THE FATHER OF THE SUBMARINE . . . Page 120

SCIENTIFIC AMERICAN

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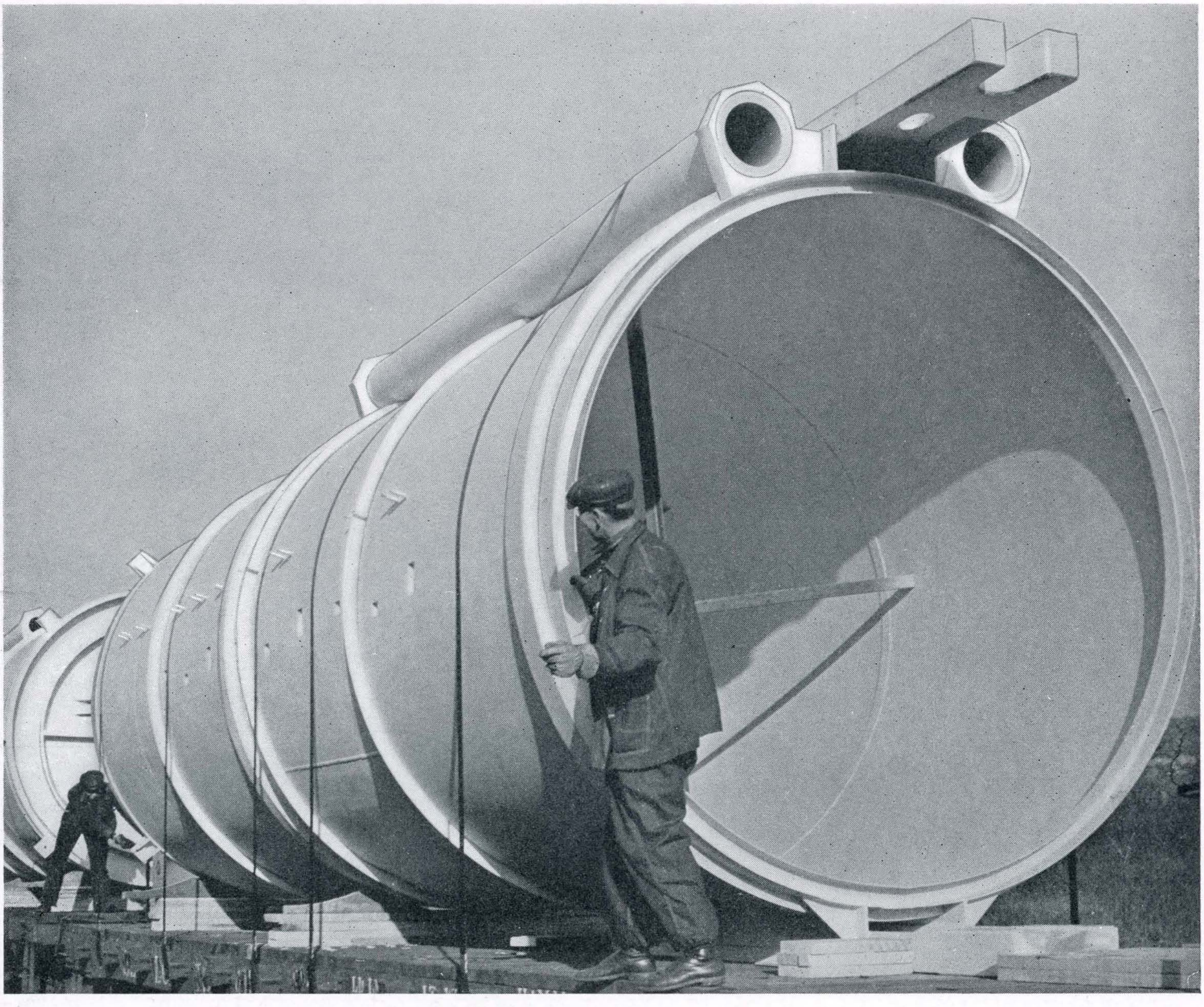

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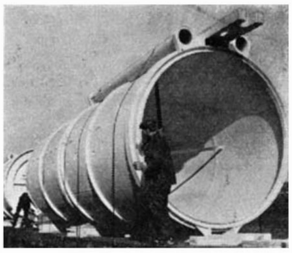

HEAT at 1650 degrees, Fahrenheit, will toughen gun barrels in the seven-ton Westinghouse electric furnaces, two shells of which are shown on our front cover. The furnace shells illustrated will later be lined with brick and equipped with chrome-nickel alloy heating elements. From these furnaces will come hardened and tempered gun barrels to blast the Axis.

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MARCH • 1943

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50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed From Issues of March, 1893)

CANALS—"The promoters of the Nicaragua Canal scheme ask the United States government to guarantee their securities, and thus father the enterprise and hasten the work of construction by giving the securities financial standing. . . . The Panama experience is a lesson from which much can be learned, and no patriot American would want it duplicated."

DRILLING RIGHTS—"The question of whether an oil operator has a right to drill through coal which has been leased previously, to reach oil or gas below, is one which has been the basis of a number of suits, and the lower courts in this State have decided that the owner of the surface has such right."

CAN SALVAGE—"In the suburbs of great cities an industry has sprung up having for its object the recovery of the solder used in making and sealing tin cans. . . . The furnace is an old soap boiler, into which a few sticks are thrown; the bowl is then filled with cans, a quart of kerosene poured over them and

ignited. The heat developed by the oil is not great enough to attack the tin, but melts the solder, which flows to the bottom of the bowl. The solder recovered from a load of cans averages forty pounds. After this process is completed the tin plate scrap is sold."

RECLAMATION—"The sweepings from manufacturing jewelry establishments, consisting of paper, dust, old crucibles, etc., are packed in barrels and carted to a refinery, where the material is first put into furnaces and burned. . . . The value of these sweepings varies greatly, averaging about $5 per barrel, although it has been known to run up as high as $500 per barrel."

SILK—"The classification of silk goods of American manufacture is now practically without limit, embracing every article made in the older silk-manufacturing countries, and fully equal to the foreign product in quality of weave, beauty of design, and excellence of finish."

BATTLESHIP—"An ironclad battleship of the first order was launched at . . . Philadelphia, on February 28, and was christened the Indiana. She is the largest vessel built thus far on this side of the Atlantic. . . . She is of 10,200 tons displacement, having a length of 348 feet, a breadth of 69¼, and a mean draught of 24. . . . The engines are twin screw, of the vertical, triple expansion, direct acting, inverted cylinder type, placed in water-tight compartments separated by bulkheads. . . . The vessel has a powerful ram bow, and is divided into a great number of watertight compartments by means of longitudinal and transverse bulkheads of 10 and 12 pound plates."

LOCOMOTIVE—"The new monster locomotive of the Mexican Central Railway . . . is probably the largest and most powerful locomotive engine now extant. It has been built for special service in drawing freight trains over the heavy grades and curves between Tampico and the city of Mexico. . . . The weight of this great machine is 130 tons. . . . The high pressure cylinder is 13 inches in diameter and the low pressure 28 inches. . . . The boilers . . . carry 180 pounds of steam to the square inch."

TIRES—"The latest adaptation of pneumatic tires is to the wheels of an omnibus which is being tried by the Glasgow Tramway Company at Glasgow, Scotland. The tires are about 3½ inches in diameter, and can withstand a pressure of 187 pounds to the square inch. To guard against any risk of the India rubber being punctured by sharp stones or otherwise, the tires are thoroughly protected by several plies of canvas, with a covering of wire-wove netting. The omnibus is said to be a very comfortable vehicle to ride in."

RAILROAD ARMY—"There is an army of men employed upon the railroads of the United States, an army of 784,000. They are not engaged in idle maneuvers, dress parades, barrack drills, or preparations for warfare, but by their diligence, energy, and toil contribute immensely to the wealth, well being, and development of the country, the interchange of its products, the diffusion of information, and the prompt transportation of vast numbers of passengers, with a remarkably low percentage of casualties."

PULP—"Compared with its predecessor, last year shows a slight decline in the production of wood pulp. . . . There are now in Norway eleven sulphite and four sulphate manufactories. Several of these are also connected with paper mills. The exports during 1892 of chemical wood pulp were about 20,000 tons dry, as compared with 17,500 tons in 1891, and about 8,500 tons wet, as compared with 9,500 tons in 1891."

INVENTORS—"Inventors, like most other men, are willing to make money out of their inventions, but many of them go about their work in just the wrong way. . . . They stick to the idea that fame and fortune come only to the inventor who makes a revolution. If such men will only look over history carefully they will find that the great fortunes and fame made of 'revolutionizing' inventions are few and far between, while the greater number of successful inventors have made their fortunes out of things that are small, simple, and capable of general use."

AUTO-PHOTOGRAPHY—"Of all the many uses to which the automatic selling machine has been put, that of taking photographs seems the most remarkable. . . . The operation, so far as relates to the exposure, development, and fixing of the picture, is entirely automatic, and the little picture which the machine throws out, after a momentary washing, appears to be a marked success over previous efforts in this direction."

