet which will form hard and durable coatings. The regular wrinkle patterns, it is reported, are obtained by the same methods as were used with former materials.

DUNKING AND DRYER BASKET

A NEWLY patented dunking and dryer basket, made entirely from scrap metal, is said to be extremely practical since it is included with a standard five-gallon steel shipping pail with a removable top containing the Curran Corporation's newly announced Carbon Met substitute for Carbon Tetrachloride.

The bench kit is shipped complete and is easy to use—all that is necessary is to place the part to be cleaned in the dunking basket and dip it into the volatile Carbon Met.

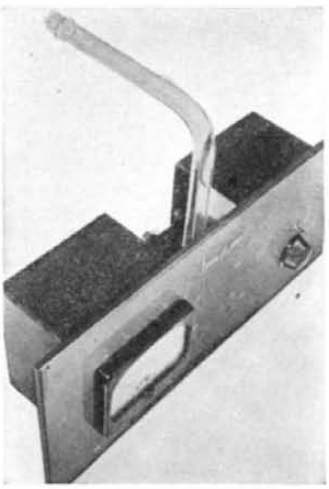
On withdrawing the dunking basket, the spring-like clips attach themselves to the edge of the container, allowing excess solvent to drain back into the pail. Within a very few minutes the parts in the basket are completely dry and clean.

Since the dunking and dryer basket is constructed entirely from extra pieces and scraps of new metal, it is not necessary to have a high priority.

Cleaning kit, complete with cleaner

CONTINUOUS COLOR READINGS

DESIGNED to register the light transmission of a liquid passing continuously through the instrument, a new colorimeter has been developed by the Photovolt Corporation. With this instrument the concentration, color, or turbidity of a flowing liquid is read in terms of light transmission.



For measuring liquid colors

The operating principle of the colorimeter depends upon light from an incandescent lamp passing through a color filter and then through the liquid. The transmitted light impinges upon a photoelectric cell, the current of which then registers on an electric indicating instrument.

The distinctive feature of the Continuous-Flow Colorimeter lies in the liquid

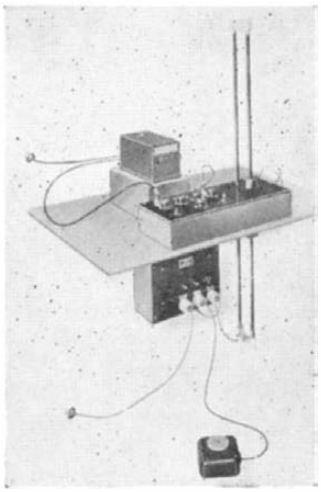
under test passing through a glass tube rather than being contained in an absorption cell or a test tube. This makes the instrument suitable for the continuous control of chemical processes in which the color or turbidity of a liquid must be checked either as a measure of its concentration or as an indication of some other chemical or physical condition. Once calibrated by means of a solution of known concentration, the instrument indicates the concentration directly and continuously, obviating the necessity of taking samples and analyzing them at regular intervals.

POLISHING POWDER

GLASS, marble, and granite formerly polished with tin oxide putty powder can now be worked with a new metallic oxide powder, which does not stain, is lighter in weight than tin oxide, and is not made from highly critical materials. This new material is called Victory Faspolish.

PRECISION TURN COUNTER

AN IMPROVED coil-turn counter for laboratory or factory use in determining with precision the number of turns in wound electric coils has been announced by the Special Products section of the General Electric Company. The counter is capable of checking or determining



Coil-turn checker

the effective turns of coils ranging from 1 to 11,110 turns, at a rate of from 80 to 100 coils of like specifications per hour.

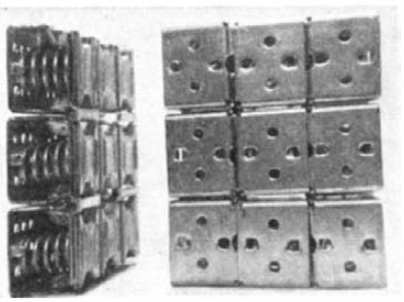
In addition to the magnetizing current control box, the new coil-turn counter comprises a portable light-beam galvanometer, two yoked test rods, a galvanometer control panel, and a foot-operated switch—all conveniently assembled for operation on table or bench.

The operation of the counter is simple. The coil to be tested is placed over the test rod and connected to test clips. The dials on the galvanometer control panel are set to the number of turns the coil should have, and the foot switch is pressed. If the galvanometer dial shows a deflection, the dial readings are increased or decreased until the deflection is zero. The dial reading is then the number of turns. When the probable number of turns in a coil is not known, a trial reading is taken and the dial is adjusted until the reading is zero on the galvanometer.

The accuracy of the counter is one turn in a thousand for coils having air cores at least ⅝ inch in diameter, an outside diameter of eight inches and less, a coil build-up to 2⅝ inches, and up to six inches in height. Accuracy is not as high for coils outside these limits.