Personalities in Science

DR. MARY ELIZABETH WARGA

When the United States Office of Education made plans for a nationwide program to train defense workers a year before Pearl Harbor, Dr. Warga was the only person, man or woman, chosen to teach spectroscopy. Today, after two years, she has taught 250 people to analyze material for shell casings, gun barrels, tank and airplane bodies, and for practically everything else made of metal from fine precision tools to battleship armor.

Dr. Warga is assistant professor of physics and director of the Co-operative Spectroscopic Laboratory at the University of Pittsburgh. In addition to government-sponsored chemists, physicists, and metallurgists, each year she trains 50 university students to read the secrets of the spectrograph. Because of this instruction, her trained men and women give an inestimable boost to war production. They work in the laboratories of steel mills and other defense plants, saving untold numbers of man-hours by their immediate recognition of the constituents of liquid steel. In a matter of minutes they can pass a batch of steel or reject it for failing to meet government specifications. Since they work so fast, the batch can be remedied while still in the molten state, should it be found lacking.

Scientists call the spectroscope the most wonderful scientific instrument in the world. It uses the color spectrum as a standard against which it compares the known color for each of the 92 elements in nature. It burns at intense heat a small sample of the material about which the facts are sought. The colors given off during the burning reveal the elements in the sample. Each element has its own physical pattern, a grouping of lines too sensitive for the eye to see but visible on photographic plates. Adept at "spot" identification of these colors and lines, Dr. Warga teaches her war workers to recognize them too. They learn what the color and pattern should be. Variations reveal defects.

Dr. Warga has worked with the spectroscope since she was 20 years old and a junior in college. Now she is able to tell in a few seconds the composition of anything she submits to the intense heat of its carbon lamp: a sample of steel, a particle of food, a drop of blood, or anything else. She knows almost at once what it is.

Dr. Warga became a general in the army of production by way of astronomy. The spectroscope was invented to read the composition of the stars and Dr. Warga started with astrophysics and now goes back to labor and industry.

An example of Mary Warga's resourcefulness is shown in the way she got herself a job. She learned that the Mellon Instiute, affiliate of the University of Pittsburgh, was planning a study of air pollution. She applied for the post of investigator, and was accepted. With her spectroscope she made studies that lasted five years, and which showed that Pittsburgh lost approximately one third of its sunlight through dust in the air.

The job came to an end and again she was out of work. But at Mellon she came across a large spectroscope lying unused since its purchase in 1912. She was told that if she could rebuild it she could have a job using it. For six months she studied how to rebuild it. She read books and consulted scientists. She put it in working order and became spectroscopist for the Institute, a job she held for three more years.

Today, Dr. Warga has two spectroscopic laboratories under her direction. Besides the one in the University of Pittsburgh's Department of Physics, she has charge of one in Industrial Hygiene in its School of Medicine. Here studies on certain toxic occupational diseases are being made.

99TH YEAR SCIENTIFIC AMERICAN MARCH 1943

HOW NAVAL BATTLES ARE FOUGHT

The Strategy and Tactics of the War at Sea

● **Six articles, analyzing the battleships, aircraft carriers, cruisers, destroyers, submarines, and aircraft of the United States Navy, have been published in our issues of May, August, September, October, November, December of 1942. The present article, prepared with the whole-hearted co-operation of the Navy Department, traces the strategy of naval battles as they are fought today. Here are the answers to those who hold for the complete superiority of the battleship, as well as those who place air-power above all else. —*The Editor.*** ●

IF THERE is such a thing as clarifying today's naval strategy, the answer perhaps is: To be ready for anything with everything.

No sooner do we have one type of sea engagement in which the opposing surface craft remain hundreds of miles apart, fighting it out with their aircraft alone, than we have other sea engagements wherein the surface craft slug it out with each other, gun for gun, almost the same as in the Spanish War.

Nor should any of us at this time formulate any hard and fast rules as to how the various types of war machinery—air, undersea, and surface—work together under battle conditions. For no two sea engagements thus far in this war have been the same.

Those who, in past years, have held out for the might of battleships above all else have been right. Those who have held out for the might of dive-bombers above all else have been right. Those who have held out for the might of carriers, more and more carriers, also have been right. The list could continue.

In brief, everybody has been right. And to prove his theory anyone has but to point for his example to some specific sea engagement. After picking the right one out of the multitude, he can say: "See, I told you, I've always told you. . . ."

The obvious catch in such logic, however, is the ruthless fact that tomorrow's sea battle may approximate something never even dreamed of; or, even if it has been conceived of as a tactical possibility, the conceiving tactician, unless he were at the scene of battle, would be unable to cope with the situation.

In the old days, in the days of the theoretical grand battle of fleets, even a youngster, playing with toy vessels on the kitchen floor, could outline the one-time accepted principles of grand fleet meeting grand fleet in the knockout and final combat for control of the seas.

Those were the days, when, according to principle, the battlefleet was organized around its biggest, hardest hitting, and most valuable men-of-war —the battleships. They would be placed in the center of the battle formation so that the lighter, more maneuverable vessels on the outer fringe might protect them from torpedoes which the battleships, supposedly, would be too heavy and too slow to avoid.

AHEAD of the battleships, according to the same established principle, would be the attack force, consisting of heavy cruisers with destroyer escorts. The destroyers protected the cruisers from torpedo attack, and the cruisers, in turn, were to block any enemy vessels which crashed through the outer lines.

Behind the main body of the fleet would be a similar force of cruisers and destroyers. They would serve as a rear guard to prevent the enemy from crashing in from behind.

Then, if possible, there would be even a third force of heavy cruisers, or even battleships, together with destroyers. This group, as the youngster playing on the floor would know, was called a support force. Its duty was to reinforce any part of the battleline threatened by attack.

Nor is this the whole picture of an ideal fleet about to meet a supposedly ideal enemy: Outside all these forces would be a screen of light cruisers and destroyers to protect the battleline as a whole. This was called the inner screen, for still farther out, perhaps 40 or 60 miles from the main body of the fleet, steamed still another screen—the outer screen of destroyers and fleet submarines. Their mission, so snuggly planned, was to scout for the enemy fleet and intercept any attacking force of the enemy. Or, again, their greatest service could have been to meet in daylight any enemy groups close enough to the main fleet to have steamed in and attacked during the hours of darkness.

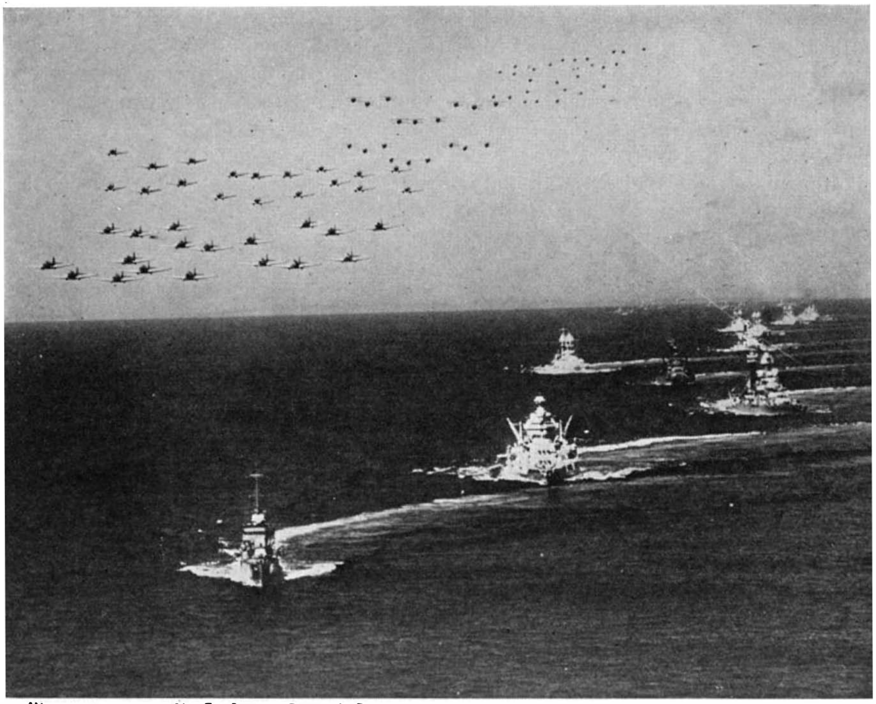
YES, THE youngster, given his toy vessels, could have arranged it all quite nicely there on the floor. Or if the boy were playing in a day when there were such things as toy aircraft carriers to go with his toy fleet, he would have employed the carriers in two possible ways. They might have been placed with the battleships in the center of the fleet, the safest possible position. Or they might take up a position alone, protected only by a destroyer escort, perhaps a hundred miles from the main body of the fleet.

In either case, the theater of operations for the planes themselves would be over the two opposing battlefleets, the dive bombers and torpedo bombers pressing home an attack on the enemy vessels, and the fighters protecting the youngster's own vessels from a similar enemy attack.

The planes would sink or damage the enemy ships, if possible, and would try to break up the formations of the surface vessels and force them to zig-zag and slow down. This would enable the rest of the boy's forces to close in so that the outer ring of destroyers could dash in with a sudden torpedo attack and retreat under cover of a smoke screen.

Soon, then, the two majestic rival fleets would close in sufficiently for the cruiser forces to press home attacks, and for the huge battleships to overwhelm the enemy with a rain of destruction—thereby ending the war.