SPRING MAT

A SPRING cushion device of all-metal construction, consisting of a cap, a stud or base, and a spring, is being used to provide effective spring action wherever cushioning is required. The parts of the



End and top views of spring mat

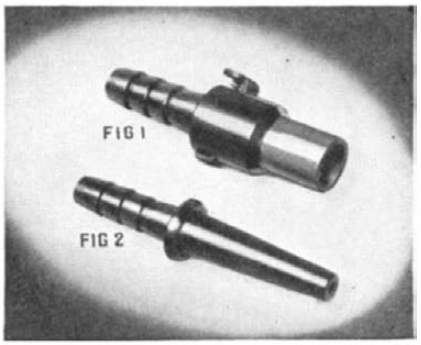
device are held together by side lips which position the springs firmly yet permit a full-floating action at all times. The construction is such as to allow free motion of the springs yet to prevent all sideway.

A standard unit of nine cells, capable of sustaining a load of 100 pounds, can be used in any number and combination to attain the cushioning area and strength required.

For absorbing vibration and mechanical shock in machine tools, printing presses, and other mechanical installations, these Rande Unit-Springs are being used to replace rubber and other vibration absorption materials.

PLASTIC NOZZLE

ONE more example of the replacement of critical metals by plastics is in the field of fire-fighting equipment where strong, durable, and light plastic nozzles are now being furnished for standard hose sizes of fire extinguishers, pressure operated tanks, stirrup pumps, and so on.

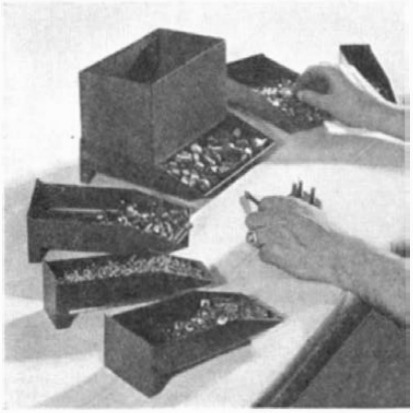


Two standard plastic hose nozzles

These nozzles, produced by American Molded Products Company, have long life qualities and are corrosion proof, non-denting, highly resistant to acids, alkalis, and other liquids, and will hold their shape perfectly under normal use.

BENCH BINS

DESIGNED for use directly on the bench and without the need for racks or other holders, a series of standard bench bins are being made available by the Gordon L. Hall Company. The bins are raised at the back, thus ensuring proper forward tilt for gravity feed of small parts. These



With and without hoppers

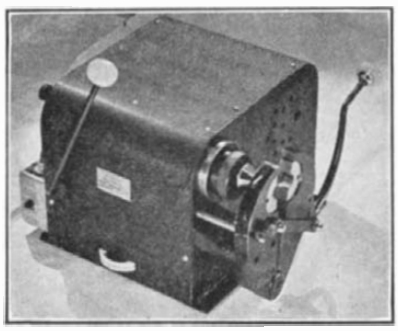
bins, adaptable to an unlimited variety of arrangement, have folded edges at the front to protect the users' hands and are ruggedly built of sheet metal. Standard models are available as well as models equipped with hoppers, as shown.

MASKING PAPER

STRIPS of pressure-sealing adhesive applied to one or both edges of a new masking paper secure the paper to flat surfaces or protruding parts which have to be masked against paint spray. The paper itself resists paint and the adhesive strips off clean after painting is completed. The use of this Edge-Gummed masking paper shows marked economy and increases ease of removal.

TUBE MACHINE

A WIDE range of sizes of ferrous and non-ferrous tubes can be flared, squared, burred, or beaded in a new machine recently placed on the market by Leonard Precision Products Company. In this machine, illustrated in these columns, a work-holder was located in front of a rotating spindle which carries an adjustable tool-holding socket. In the socket can be placed a combination burring and squaring cutter, a flaring tool, or a beading device. Arrangement is made for positioning the tube for accurate operation.



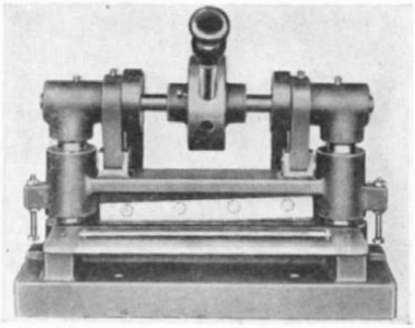
Levers control the tube machine

CHECK VALVE

SIX basic combinations of check valves are available with a new universal check valve recently developed for aircraft hydraulic lines, but adaptable to other purposes. These combinations are made possible by the use of a standard body and three types of adapters. By reversing the plastic poppet in the check valve assembly, the direction of fluid flow can be changed, making a total of 12 possible valve combinations.

SHEAR

AN IMPROVED bench shear for precision work on light and medium weight metals, shown in the accompanying illustration, has recently been added to the Di-Acro line. This shear, ruggedly constructed for



Front view of bench shear

long life and ease of operation, can be quickly arranged for shearing, squaring, slitting, stripping, or notching to extremely close tolerances. The use of this tool frequently eliminates the preparation expense and time delay of preparing blanking and forming dies.

RELAY

DESIGNED particularly for aircraft power circuits, a new Ward Leonard relay will perform its functions under high values of acceleration of gravity and under severe conditions of vibration and shock. Under these conditions the armature and the contact assembly will retain operating position. These functional factors have been achieved through compact and sturdy design and through rigidity of the entire relay assembly.

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READERS desiring further information on new products, or research and development work reported in these pages, will be referred to manufacturers or additional sources upon request. Address our Research Department, giving specific references, including date of issue and page number.— *The Editor.*

Pre-Flight Training

Economy of Both Time and Money are Achieved With Trainer that Gives Complete Illusion of Flight

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

THE Soulé-Rabkin pre-flight trainer bids fair to speed-up and even improve the process of training young pilots. The student enters the trainer, closes the hatch, fastens his belt, and achieves the illusion of being in a flying airplane. This illusion is achieved by a combination of effects. A moving picture on a screen close ahead of the young man gives the impression of movement. As he moves the controls, the airplane nose mounted in the screen inclines in such fashion that the student can readily imagine that he is

Complete illusion of flight

executing a bank or a turn, is climbing or descending. On the instrument panel, the instruments automatically register the true character of the maneuver. Thus the turn indicator shows the direction of the turn, the degree indicator shows the degree of the turn, the bank indicator tells the would-be pilot whether he is coordinating rudder and aileron correctly. The rate of climb indicator, the air speed indicator and the tachometer or revolution counter all register precisely as they do in a plane. A motor sound effect trains the ear and heightens the illusion of movement.

The "mistake counter" is still another valuable aid in this training system. Suppose the turn is made incorrectly and the ball indicator shows a skid or a side slip. The mistake counter will record the error, though a time relay gives the student three seconds in which to correct the error. By keeping a chart of the mistakes from lesson to lesson, the rate of improvement can be noted.

Then, too, there are other valuable features in the trainer, such as interchangeable noses which accustom the student to the different silhouettes of trainer, advanced trainer, fighter, and bomber. Also, the scenic strip can be changed so as to familiarize the pilot with any particular area.

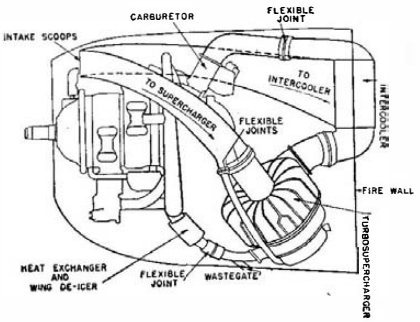
Both economy of equipment and time are provided by the new device and, in some respects, the pre-flight trainer is actually an improvement on the training plane itself. Of course, however, nobody could possibly learn to fly well without actual hours and hours of experience in the air.

• • •

INTEGRAL SUPERCHARGER Can Overcome Many Airplane Power Plant Difficulties

IN THE installation of the supercharger there are apt to be many lengthy duct connections, difficulties in the intercoolers, difficulties in lagging pipes, and so on. In one airplane the supercharger has had to be placed far back towards the tail end of the fuselage, with structural complications and much added weight. Dr. Sanford H. Moss, who has for so many years been identified with the development of the turbo supercharger, now outlines, in a paper presented before the Society of Automotive Engineers and entitled "Aviation Power Plants," the advantages of integral power plants for airplanes and suggests that the entire turbo supercharger installation become a part of the integral power plant.

The proposal is well put forth in one of our illustrations, in which it is seen that engine and supercharger—the whole unit, in fact—will be compactly and conveniently mounted again on the fire wall. It is easy and worthwhile to identify the main elements of the installation. From the rear of the engine the exhaust gases will be lead through a pipe around which there would be placed a heat-exchanger which would lead heat to the wing de-icer. Via a flexible joint and a waste gate, the exhaust gases would go to the exhaust gas turbine which would drive the super-



Engine and supercharger unit

charger proper. The intake scoop would lead air into the supercharger. Since during the compression process the air would heat up, it would then pass through an intercooler where outside air would reduce the temperature to reasonable levels. The cooled air would then go to the carburetor and subsequently to the engine manifold.

It would be a decided advantage for the airplane designer and constructor if he could indeed secure an integral supercharged power plant and avoid all the "headaches" of designing a complete installation himself.—*A.K.*

POST-WAR

Aviation Will Not Need Government Interference

WHEN the end to the war and allied victory come, peace-time aviation will be resumed with renewed vigor; it is thus desirable to turn briefly to considerations of post-war aviation. No one can speak with more authority of America's aviation tomorrow than Colonel Edgar S. Gorrell, distinguished flying officer in the last war, and now president of the Air Transport Association.