This, then—on kitchen floor or on paper—was the clashing of fleets as envisioned before actual war came along, in such a distributed way, to prove that there was no such thing as one big grand fleet anymore. At least, not yet.



Illustrations are U. S. Navy Official Photos.

A battle line, with carrier-based planes

THE NEAREST, or at least the earliest, resemblance to such a paper-perfect engagement in the present war was, perhaps, the meeting between Britain's Mediterranean Fleet under Admiral Sir Andrew Cunningham and a large force of the Italian fleet. This engagement occurred March 28, 1941, and was not entirely surface. Reconnaisance aircraft were the first to report that the Italian fleet, after being in hiding so long, was showing signs of activity. It is now believed that the purpose of the Italian fleet was to keep Admiral Cunningham's forces busy while Axis convoys were rushed to Rommel in Egypt.

But the English had no way of knowing the Italian's plan and were delighted to receive the reconnaisance report that the enemy finally had ventured into the open. To meet the Italian fleet the British sailed out of Alexandria on the 27th. The British force consisted of three sister battleships, *Warspite*, *Barham*, and *Valiant*, the aircraft carrier *Formidable*, and a full complement of cruiser and destroyer forces.

The battleships steamed along in single file, exactly according to Hoyle, so to speak, and with the *Formidable* just astern the flagship *Warspite*. The cruisers and smaller ships were disposed in approximately the classical manner. Early the following morning, reconnaisance planes reported three Italian battleships about 100 miles away, heading eastward, accompanied by several cruisers and destroyer forces—also aligned in the classical manner.

Soon one of the outlying British cruiser squadrons exchanged a few shots with an outlying Italian cruiser formation, and attempted to lure it southward into the path of the British battleships. But the Italians shied away.

Nevertheless, the battle gradually took shape along the best of accepted theories. The two battle lines continued to draw closer until the Italian battleship *Vittorio Veneto* opened fire at extreme range upon British light forces. In retaliation, the *Formidable* launched two squadrons of torpedo bombers which succeeded in getting several hits, cutting the *Veneto's* speed by two thirds and setting her afire.

One plane also hit the cruiser *Pola*, damaging her steering device. The Italians likewise attacked with torpedo planes, but were beaten off. At dusk, the British battleships turned to finish off the *Pola*, but before they reached her, an Italian cruiser squadron, apparently unaware of their proximity in the darkness, and apparently unaware of the rules as well, cut across their path. The *Warspite* opened up at point-blank range with her 15-inch guns and seven tons of shells crashed into the *Fiume*, last cruiser of the Italian line. She went up in flames before she could fire a single shot.

Two destroyers escorting the cruisers immediately dashed toward the line of British capital ships and launched torpedoes, but they missed and the Italian destroyers were sunk. Then two more Italian cruisers received the same treatment from the *Valiant* and the *Barham* that the *Fiume* had received from the *Warspite*.

Therewith the battle of Cape Matapan—almost a perfect example of a fleet engagement exactly as the theorists would have it fought—was over and won. Most of the larger Italian men-of-war were either sunk or badly damaged.

So, with this early example, the theorists certainly had an excuse to presume that the same old manner of winning sea engagements would continue to be the same old manner of winning sea engagements. Maybe they are right, and maybe the battleships, as usual, should be counted on for the kill.

YET IF one does care to figure that way too strongly, especially in this war of strange upsets, it would be better for him to forget, or at least not to mention, the battleship *Prince of Wales* and the battle cruiser *Repulse*. No enemy surface craft, it appears, shared in this battle at all, the two great vessels going down off Malaya under the hammering of land-based planes alone.

It was a lesson, to be sure. But a lesson which, since then, has worked both ways; the aftermath occurring not far from Guadalcanal. There the Japs tried it again, this time on an American battleship under command of Capt. Thomas L. Gatch. The Japs, remembering the *Prince of Wales* and the *Repulse*, confidently launched upon this American battleship what is described as "the heaviest air assault ever made on a dreadnought." The first attack (on October 26) was made by 20 enemy dive bombers. All were shot down. Half an hour later, 40 enemy torpedo planes and dive bombers returned to the attack, approaching at the rate of about one every minute. All but one torpedo plane either fell or turned back.

An hour later 24 more Jap torpedo

planes and dive bombers roared at the battleship in a third try. One of the dive bombers did get through, slightly damaging a turret and inflicting Captain Gatch with a neck wound from a bomb splinter. But the score in all was 32 Jap planes downed by automatic anti-aircraft guns and a secondary battery of larger guns. Fighters from an American carrier also answered the challenge.

Anyway, despite their success with the *Prince of Wales* and the *Repulse,* the Japs today certainly cannot be too sure of anything, either. Because planes have taken such an important part in nearly all sea engagements, landings, and the like, the difficulty today, for a fact, is trying to remember some important sea engagement in which planes did not share importantly, at least in the destruction. The celebrated fight with the *Graf Spee,* so early in the war, might be the best example of one such engagement.

THE *Graf Spee* was at sea when Germany invaded Poland, and immediately began harrying British merchant shipping off the coast of South America. One of her victims succeeded, on December 2, in sending distress signals before she was silenced, and these were relayed to Commodore H. H. Harwood, in command of the South American Division of the America and West Indies Station of the Royal Navy.

Commodore Harwood was faced with an extraordinary problem. He had only three vessels at his disposal: the 8400-ton *Exeter,* mounting eight-inch guns; and the *Ajax* and *Achilles,* both 7000-tonners and both with only six-inch guns. Opposing him was a much larger, more powerful ship, mounting two turrets of 11-inch guns.

Not only did the *Graf Spee* have greater range, so that she could fire on the British ships before they could close in to their own range, but she could hurl 4700 pounds of metal and explosive in a single broadside, as against a total of only 3136 pounds for the three cruisers combined. In addition, the greater armor of the German ship would enable her to stand more punishment that the smaller vessels.

Contributing to Harwood's problem, too, was the fact that his vessels were scattered over several thousand miles of ocean when he received the distress signal. He had to choose some rendezvous point, but the question was: Where? He knew that the *Graf Spee* would not linger long at the spot of her most recent sinking, for the raider's mission was to sink more merchant ships. The last thing the *Graf Spee* desired was to brush with enemy warships. Reasoning that the German ship might make a run for the River Plate, where there was always a great concentration of shipping, Harwood decided on a point 150 miles east of the Plate's mouth for the rendezvous, and set 7 A.M., December 12th as the time.

The three cruisers met on schedule and began cruising at 14 knots, their captains directed to act "without further orders so as to maintain decisive gun range." On the morning of the 13th the *Graf Spee* was sighted to the starboard and slightly astern of the squadron.

THE *Exeter* made a sharp turn at once so as to cut across the battleship's bow and be on her starboard side. The other two ships made a similar turn shortly afterward to take position on her port side, thus forcing the German commander, Captain Langsdorff, to split the fire from his two turrets of 11-inchers. This the German commander did as he opened fire. The *Exeter* replied with eight-inch guns as soon as she was within range, and the other two opened up with their six-inchers a few minutes later.

The German captain, however, was more worried about the *Exeter's* larger guns, and swung both turrets of 11-inchers to bear on her. Immediately he landed a series of destructive hits. But, at the same time, the *Ajax* and *Achilles* were allowed to close their range, opposed only by ragged and inaccurate fire from the German's 5.9-inch batteries.

Two broadsides from the six-inch guns of the cruisers found their mark, putting the *Graf Spee's* fire control apparatus out of commission and killing most of the officers in the fire control tower. Still the two British cruisers closed in, to within about a mile.

The *Graf Spee* was demoralized. The battleship began to lay down a smoke screen, made a 150-degree turn, and began to run.

The British were ready. Working at a killing pace, their engine-room crews had built their speed from 14 up to 28 knots while the battle was raging. They started pursuit, launching the observation plane from the *Ajax* to spot their fire; this is about the only mention ever made of a plane in the battle.

The *Exeter* received two more direct hits. By now two of her three turrets were out of action, her compasses were smashed, she was on fire, and had a seven degree list. But she steamed ahead at full speed, and continued to keep the *Graf Spee* under fire.

The German ship laid a series of smoke screens and changed her course in a frantic effort to escape. Under cover of a smoke screen, she desperately turned on the *Exeter* to try to finish her off, but the accurate fire from the other two cruisers, closing in, again forced the battleship to split her fire.

The two lighter British ships were hit but continued fighting: the *Exeter,* her last gun put out of action by flooding, was forced to turn away. Finally, the cruisers' ammunition was running so low that it might be exhausted if the fight continued until dark. So Harwood chose to break off the battle and simply follow the *Graf Spee* until he might sneak up on her under cover of darkness and perhaps finish her off with torpedoes.

The pocket battleship succeeded in making the River Plate where, as the world knows, she was trapped by other British warships hurried to the spot. And there she was finally scuttled.

Although the sea fight itself, if judged by the whole war, may not have been of decisive importance, nevertheless the fight does remain a superb illustration of British tactics—to close with the enemy, regardless of odds, to use bulldog tactics up close and slug it out.

But, at the same time, one rather wonders what would have happened if planes—bomber or torpedo—had been as furiously involved in this engagement as they have been in later ones. For planes do seem to disrupt, by a single lucky hit, the best laid tactical plans of man or war college.