One of Colonel Gorrell's first points in an address presented before the Foreign Commerce Club was that while aviation is a new industry, its development does not call for extraordinary social measures, for mumbo-jumbo, for "statization." Aviation did remarkably well in the hands of the pioneers and is doing well with the airlines of today. There is not the slightest necessity for government ownership either in domestic or in foreign commerce. Readers will recall the sad days when the Army took over the carrying of the mails. Direct governmental intervention or ownership has been familiar in Europe for many years, yet European airlines have lagged far behind our own, in mileage flown, in the number of passengers carried, in the speed and safety of operations. The very significant index of passenger miles per route mile operated was, in 1938, four or more times better for American air carriers than for government supported or owned European airlines.

The private airlines have now accumulated a vast degree of skill and tradition. They have *esprit de corps* and the stimulus of competition. Why should we throw all this away to let the lethargic bureaucratic spirit intervene?

We do not quote Col. Gorrell directly, but paraphrase freely and perhaps our remarks are even stronger than those of the speaker himself.

Besides advocating freedom from government ownership, the speaker drew attention to one very important bill now pending before Congress; namely, the Lea-Bailey Bill by which it is proposed that federal regulation be extended to all air commerce whether between points within a single state or between points in different states. It will be a sad day for the United States when our great states become insignificant appendages to Washington, but federal regulation of

scheduled air flying seems highly desirable. Said the speaker: "The reason is to be found in the special characteristics of air commerce. The speed of an airplane, even were it to move no faster than surface vehicles, would be much greater than the speed of surface transportation because it is able to move directly to its destination unimpeded by surface barriers. And bear in mind that even the pre-war airplane moved at a rate often five or six times faster than ordinary surface transportation."

A strong aviation industry in peace time would also mean a strong manufacturing industry, invaluable in time of war and the best safeguard against more vagaries on the part of Germany.—*A.K.*

MODIFICATION CENTERS
Perfect Aircraft Changes With Minimum Production Delay

IN THE last war and in the present war, every military aviation unit tried or tries to modernize its planes, to keep them supplied with up-to-date instruments, to introduce as rapidly as possible the changes which actual combat have shown to be necessary, to make the adjustments which a change in season or a change in climate make advisable. It remained for the American Army Air Forces to carry this principle to its logical conclusion and to provide gigantic modification centers (another name for modernization centers) all over the world.

The great advantage of these modification centers is that the airplane manufacturer can proceed with quantity production, on well planned, well organized lines, while the modification center can carry out minor work with a minimum of trouble and delay.

The service manager of one of these modification centers states the guiding principle in words upon which we cannot improve: "Production methods would require planning and tooling for 18 months to two years to build perhaps 300 ships for a special purpose. We can modify the same number of basic airframes in a fraction of that time. . . . We'll say it would take a month to make a certain die. We can beat out enough parts to do the job in a week, without slowing basic production or making it wait for change-orders." Incidentally, change orders used to be the bane of aircraft constructors.—*A.K.*

LIFE RAFT
Automatically Ejected From Forced-Down Plane

THE UTMOST ingenuity is being exercised to save the lives of airplane pilots, whether carrier-based or land-based, who may be forced down at sea. The latest and not least important device is an automatically ejected and automatically inflated life raft.

The new device, originated by engineers of Walter Kidde and Company, employs a water-sensitive switch which is mounted on the underside of the fuselage. When the fuselage of the land plane touches water, release valves on two cylinders of carbon dioxide are opened automatically. The gas from the first of these cylinders opens the hatches of the raft compartments in the top of the fuselage. Gas from the second cylinder expands to 450 times its stored volume and inflates the raft which then floats free except that it is held to the plane by a light line.—*A.K.*

Compressed gas does the job

AUTOMATIC RIVETING
Speeds Production of Wing Spars and Skin Coverings

IN THE construction of all-metal combat aircraft, production speed is governed by the fact that thousands of rivets have to be inserted in their respective holes and driven home. To increase this speed, an automatic riveting machine, developed by General Engineering Company and illustrated in one of our photographs, provides for the mechanized riveting of wing spars or wing skin coverings.

The parts to be riveted are placed on light handling frames or run through the machine automatically on simple roll stands. Powerful hydraulic cylinders are provided, having a maximum force of 56,000 pounds. Bucking units are mounted on the upper frame, riveting units on the lower frame and the two units move together.

Actual tests has proved that the use of this machine results in savings in man power as high as 30 to 1.—*A.K.*

Aircraft riveting speeded-up

Our Book Corner

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

Conducted by JOHN P. CANDIA

FOOD FOR THOUGHT
By Willkie and Kolachov

ONE of the most controversial subjects in the whole broad field of internal combustion engines and their use is that of gasoline *versus* alcohol. Here is one side of the question, prepared by two men who are thoroughly conversant with the art of alcohol distillation, and presented as a solution to many of the phases of the agricultural problem. One-sided though the discussion must necessarily be, it is thoroughgoing in all its ramifications. (210 pages, 6½ by 9½ inches, a number of charts, photographs, and tabulations.) —$2.10 postpaid.—*A.P.P.*

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By Pennington, Hough, Case

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By P. C. Sandretto

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By E. F. Goad

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TELESCOPTICS

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

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

NOW AND then this department learns of a telescope mirror which, while its performance on the stars apparently is not affected, exhibits under the knife-edge the entire outline of the lap on which it was cold pressed. George A. Kennedy, mining engineer, of Denver, before he died, described a mirror figured for him by C. S. Walton, 5975 W. 44th Ave., Wheatridge, Colo. (after a very noted old optical firm in New England had re-figured it for $100 and done a botch job). The lap had often been left for many hours on the mirror, under a seven-pound weight. At the end of figuring, the Foucault test made clearly visible the pattern of the lap. "It does not seem to interfere in the least with the excellent performance of the mirror on the stars," Kennedy wrote. Yet his curiosity was aroused.

A. W. Everest commented as follows: "I've seen pitch that would etch glass, and I know of several cases where ordinary city water ate a hunk right out of it. Leo Scanlon has a mirror that looks like a perfect pitch lap under the knife-edge test, yet with a perfect visual polish. He blames it on the water in the Monongahela River. Kennedy's, however, sounds like that other monster, pitch flowing into the glass, with long pressing. Glass molecules are rather loosely packed, and pitch will readily flow in between them if the water film is missing. When the lap is removed, generally only after a fight, this pitch is sheared off and stays there, making the pattern of the lap harder than the rest of the surface. You can't see it at first, but, since this part of the surface polishes slower than the rest, about the time you think you are finished, there the thing will stand out in relief under the knife-edge test. Several hours' hard polishing would cut through this hard skin."

"Why, however," Everest continues, "does anybody press any lap more than an hour or so with only enough weight to get it into contact? The lap doesn't fit the mirror ten seconds after you start to use it, anyway."[See Everest's chapter on advanced mirror making technique, in "A.T.M.A."—Ed.]

Referred to Kennedy, these comments elicited the following: "The lap was never in contact with the glass *dry* for a moment. Also, acid etching would seem to be the most probable answer if the image on the glass were all criss-crossed, because of the numerous times the lap had been replaced in a different position during pressing and polishing. But it is not. The lines of the facets are all clear and unbroken."

This appears to eliminate the effect described by Everest, in connection with this particular mirror, but the effect, with its odd cause, is well worth remembering.

The correspondence was shown to Leo Scanlon, who passed it to Dr. Lee Devol, at the Mellon Institute of Industrial Research, who is interested in glass. He commented as follows: "Glass does many strange things which we have not yet learned how to explain. I do not believe any of us can say exactly what took place in the transfer to the glass. We do know that glass is readily attacked by different chemicals. Even pure water can be guilty of the attack. There was moisture in the lap, together with a large number of compounds whose action it would be impossible to predict. The remaining surface may be more resistant to polishing because it is harder, or because it is more resistant to chemical attack by the water in the rouge, or it may be that the chemical nature of the glass surface is such that it is less inclined to attach itself to rouge than it would have been before exposure to the lap. In this case there should be, for the portion of the glass which has been covered by the lap, a lower coefficient of friction in polishing."

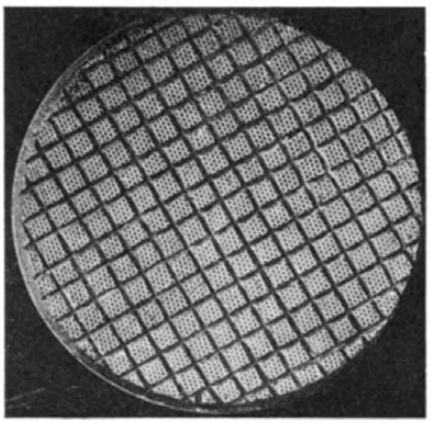

Figure 1: **Sub-facetted lap**

Well, so what? This: We have hypotheses but no final answer. Can anyone else provide the definitive one in this odd puzzle?

ONION SACK or any kind of coarse-mesh netting may be used for cold-pressing sub-facets, or facetettes, into the ordinary facets of a pitch lap (Figure 1). This has long been common among professionals. There is no mystery about it and it is simple to do. The fabric (wet) is laid on the pitch lap, and the mirror is then laid on the fabric, and cold pressing is done as usual.

Commenting on the use of onion sack, Cyril G. Wates, Edmonton, Alberta, says, "I wouldn't go back to the plain lap. You can lift the mirror right off the sub-facetted lap with no suction at all. The objection, sometimes heard, that the facetettes soon press out seems without much foundation. They remain after 24 hours' cold pressing (without weight). I also find them a complete remedy for the mottled effect known as 'dog biscuit.'"