THE Battle of Java sea (starting February 26, 1942) may be used as another example of closing in on the enemy in the classical manner, and also as another example of carrying the attack to the enemy, against great odds. The attack was made by a combined force of Dutch, British, and American ships.

On the date mentioned, Admiral Doorman, of the Dutch, received report of a Japanese convoy of 40 transports, protected by divisions of light and heavy cruisers and destroyers. Doorman was ordered to "proceed, search for, and attack the enemy."

Although all the men of his little fleet had been at their action stations for 37 hours without rest and were completely exhausted, Doorman proceeded as ordered, shaping his battle line as he went.

Heading the line were the two British destroyers, *Jupiter* and *Electra.* Next came the Dutch heavy cruiser *De Ruyter,* followed by our old friend the *Exeter,* the American heavy cruiser

Houston, the Australian light cruiser *Perth,* and the Dutch light cruiser *Java.* Following the cruisers came a line of four United States destroyers in single file. On the port side of this battleline was a line of four other destroyers.

As the allied force pulled up parallel with the Japanese battleline, it was seen that the latter was composed of two heavy cruisers, followed by six light cruisers. Beyond them were two lines of four Japanese destroyers each.

Even if the allied force had been fresh and undamaged, it would have been outweighed two to one and heavily outclassed in fire power. But to make matters worse, the after turrets of both the *Houston* and the *Exeter* were out of commission.

The Japanese heavies opened fire at 25,000 yards, a range at which only 8-inch guns would bear. The *Houston* and the *Exeter* returned the fire with their own 8-inchers, setting both the Japanese heavies afire. Then Doorman closed in to under 20,000 yards, maintaining the same formation, and the firing began between the cruisers all the way down the line.

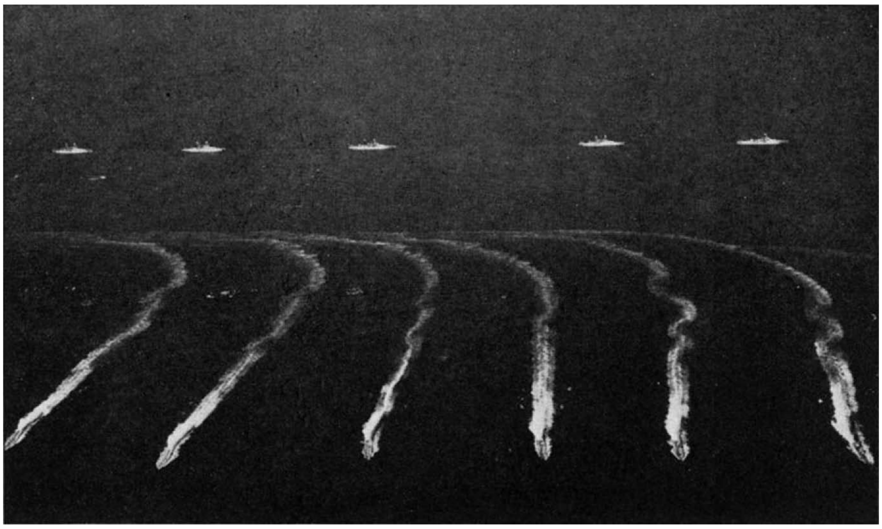
Both sides were hit hard, and the two Japanese heavy cruisers were burning badly. At this moment, the Jap cruisers laid down a smoke screen, through which their destroyers wheeled to launch a torpedo attack. Before they could begin, the two burning Japanese heavy cruisers dropped out of line, and four of the destroyers turned to screen them. The other four continued for the Allied line of battle.

The British destroyers *Jupiter* and *Electra,* at the head of that line, turned sharply and dashed into the smoke screen to intercept the attacking Japanese ships. They were never seen again. The *Perth* and the *Java* then had to shift their fire from the cruisers to the attacking destroyers, enabling the Japanese cruisers to fire more easily. The *Exeter* got a bad hit in the fire room, slowing her down, so she turned to port to escape the torpedo attack. The *Perth* turned to lay smoke to protect her, leaving the *De Ruyter* and the remaining cruisers so hopelessly outgunned that they had to turn, too.

Four of the allied cruisers rushed to screen the wounded *Exeter,* and the four American destroyers covered the general retreat, torpedoing and sinking two of the attacking Jap destroyers.

This was the end of the action. The Japanese had taken too much punishment themselves to pursue the scattering allied ships.

Despite the tangled outcome of the Battle of Java Sea, students of the classical manner of doing things may find in studying this battle a demonstration of the tactical co-operation of the various kinds of warships. Much of it was performed exactly according "to the book": the Japanese heavy cruisers opening fire at the range where their largest guns could be used to the greatest advantage; the Allies closing in until they could use all their guns; the concentration of allied fire on the heaviest Jap units until they are put out of action; the Jap cruiser laying a smoke screen through which the destroyers might dash to attack the larger allied units in retaliation; and finally, the use of the destroyers both to screen larger ships and to try to head off the Japanese destroyer attack.



Destroyers execute a right turn while in operation with battleships

At the time of this writing the more important sea engagements in the Solomons can be grouped into five distinct battles, each bearing a name. The first of these, already titled the Battle of Savo Island, occurred the night of August 8-9, and marked the first real offensive of the United States in the war.

This article being confined to sea-fighting, the concern here is not with the exploits ashore, after the marines had been landed from transports, but with the action at sea preparatory to and during these landings. The engagement also was the first between surface forces in the Solomons.

A strong enemy force, seeking to attack our transports and supply ships, was opposed by a screen of our cruisers and destroyers disposed southeast of Savo. After a brief but fierce engagement, the Japs changed course and attacked a second screening force northeast of the island. A close-range action ensued. We lost the *Canberra, Quincy, Astoria,* and *Vincennes.* The enemy losses remain unknown, but the enemy did fail in its objective because our transports were saved, and our Marines were landed.

The great part that aircraft played in this battle, and in the subsequent Solomon Island battles, too, would require a chapter of its own.

The second main sea engagement in the Solomons, now labelled the Battle of the Eastern Solomons, occurred August 23-25. This was when the enemy attempted to recapture shore positions. Several groups of enemy ships, including transports, approached from the north and northeast. They were attacked first by our aircraft, and later by our surface forces. The series of running engagements resulted in the withdrawal of the Japs. Their losses included damage to one battleship, two carriers, several cruisers, a destroyer, a transport, and four other vessels.

The part that aircraft again played in this battle is best demonstrated by the fact that on the afternoon of August 23 (Washington time), Guadalcanal was attacked by enemy planes, and 21 were shot down against our loss of only three. Much the same type of attack occurred two days later when the enemy attacked Guadalcanal with 16 two-motored bombers and 12 Zeros. Seven of these bombers were shot down, and also five Zeros against our own loss of one fighter.

So, in a report of these sea-engagements or surface engagements, one does find difficulty at times in distinguishing the out-and-out air action from the surface action. Both types of action obviously go together; the Navy's job being not only to be ready for fleet-against-fleet battles, as previously described, but also the convoying of troops and supplies, harrassing enemy commerce, protecting our coasts from enemy raiders both on the sea

(*Please turn to page* 137)

Industrial Air Control

Compact Survey of Air Conditioning Shows Its Importance on the War Production Front

MARGARET INGELS, M.E.
Engineering Editor,
Carrier Corporation

MANY of the mechanisms of modern warfare have become so complex and precise that control of the air is as vitally important in many war industries as it is on the fighting front. On the battle line, the outcome of many an action hinges on control of the air as planes engage planes with machine gun bullets and shell fire and rain bombs on key objectives; on the home front—the production front—control of the air, while less dramatic, is equally significant. Here the job is one of controlling the air in laboratories, assembly rooms, tool shops, and precision instrument plants where the equipment for our fighting men is being made.

Control of the air, actually just another phrase for air conditioning, is a complicated business of far greater importance than the familiar comfort cooling. It includes control of the temperature, humidity, cleanliness, and movement of the air. Were it not for the precise art of air conditioning, pioneered a few short decades ago by Dr. Willis H. Carrier, American weapons would not have attained their high degree of effectiveness, nor could they be produced in the astounding numbers that, today, are accepted as run-of-the-mill operation.

Suppose that an airplane instrument should fail at a crucial moment because perspiration on a worker's hand on the home front had caused corrosion, that a torpedo failed to function properly because of excessive moisture in the air during manufacture, that a stick of bombs went wide of its objective as the result of a drop of moisture or a particle of dust in some American war plant thousands of miles away: These are just a few of the possibilities that might occur if American industry did not have available this accurately controlled tool of air conditioning. So widespread has become the use of air conditioning in certain vital war industries, in fact, that it is difficult to imagine the effect of eliminating this important aid to production.

Such a thought opens interesting but disaster-laden possibilities. If there were no such art as air conditioning, many plants could operate only part time; extremely accurate work to close tolerances would become far slower and more difficult; many modern processes could not be carried on at all.

The author

Without control of industrial air, there would be only about five days in an average year when the unaided weather would be suitable for the manufacture of rayon. And this specialized conditioning of the air needed for making rayon fabrics is equally necessary in the manufacture of nylon used in parachutes, powder bags, and for countless other requirements of modern warfare.