F. B. Ferson, Biloxi, Miss., who also uses onion sack, says, "My experience is, as Wates says, that the facetettes take quite a long time to press out. I like facetettes from onion sack because the lap seats almost at once. I use common onion sack from a grocery store—first washing it, of course. The lap hardness and pressure of polishing govern the sinking speed of facetettes. They should sink out in not over two hours of actual work of polishing by hand."

Your scribe years ago used marquisette for the same purpose. If you don't know this word, ask the feminine side or, simpler still, yank down a window curtain (justified, of course, in the name of sacred science). Figure 1 shows a 6" lap with facetettes pressed in with some such material, as used by H. Lynn Bloxom, 1425 Fourth Ave., N., Fort Dodge, Iowa.

AS IS WELL-KNOWN, after several years' effort to teach his invention, the HCF lap, perfect manners, A. W. Everest decided that it probably would never become a true smoothie. He, therefore, revised his chapter on the HCF lap in "A.T.M." (4th ed.), recommending its use through the polishing and gross figuring stages alone, and a pitch lap for final figuring. The reason for this was the uneven surface texture HCF gives.

Others found that HCF will not always make a perfectly fitting lap: It is often rather inflexible. William A. Rhodes, 1206 E. Garfield Street, Phoenix, Ariz., obtains a perfectly fitting HCF lap by softening the beeswax tetrahedrons with radiant heat and pressing before they cool.

First, the tool is primed by rubbing pieces of HCF or other beeswax into its pits. Next, the HCF is applied, the mirror laid on it, and the protruding HCF trimmed off.

Then, with a bowl type of electric floor heater, the lap is warmed to the exact temperature "at which, by touching the very edge of the HCF with the finger, it will feel as if about to collapse, but no higher." Rhodes points out that, if carried a whisker higher, it "will suddenly disintegrate into a puddle even before one can withdraw the lamp. What is wanted is a mushy condition."

In the meantime the mirror has been warmed, and rouge mixture has been swabbed on it.

The warm mirror is placed immediately on the lap and loaded with about ten pounds extra pressure, and the two are left to cool to room temperature.

"Instead of the tetrahedrally embossed

HCF surface it will look as if buckshot had been pressed into it. This gives 50 percent added surface at the start of polishing and the surface will fit the mirror."

This, of course, is now essentially a plain beeswax lap, not an HCF lap, but many prefer beeswax laps anyway, and this is one way to make one.

Rhodes roughs out his mirrors with crushed steel and makes a separation of glass particles from the particles brushed off the tool, for re-use, by means of a magnet, which picks up the steel grains. These are then pulled off the magnet by hand.

THE FOLLOWING communication written by F. W. Bubb, Professor of Applied Mathematics at Washington University, St. Louis, Mo., appeared in the *Journal of the Optical Society of American* (Vol. 32, p. 400), and is related to the note on page 319, "Amateur Telescope Making" (Prof. R. W. Wood's experiments).

"It is well known that a liquid rotating in a vessel with constant angular velocity develops a central cavity in the form of a paraboloid of revolution. Such a liquid surface formed upon mercury was used by Professor R. W. Wood as the reflector of a telescope.

"The thought naturally comes that, if one could solidify a liquid after rotation had been set up, one might get a very perfect parabolic mirror—possibly of great size and of any desired focal length.

"A number of synthetic resins are now available in liquid form, which harden into solids upon heating. Some of these solids are remarkably strong, having a tensile strength of about 15,000 pounds per square inch.

"May it not be possible to rotate a vessel containing one of these liquids, heat it while maintaining the speed of rotation constant, and thus harden the plastic with its perfect parabolic cavity? Such a surface could then be coated with a reflecting metal film.

"Certain questions arise as to the practicality of this scheme. Would the rather high viscosity of these liquids permit the parabolic surface to form before hardening sets it? After hardening begins, does the volume of the plastic change—thus altering the shape of the surface? Will evaporation from or absorption of moisture into the body of the plastic alter the shape? Might not these objections—as well as those which others will find—be overcome?"

Your scribe referred this question to some of those in charge of the 200-inch telescope. It will be recalled that, before using glass for the mirror, a variety of other substances were carefully studied. It proved that the trouble with this idea was the "mosaic" structure that forms on the surface of the synthetic resins.

TEST for turned down edge on a mirror is offered by William M. H. Grace, Jr., 304 S. Foster St., Dotham, Ala. Place the mirror on edge on a table so that the image of a naked lamp bulb, behind the observer, appears on it. The lamp bulb should be far enough from the eye (via the mirror) to appear about one fourth the mirror's diameter. Look at the image and move the head until it shifts to the mirror's edge. If the bulb appears to flatten just before its image runs over the edge, the edge is turned down. If it appears to be sucked over the edge, the edge is turned up.

Grace finds this test more delicate than the eyepiece test—which, however, isn't nearly so sensitive, according to Harold Lower, as the Ronchi and diffraction tests, especially if the eyepiece is a cheap one. But it would show a grossly turned edge, and such a test is useful to beginners who don't yet feel sure of their own interpretation of other tests.

THERMAL effects caused by evaporation of the water used in polishing are explained by Everest in "A.T.M.A." page 27. To obviate this, J. R. Haviland suggests a trial of Prestone or a saturated solution of magnesium chloride and water —neither of which liquids will dissolve pitch or wax and, being non-volatile, will not evaporate.

SHARKS who can handle optical design, including its mathematical equations, will find in the May number of the *Journal of the Optical Society of America* a 15-page article by W. M. Stempel of Stevens Institute of Technology, entitled "An Empirical Approach to Lens Design." The design of a Huygens eyepiece is the example used for setting forth this empirical method.

HAVE you a copy of Conrady's "Applied Optics and Optical Design" which is not at present in use, and which you will be willing to place in the hands of war production workers in optics who need this book? It is now (temporarily, we hope) out of print and apparently unobtainable anywhere. You could probably obtain from sale whatever you originally paid, even for a worn copy. Other books on optics are out of print, one being Martin's "Applied Optics" which, it is said, will not be reprinted for the duration.

NEW BOOK entitled "Prism and Lens Making," by F. Twyman of Adam Hilger Ltd., England, embodies that author's lifetime experience in this work and will soon be reviewed in this magazine. It contains much that would interest precision opticians in any kind of production .(Advance notice.)

TROPICAL sky maps are not common. In an English scientific journal (*Nature,* March 27, 1943) we discover a brief listing as follows: "Watson, H. E., compiled by. The Tropical Sky; maps of the constellations visible in the latitudes of the West Indies, Guianas, Nigeria, E. Africa, Ceylon, Malaya, etc. (5° to 10° N. or thereabouts) and of the planets and Solar System, showing how and where to identify them in the starry background. Pp. 27 plus three maps. Georgetown, British Guiana, *Daily Chronicle, Ltd.,* 1942. 3s 6d. net." These maps are *not* available from Scientific American, and interested readers must order direct from the publishers. We have not seen the maps. The above are *all* the data we have concerning them.

CURRENT BULLETIN BRIEFS

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

DY-NAMIC BALANCING MACHINES is a loose-leaf booklet presenting condensed specifications for a line of floor and bench model machines designed for accurate balancing of rotating parts. Supplementing this material is a resume of the need for balancing certain types of mechanical equipment. *Bear Manufacturing Company, Industrial Division, Rock Island, Illinois.—Gratis.*

WOOD PRESERVATIVES is an eight-page illustrated brochure directed toward constructors of laminated beams and arches as well as manufacturers of sash, doors, plywood, and other wood products. The text explains the advantages of a complete series of low-cost wood treatments for protecting against moisture and fungi decay. *I. F. Laucks, Inc., 911 Western Avenue, Seattle, Washington.—Gratis.*

HANDBOOK ON EDUCATION AND THE WAR is a 359-page book reporting statements made by heads of Federal war agencies which are concerned with education and symposiums held on 26 of the more acute wartime educational problems. *Superintendent of Documents, Washington, D. C. —55 cents.*

THE STORY OF LIGHTNING, a 24-page booklet, is an account of how "thunderbolt hunters" study and counterfeit lightning in order to help improve electric service. Photographs of the equipment and of actual flashes of lightning are included. Bulletin GEB-124, *Publicity Department, General Electric Company, Schenectady, New York.—Gratis.*

LADY, WILL YOU GIVE A LIFT? is an illustrated manual designed to provide a short cut method for teaching women to operate industrial power trucks. In it the prospective operator is told how to run the truck, given pointers on how it should be cared for, and impressed with the importance of her job. *Elwell-Parker Electric Company, Cleveland, Ohio.—Gratis.*

UNICHROME ALKALINE COPPER PROCESSES is a pocket size folder which describes a process of depositing copper with an unusually fine-grained, homogeneous structure, and with good adherence and smoothness. Advantages and applications of this copper plating method are briefly described. *United Chromium, Incorporated, 51 East 42nd Street, New York, New York.—Gratis.*

MACHINING COPPER AND COPPER BASE ALLOYS is a 32-page booklet which presents condensed data on basic machining operations, including tool rakes and clearances as well as cutting speeds and feeds. Additional tabulations give physical constants, theoretical rod weights, and standard specifications for copper and copper alloy rods. *American Brass Company, P. O. Box 790, Waterbury, Connecticut. —Gratis.*

SHALL RESEARCH BE SOCIALIZED? is a 22-page analysis of the Kilgore bill, S. 702, entitled "a bill to mobilize the scientific and technical resources of the nation, to establish an office of Scientific and Technical Mobilization, and for other purposes." *National Association of Manufacturers, 14 West 49th Street, New York, New York.—Gratis.*