Only an almost impossible Weather Bureau forecast of "Temperature Unchanged" would point to suitable air conditions for technicians making precision gages, since these instruments are accurate only when manufactured and calibrated at constant temperature. A sharp rise or fall of the thermometer, if not offset by man-made weather, would serve to negate the most accurate work of skilled craftsmen. An extended period of "Cool and Dry" weather would facilitate the production of precision instruments where work to close tolerances is required, but obviously the demands of war production cannot wait on the vagaries of the elements.

Today, therefore, more than 200 different industries utilize as a production tool one or more of the factors which go to make up modern air conditioning. And such control of the air, as has been briefly shown, is playing a vital role in the nation's war production.

School boys and girls learn in physics classes that objects take on the temperature of the air surrounding them. But the significance of this to war production is not always recognized. Some objects come to temperature equilibrium very quickly, with little physical change, while others, especially those made of metals, take a long time to reach room temperature and will measurably expand or contract in doing so. For this reason it is necessary to hold room temperature constant when close measurements are to be made and where work to extremely close tolerances is to be undertaken. Rooms used for gage calibration and measurement of precision instruments are air conditioned to assure constant temperature. Thus, a precision machine part made in a Texas factory may be fitted accurately with a companion piece made in Massachusetts. If the temperature of the parts is not the same when measured, they will not fit together in the final assembly; differences in temperatures produce the same effect as taking the measurements inaccurately.

A familiar example of the effect of one of man's concessions to the effects of temperature changes is the "clankity clank" of railroad car wheels as they pass over the space between rails, left to allow for expansion and contraction of the rails as the temperature changes. But no such simple solution may be used where work of great precision is required—as in the case of bombsights, range finders, and other close-tolerance instruments of war. Instead of fractions of an inch, measurements for such precision instruments are made in "light rings," which means that accuracy is sometimes held within tolerances of 6/1,000,000 of an inch. Such close measurements can be maintained only in conditioned air where temperatures are held at specified levels at all times.

Temperature control is also required for testing radios to be used in military airplanes to be sure that they will meet the rigors of field service. In some of the tests, however, it is not a question of holding temperature constant but, rather, of changing it at the rate of change that occurs when the plane is in use. The reason for this is not hard to discover. The radio in a plane leaving the ground in the tropics may be at a temperature of 120 degrees. As the plane climbs, the temperature drops, often dipping as low as 60 degrees below zero. Yet, throughout wide and rapidly changing temperature ranges, the radio must function perfectly. To build radios that will react to fast and extreme weather changes, laboratories use air conditioning to simulate conditions ranging from tropic heat to subzero temperatures of high altitudes, changing from one to the other at a rate approximating actual flying conditions.

Just as constant temperatures are called for in precision work and controlled fluctuation of temperatures serve in testing radio and various equipment, so other war production processes find essential one of the several machines developed for air conditioning at Carrier's huge plant—low temperature refrigeration. For example, the manufacture of one type of synthetic rubber requires a temperature of minus 98 degrees, Fahrenheit, during processing. Liquification of chlorine also calls for temperatures well below zero. And a low and constant temperature in blood banks makes it possible to hold large quantities of blood plasma or whole blood in readiness at all times, the coolness making possible the preservation of the original quality.

Coating photographic films, manufacturing certain plastics, processing rubber, chemicals, and pharmaceuticals —these are some war jobs that utilize low temperature air conditioning. But not all conditioned air is cold air. If someone were to tell you that "hot air" would help win the war, an argument involving much of that very commodity might ensue. But the statement is true, nonetheless. Warm, dry air facilitates powder drying in ordnance plants, makes possible scientific food dehydration, and serves as would nothing else in numerous other processes including smoking of meat, leather drying, and flour milling.

Overhead ductwork in a paper sorting and cutting department

Moisture in the air, another phase of air control, can be both friend and foe of war production. The finely machined parts of precision instruments, for example, are highly susceptible to both corrosion and rust. A fingerprint from the moist hands of a worker may mar the finished surface or cause corrosion after the instrument is completed. An over-abundance of moisture in the air condensing on a metal part may be the cause of rust which will soon destroy the accuracy of fine mechanisms completely. Air conditioning guards against such dangers by dehumidifying the air in work shops, assembly rooms, and storage spaces.

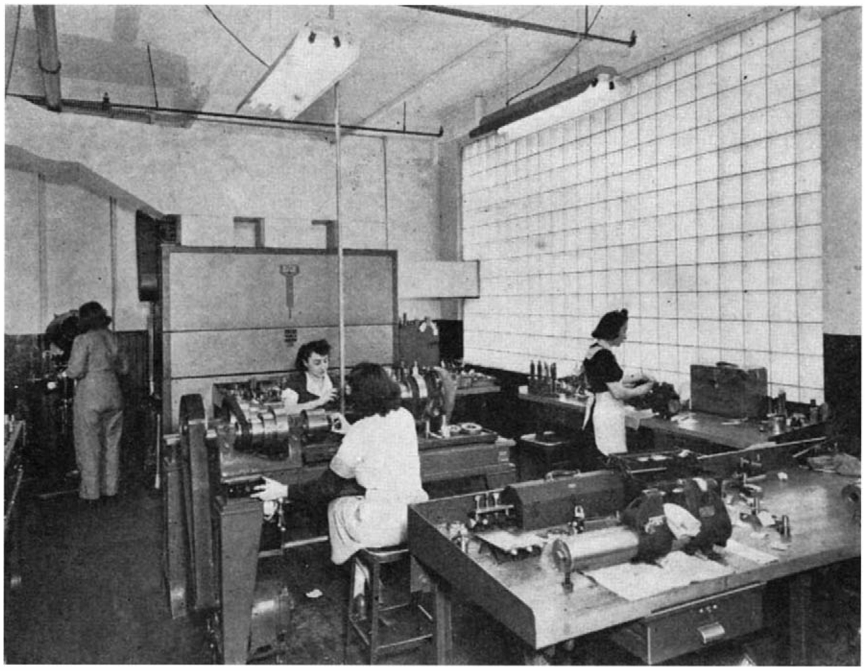
In some processes, damp air means slowed up production and even possible shut down. Many plastics are processed in air that is dehumidified because moist air makes the sheets "tacky" and difficult to handle. Concentrated foods, such as bouillon cubes, are prepared in dehumidified air because high humidities slow up production and affect quality. Many drugs are manufactured in dried air because an excess of moisture would ruin the value of the medicines; compounding these same drugs is a hit-and-miss proposition if they are allowed to absorb varying and unknown amounts of moisture, making basic weights of the ingredients questionable.

On the reverse of this last situation are to be found some industries in which lack of moisture in the air makes efficient production impossible. In dry air indoors during cold winter weather, "static" causes a shock when a person touches a metal doorknob or wall switch. Under similar conditions, static collects on fibers in textile mills or on paper in printing plants. The result may not be an electrical shock that can be felt, but production schedules frequently cannot be maintained when static is present: Threads become fuzzy and break often; fabrics cannot be woven evenly; papers stick and do not feed uniformly into the presses. In plants where static causes trouble the air is humidified—moisture is added—when the want of moisture in the air makes a difference in production.

Textile mills were among the first to adopt the tool of air conditioning. Control of indoor weather made possible the high-speed manufacture and tremendous growth of rayon. Nylon requires a low temperature during processing. Fortunately, long use of controlled temperatures and relative humidity in textile mills has made possible the rapid development of synthetic fabrics that are now being used for parachutes, powder bags, and clothing for our Armed Forces.

In the printing of maps and charts, often in many colors, conditioned air contributes largely to an accuracy which would be impossible if this industrial tool were not used in press and paper storage rooms. This is because variations in temperature and humidity may cause paper to expand or contract between the times when the different inks are applied.

Some industrial operations must be done in dust-free air, since a particle of dust may ruin the product. Clean air is required in the assembly of precision



Wall and floor duct installation in a precision tool plant

instruments; a dust particle in the works could seriously impair the accuracy of the gage, bombsight, or range finder. Just as watches cease to be good time keepers if not clean, so do other precision instruments lack accuracy under the same conditions. Optical lenses, built up of several elements of carefully ground glass, are virtually valueless if dirt is permitted to fall on the inner surfaces during assembly.

Besides being used as a production tool, air conditioning serves in many vital places outside of the factory. "Cold banks," that provide locker or food storage in rural communities, preserve the food in low temperature air conditioning. Men in the services are equipped and fed with the aid of conditioned air. For example, fur coats for fliers are kept in the best state of preservation in low-temperature air conditioned vaults; food refrigeration on ships and in camps maintains meat and other foodstuff at top quality. Mobile photographic laboratories of the Army are equipped with air conditioning to assure accurate and speedy photographic work in the field. Parachutes are made to last longer by being stored, whenever possible, in conditioned air to prevent mildew or other deteriorating effects which might occur in storage when the air is not controlled.

So universal is the use of air conditioning as a production tool, and so great are its uses in preserving manufactured goods, that it is difficult to imagine industrial America without air conditioning. In many respects war production as we now know it would not be possible were it not for air conditioning; it is a vital tool in helping industry to produce the materials of war needed to preserve the American way of life. It is not, as some people still believe, a mere means to comfort.

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PAPER

For Many Wrapping Purposes, Is Stretchable

DEVELOPMENT of a new application for creped paper has been made by the Arkell Safety Bag Company. This new paper, designed to take the place of scarce textiles in wrapping and baling materials for shipment, can be stretched in all directions, providing a characteristic which is claimed to protect the paper against tearing in ordinary wrapping services. This new paper is available in various grades and weights and in roll or sheet form.

SHIP CLEANER

Can Remove Oil in Presence of Salt Water

MERCHANT ships, battleships, tankers —any ships which have been damaged in battle, in fact—are usually badly contaminated with heavy, black, tarry bunker oil when received in repair yards. This tar-like oil penetrates into machinery and instruments and presents a serious removal problem, which is complicated by the fact that the oil is also associated with salt water, which breaks down ordinary cleaners.

This unusual and pressing problem has recently been solved by the use of Gunk P-96, a concentrated and self-emulsifying degreasing solvent developed by the Curran Corporation. This product can dissolve, emulsify, and remove heavy concentrations of fuel oil in the presence of salt water.

It is claimed that the action of Gunk P-96 is so thorough that all traces of oil are made water soluble and need only be sluiced with a water hose to rinse and decontaminate large areas such as the hold of a ship.

It is also stated that degreased surfaces so provided are particularly suitable for the application of red lead.

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SURFACES—Paints have been formulated which can be applied under all conditions under which a man can work—some paint can be applied at temperatures as low as zero degrees, Fahrenheit, on frosty or icy surfaces, and can also be applied when the temperature is as high as 130 degrees, Fahrenheit.

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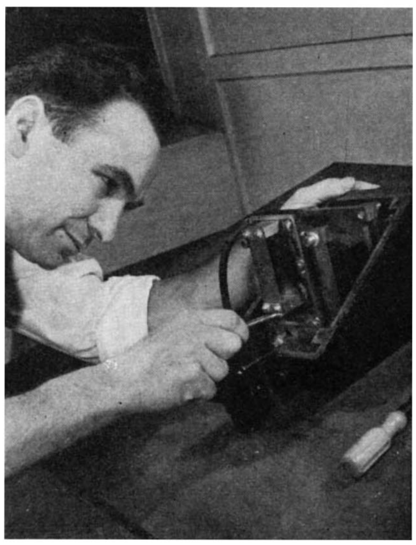
GENERATOR "WATCHMAN"

Detects and Records Vibrations in Rotating Shafts

AN automatic electrical "watchman" the size of a large box camera has been developed by a Pittsburgh research engineer to jot down a warning in red ink when it detects vibrations that might eventually cripple a power-producing machine. Harry G. Werner, "machine-quake" expert at the Westinghouse Research Laboratories, devised the instrument—a midget-sized generator of electricity—to measure in thousandths of an inch the slightest tremors in the spinning shafts of turbo-generators. By discov-



Adjusting an automatic "watchman"

ering quivers in shafts turning at 3600 revolutions a minute and recording a warning, the detector provides a perpetual diagnosis of giant power-house machines.

Like a business chart, the vibration record shows month after month how a hard-driven steel shaft is performing. "The line usually stays at a steady level, registering normal balance," Mr. Werner explains, "but in rare instances the line deviates from its steady course, warning that a vibration has developed. That deviation tells a power plant operator that a minor adjustment is needed to eliminate the unbalance, remove the resulting vibration, and prevent a possible breakdown."

Mr. Werner's vibration detector consists of a babbit-tipped rod that touches a revolving shaft; a miniature generator rated at about one millionth of a watt; an amplifier to step up the current to two or three watts; and a recorder that pens a vibration "curve." Vibration in the shaft bounces the pencil-shaped rod up and down. A coil attached to the upper end of the rod moves back and forth inside an electro magnet. This action generates a tiny amount of electricity that travels to the amplifier where it is stepped up enough to move a mechanical pen that marks down a record of the vibration.

The slightest quiver in a silently-spinning shaft is thus "felt" and recorded by the automatic instrument. Change in intensity of vibration is determined by the deviation from a straight line penned on a paper chart moving through the recorder.

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STRATEGIC—In 1921 Government officials listed 42 strategic materials, vital to war, which had to be imported, either wholly or partially. Thanks in part to chemistry, metallurgy, and their related sciences only 15 are on the list now.

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WOOD ARCHES

Advantageously Used Instead of Steel

TONS of steel were saved in the construction of the recently-built USHA Recreation Center at Bremerton, Washington, by specifying the use of wood-and-glue laminated arches. The six arches stretch 71 feet from foot to foot and each weighs two tons.

In constructing these arches the fabricators used 26,000 board feet of dimension lumber, 1590 pounds of Laucks casein glue and 10 gallons of Rez, a synthetic resin sealer. The arches were constructed in Seattle and were transported by logging truck to the site. They were built in two sections and were joined together in the center.

Wood-and-glue arches are said to be superior to corresponding structural members of steel in many ways. Laminated beams such as these are particularly adapted to this type of construction because they are easy to handle, meet all structural requirements, and while steel melts and buckles in the extreme heat of a fire, laminated wood will char and provide a much longer fire-resistance period.

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HIGH-OCTANE—The United States is the world's largest producer of high-octane super-aviation gasoline. Present-day production figures are secret, but a year ago the output here had been set at the rate of 55 million barrels a year.

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GAGE BLOCKS

Reclaimed by Controlled Plating Process

A CONTROLLABLE chrome-plating process has been developed for reclaiming precision gage blocks worn to below required accuracies. The method by which the old blocks are built up is stated to give them five times the life as when they were new.

The three-step reclaiming process is, briefly, as follows: First, the blocks are lapped 0.0002 inch undersize. Then an even coating of chrome plate 0.00015 inch to 0.0002 inch thick is applied to each of two working surfaces, making the blocks from 0.0001 to 0.0002 inch oversize. In the third step, the blocks are lapped to size.

They are checked for size and parallelism on a Pratt and Whitney-General Electric electrolimit gage, and for flatness on an optical flat.

Maximum tolerance over or under the required size is 0.000005 of an inch (five millionths of an inch). The average error is no more than one thousandth the thickness of a human hair. The blocks are checked periodically with a master set to make sure they are up to standard.

An electrolimit gage is used to check gage blocks for size and parallelism

DIAMOND DUST

Now Being Recovered in Half Former Time

PULVERIZED diamonds are used to perform one of war industry's "hardest" jobs, that of polishing tungsten carbide dies to a degree of smoothness which eliminates much friction. Diamond dust is the best substance for polishing tungsten carbide, one of the hardest compounds yet devised by science. Dies made of this compound are used in drawing large size copper wire.

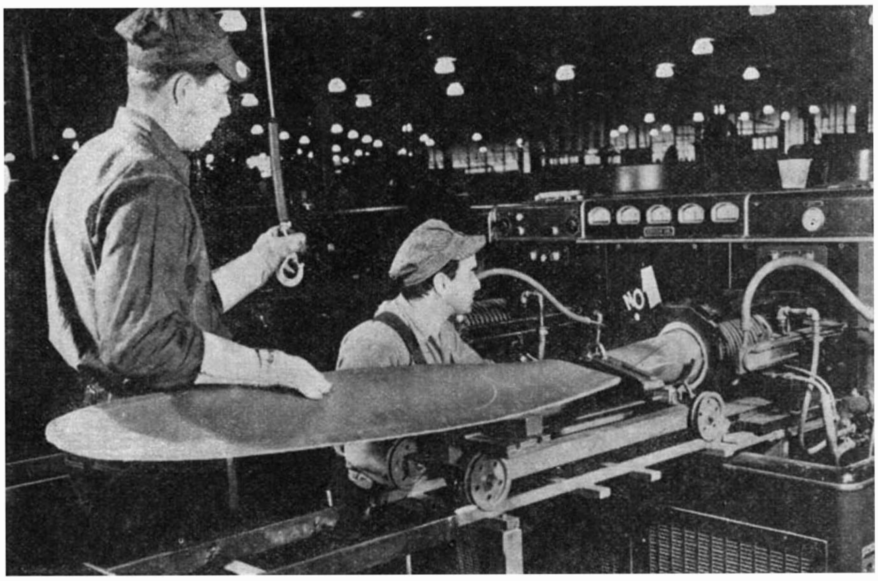
A small electric furnace is part of the equipment for diamond-dust recovery

Diamond dust may be used over and over again, but recovery is a problem. During polishing, the dust falls into a receptacle with oil, tungsten carbide particles, and bits of cloth. The recovery ordinary requires large amounts of acids which destroy everything but the diamond dust, but a greatly simplified method, recently devised, requires only small amounts of chemicals and the process can be completed by technicians in half the time formerly required.

PLASTIC BEARINGS

Self-Lubricated With Fruit Juice

LARGE rotary fruit-juice extractors, capable of turning out 200 gallons of citrus juice per hour, now depend on self-lubricating bearings of Lucite methyl methacrylate resin to keep going in wartime. Faced with a shortage of bronze bearings, one machinery manufacturer, after several months of exhaustive trials with new materials, found that, in addition to outwearing other types several times, bearings fabricated of "Lucite" were actually



Propeller-blade shank being rapidly heated by induction

lubricated by contact with citrus juices and periodic steam baths—two things that always shortened the life of bronze bearings. Du Pont chemists have been advised that the new bearings are equally resistant to orange, grapefruit, and lemon juices. "Lucite" is now on high priority—available for only the most essential uses.