HOW TO MAKE YOUR SAFETY EQUIPMENT LAST LONGER is a 32-page illustrated handbook covering all types of personal protective industrial equipment. Practical "do's and don'ts" serve as a guide for instruction of equipment users. *Mine Safety Appliances Company, Braddock, Thomas, and Meade Streets, Pittsburgh, Pennsylvania.—Gratis.*

ENGINE DESIGN AS RELATED TO AIRPLANE POWER is an 80-page lavishly illustrated booklet which attempts to acquaint the average person with a few of the problems involved in the design of military aircraft. Special emphasis is placed on engines and supercharging equipment. *General Motors Corporation, Detroit, Michigan.—Gratis.*

PEDIGREE INSULATING VARNISHES is a 36-page illustrated booklet describing the production of these varnishes and giving brief summaries of their uses. A tabulation lists a number of coatings for specific applications. *The P. D. George Company, Saint Louis, Missouri.—Gratis.*

COLLOIDAL GRAPHITE is a 12-page folder which gives a most complete and up-to-date story of colloidal graphite and its usefulness to industry through application of its lubricating and other desirable properties. *Acheson Colloids Corporation, Port Huron, Michigan.—Gratis.*

AUTOMATIC TUBE-ICE MACHINE is a 16-page illustrated booklet which describes a modern method of producing sized ice for refrigerating purposes in the food processing, food catering, and industrial fields. *Henry Vogt Machine Company, Louisville, Kentucky.—Gratis.*

LAMINATED ARCHES AND BEAMS is a 12-page illustrated catalog describing these types of units for a wide variety of structural purposes. *Unit Structures, Inc., Peshtigo, Wisconsin.—Gratis to constructors, engineers, architects, and draftsmen.*

GRAIN SIZE IN TIN ALLOYS is a technical paper throwing interesting light on the part played by grain size in the physical properties of pure tin and its alloys. *Tin Research Institute, Fraser Road, Greenford, Middlesex, England.—Gratis.*

THE REDESIGNED 40-MM. ANTI-AIRCRAFT GUN CARRIAGE, by Dr. John L. Miller, is a technical report of the application of welding to this specific wartime job. A number of interesting tabulations and comparison photographs are presented. *James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.—Gratis.*

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

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"the impossible we do immediately the miraculous takes a little longer"

ARMY SERVICE FORCES—

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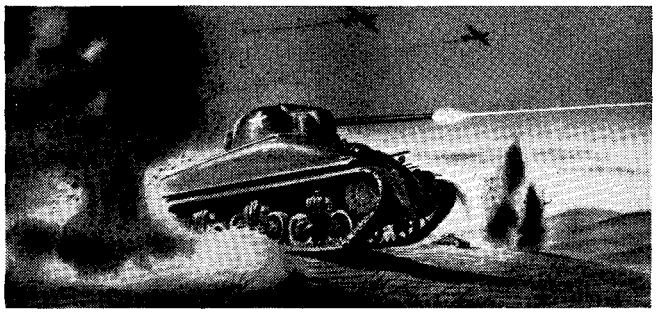

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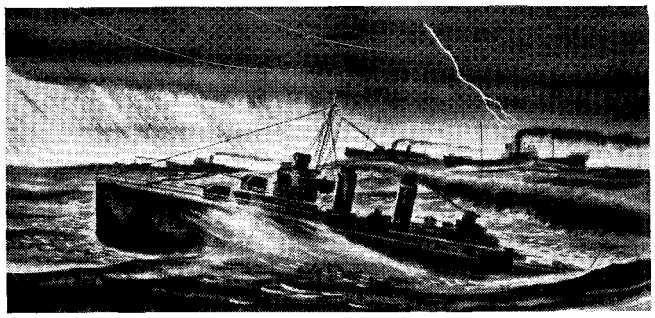

3. On the Seven Seas, helping to keep our supply lines open, are scores of Westinghouse products. Among them are turbines, gears, electric drives, motors, anti-aircraft gun mounts, instruments and controls.

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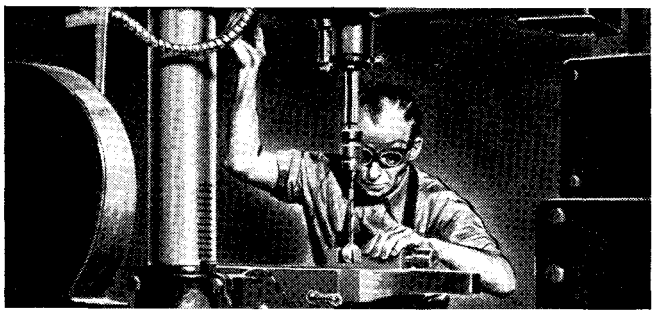

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