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HORSEPOWER — **American firms now engaged in production of air-cooled and liquid-cooled aircraft engines are turning out more horsepower every 15 days than was produced here during the entire period of World War I.**

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PROP BLADES

Production Speeded by Induction Heating

Heating an airplane propeller-blade shank for two important forming operations in approximately one-fifth the time formerly required, is said to have resulted in one of the most time-saving procedures to be adopted in war-plane production. The shank is heated by the Tocco process of heating by electrical induction, a method originated by Ohio Crankshaft Company.

In the new process, the shank of the hollow steel propeller blade is first heated, preparatory to swaging, in a 100 kilowatt machine, which raises its temperature to approximately 1700 degrees, Fahrenheit, in 150 seconds.

When the correct temperature is reached, the operator hooks the blade on an overhead spring balance crane and conveys it to a huge National forging machine, capable of producing a 27-ton pressure, where it is swaged into a true cylindrical shape.

At the completion of the swaging operation, the blade passes through two welding processes, a thorough inspection, and a lathe machining operation before it is again mounted on the movable rack and heated a second time for 210 seconds to a temperature of about 2200 degrees, Fahrenheit.

When the proper heating is attained, the overhead crane again conveys the heated piece to the adjacent upsetting equipment in a few seconds. The upsetting operation consists of forming the heated shank in a three-pass set of dies to increase the wall thickness of the shank from .520 inches to approximately 13/16 inch, and to decrease the length of the shank area from 12-5/8 inches to 9-3/16 inches.

Prior to the adoption of the induction heating principle, the blade shanks were heated by means of gas furnaces. Fifteen minutes were required for heating to the desired temperature, and color of the heated work was the only way in which the operator could judge whether the correct temperature had been reached.

REVERSE SYNTHESIS

Nylon is Reverted to Original Chemicals

One of the most interesting new projects developed in the Du Pont Nylon Research Laboratory is in connection with the nylon salvage program. This was undertaken because of the urgent need for more nylon for government use. The high-pressure synthesis equipment which makes nylon chemicals from coal, air, and water is already taxed to capacity, and to make additional equipment would require large amounts of strategic metals needed for airplanes, ships and ordnance. The logical alternative was to salvage nylon scrap and make new nylon of it.

The dyed nylon material, including the stockings which women are now turning in at stores and other collection depots, is subjected to complicated treatments. They are, in effect, chemically "unraveled" until the original two starting chemicals from which they were made—adipic acid and hexamethylene-diamine—are obtained.

First step is to boil the stockings in strong hydrolyzing agent. In a laboratory demonstration this is done in a glass flask, to which is attached a reflux condenser; on a plant scale it is carried out in a lead-lined vessel. By the end of the first hour of boiling the stockings have completely disappeared and the vessel contains only a dark brown solution. A precipitate forms on cooling.

Filtering through a glass fabric separates the precipitate, which contains the adipic acid, from the filtrate, containing the diamine.

Each of the two components is now purified. The adipic acid, which is a powder and in the unpurified form may be any color depending on the amount of impurities present, is redissolved and recrystallized and is then treated with decolorizing agents. These steps

Nylon reversion on a laboratory scale

yield a very pure final product. The diamine solution is neutralized by addition of lime, which produces a precipitate of calcium sulfate. The mother liquor is drawn off and the water distilled off to leave the diamine. The diamine, which has a higher boiling point than water, is now distilled and it condenses as a colorless liquid, which becomes crystalline on cooling. The "reverse synthesis" of a stocking into its chemical components is now complete.

INDUSTRIAL TRENDS

WHAT TO PUT IT IN

THE container industry—frequently thought of as made up chiefly of producers of glass and tin containers—is in such a state of flux at present that almost any outcome can be anticipated, and with some basis of reason. Hence it is of interest to scan some of the present and near-past happenings, with a view toward watching future events and interpreting them in terms of trends.

A bit of history will help to shape up the whole situation. Scarcely possible does it seem that bottles have been made in huge quantities only during the past generation. Before 1905, all bottles were made by hand—or, rather, by mouth. Then came the invention that led to the perfection of bottle-making machines, and bottles became both plentiful and cheap. Long before that, however, the can manufacturers had been making good use of automatic machinery for high-speed production of sheet-metal containers.

Once the bottle manufacturers got started, they opened new fields for their products, and during recent years have penetrated deeply into territory formerly considered as the private property of the can makers. Back and forth went the balance, most recent and famous of the swings being the virtual capture of the beer field by the can manufacturers, only to have much of the business retaken by the glass men with containers for the beverage which held all of the advantages of the can and could be tagged with the slogan: "Beer is better in bottles."

But it is no part of our purpose here to hold forth on the accuracy of advertising slogans, even when concerned with the amber fluid that quenches many a thirst. The war put a temporary end to the beer can, and to tin-plate containers in many other fields. At the moment it appears that some of the stress which necessitated this ending may be relieved by improvements in the sheet-steel situation and by an increased supply of tin, but even these bright spots do not indicate any possibility of unrestricted tin-can production before the end of the war. It is possible, however, that there may be some relief in the matter of sheet-metal containers that do not require tin-plate. This would include such products as paints and dry materials that need the protection of a metal container for one reason or another, but do not need the corrosion-resistance of tin.

In the meantime, glass has been progressing favorably in many spheres of packaging. Light-weight, strong glass containers, reported previously in these pages, have taken over much of the tin-can business, and probably will take over much more, especially in the food container field. Glass has the advantage of being made of non-critical materials, in which phase it leads many other products in that it can meet extremely large demands, provided that labor is available.

But all is not sweetness and light for the glass container manufacturers. Research on fiber board, plastics, synthetic rubbers of various kinds, and other possibilities in the packaging industry have revealed many new ways of making containers out of materials other than glass and metal. Then, too, "styles" in many things that require containers are changing, making necessary corresponding changes in the containers themselves. Dehydrated foods are one example, and an example that is going to have far-reaching effects on our shopping and eating habits by the end of the war, if not before. Many foods that can be successfully dehydrated and "de-bulked" were formerly packed in tin or glass, in their natural state. Now, devoid of water and often compressed further to decrease their physical volume, these same foods can be wrapped in water-proof paper, synthetic film, or other covering that will afford whatever protection is needed from deteriorating factors.

Then there are the frosted foods which, while not "dry" in the accepted sense of the word, nor de-bulked, do not require the protection of a tin can or glass jar. Here, again, a wrapping of some sort is the only protection needed, so long as the food is kept at the required temperature, and once more the glass and metal container manufacturers lose an old customer or a potential new one.

Of course, metal-container manufacturers have all the business they can handle at the present time, either making cans for food and other products on a restricted basis, or engaged in the manufacture of one kind or another of war materials. The glass companies are doing all right, too. But there is a day coming—and it is to be hoped that it is not too far in the future—when the military war is over and the war of containers starts once more. Then it will be more than just glass *versus* metal; the know-how piling up in other fields will be released . . . and the fight will be on!

UP-AND-COMING POWDER METALLURGY

POWDER metallurgy, dealt with in detail in past issues of Scientific American, is making a big place (exact size maintained as a military secret) for itself in many present-day industries. This definite and highly important trend has been so clearly and patly put in *The Research Viewpoint* of Gustavus J. Esselen, Inc., that we turn the rest of this page over to the editor of that recondite reporter of industry's changing scene, and quote:

". . . The process is more than 100 years old, but has made especially rapid strides in the past few years, and is creating a minor revolution in metallurgy.

". . . It was in 1829 . . . that finely divided platinum was pressed and sintered into solid ingots. Later the technique was used to make finished products from tungsten, molybdenum, and other metals with melting points so high that they could not be handled by ordinary molding methods.

"The next step was the production of high-speed cutting materials such as the hard cemented-carbides, some of which could never be made by any other method.

"The trend suddenly took another direction when the powdered metal technique was applied to materials that could be and always had been molded. In some instances more intricate shapes, with closer tolerances, were obtained. In others the production of scrap was eliminated. And what interested industry even more, costs were lowered on quantity production.

"The latest development, announced before the war made all technological progress secret information, was the alloying of metals by mixing mixing two or more alloys in powder form. This is known as diffusion alloying.

"When war restraints are removed, it looks as though there might be a mad scramble among materials, with plastics, wood, glass, metals, and metal alloys competing with one another. As each one finds its place of maximum economic usefulness it is likely that powder metallurgy will become one of the standard processes contributing to a more efficient post-war world."

—The Editors

Highways to Strategic Materials

Completed Portions of Pan-American Highway

Can Help the United Nations' War Effort

EDWIN W. JAMES

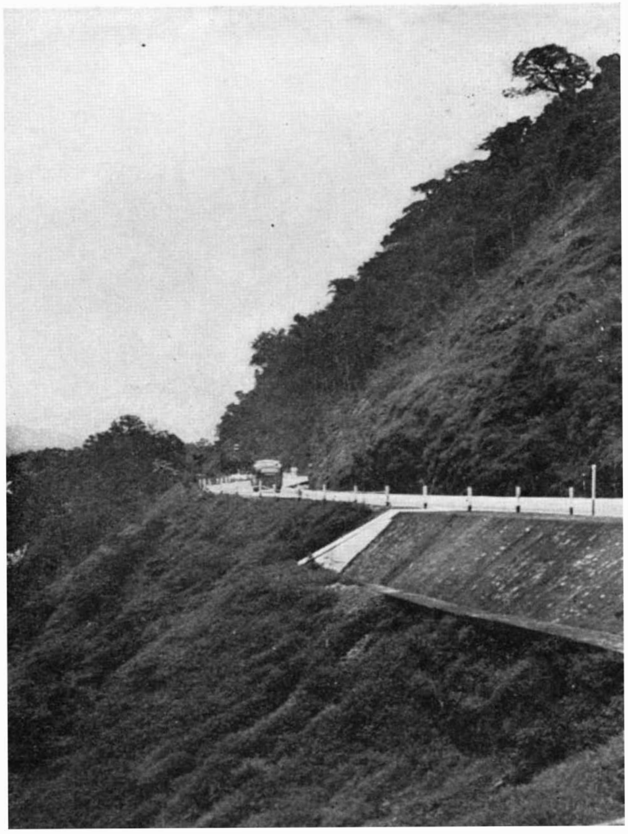
Chief, Inter-American Regional Office, United States Public Roads Administration

THE construction of the Pan-American Highway is a monument to the co-operative spirit of the Western Hemisphere republics, in sharp contrast to the holocaust of destruction now consuming the social and economic fabric of the Eastern Hemisphere. The universal shortage of ship transportation has increased the importance of the Pan-American Highway as a potentially vital factor, not only in the "Battle of Supply Lines," but also in the "Battle for Raw Materials," so essential to our increased war production. South America is veritably a storehouse of strategic materials for the great munition industries of the Arsenal of Democracy, and is now more important than ever before as a source of strategic materials formerly obtained from the Far East.

The Pan-American Highway System has been under construction for almost 19 years. When it is completed, nearly half a billion dollars will have been expended on it. Construction and improvements of this highway system are continuing today throughout the Americas.

For the internal movement of materials in South America there already exist various railroad, air, and river shipping facilities. Others which have been proposed or are under construction can be coördinated with the Pan-American Highway. The course of the highway has been strategically laid out so that there are now convenient connections with other forms of transportation.

Highway transportation has figured very prominently in this world crisis. Our Government has recognized the importance of highway tranportation for the movement of materials by granting large loans and appropriations to the other American republics, totaling between 85 and 95 millions of dollars, for the building of the Pan-American Highway through Central and South America. The same objectives are involved in the recent decisions to rush a "pioneer road" from the Mexican-Guatemalan border to Panama City, soon to be linked with the Mexican railway system leading north to the United States border, and to rush to completion the Canadian-Alaskan Highway to make it available for motor transportation for defensive as well as offensive operations. But even these loans and appropriations may be inadequate if speedier construction is wanted.



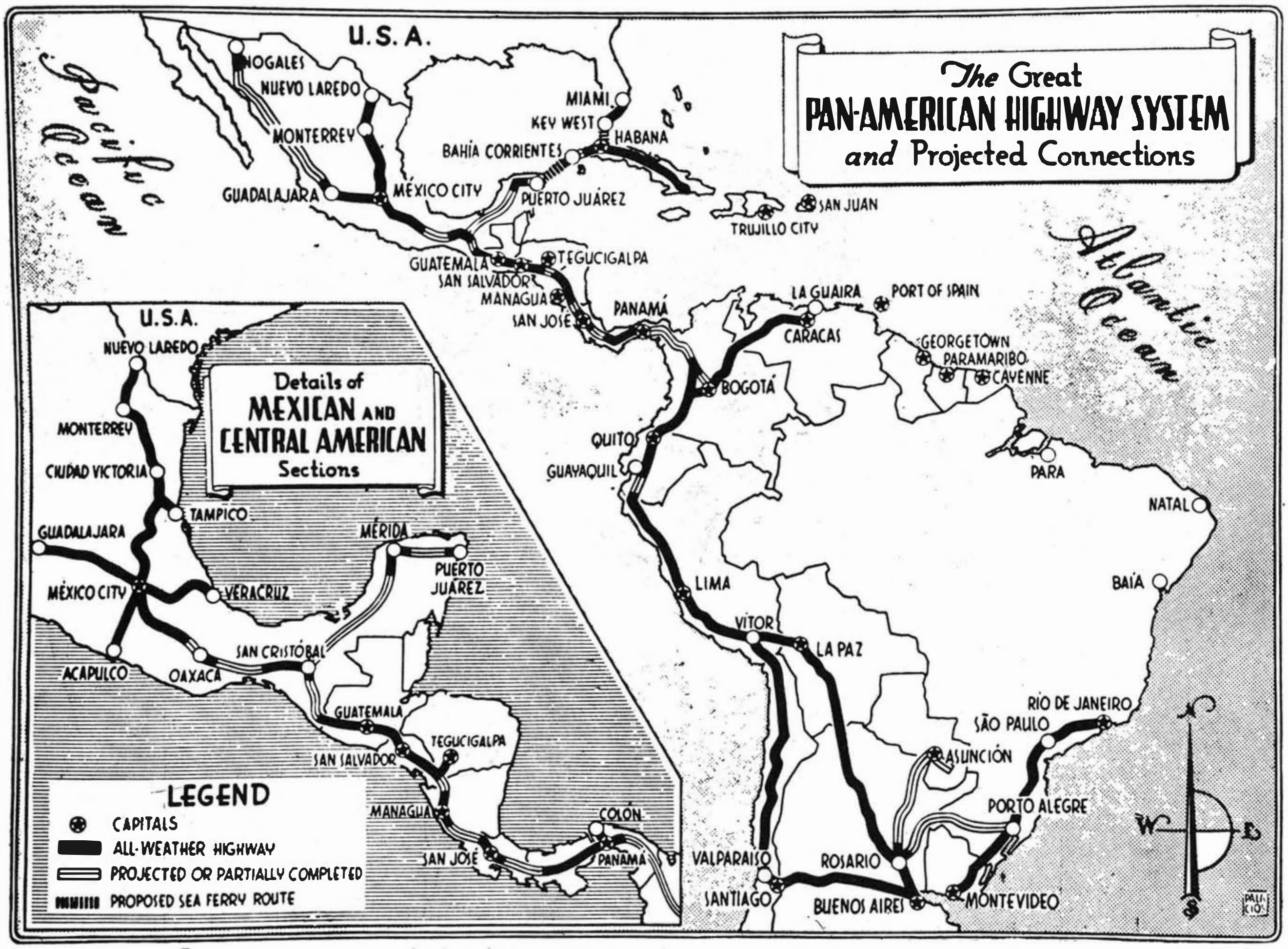
Between Rio de Janeiro and Petropolis, Brazil

The wisdom of a planned international highway system as a basic part of our war program has been dramatically exemplified by China's Burma Road over which has moved strategic materials. Reports indicated that a large percentage of the truckloads consisted of fuel—there being few sources of gasoline supply on the road. Such trucking of fuel would not be necessary along the Pan-American Highway System, since some fuel facilities are now available and gasoline depots could readily be established.

Ships still are the principal means of moving commodities in inter-American trade. Therein is the crux of the inter-American transportation problem. It is the long sea distance which makes this menace to our shipping so crucial. If transportation between the Americas over the long sea routes can be sharply reduced and if, at the same time, a continuous flow of essential supplies can be maintained, we are on the way to a solution of the problem.

Shipping distance from Buenos Aires, Argentina, to New York is 5871 nautical miles, if ships follow the normal peacetime shipping lanes around the northeastern hump of Brazil, and then sail in a straight course in the general direction of Cape Hatteras and thence to New York. The usual freight ship passage during peacetime over this route requires 24 days and often more. A major portion of the trip is in the South and North Atlantic Ocean, where the incidence of ship sinkings has been highest, including sinkings of vessels of South and Central American registry. A part of the voyage from Trinidad north is made in secondary naval and aerial patrol zones. Through a greater part of the trip, ships do not have the primary protection of the Army or Navy patrols except at the time ships are about to enter waters adjacent to ports of destination in the United States.

Obviously there is a great advantage in routing shipping over the Caribbean Sea and the Gulf of Mexico. Not only is the sea route shortened, but the Gulf and Caribbean region is already under the vigilant eyes of Army and Navy, because of its proximity to the Panama Canal. The concentration of the major part of inter-American transportation in this area would also permit concentration of Army and Navy protective units in this region. Thus protection will be in-



Economic importance of the Pan-American Highway System can readily be seen from this sketch map

creased in proportion to the shortening of the dangerous sea distance.

In weighing alternative combinations of land and water routes, it is the South American section of the Pan-American Highway with which we are at present concerned. Except for about 2000 miles of continuously surfaced roads in Mexico, the 3500 miles of the North American section of the Pan-American Highway (known as the Inter-American Highway north of the Panama-Colombia border) is not being considered, as that section is still under construction. Some intermediate sections are completed, but will not be continuously connected until June, 1943. Approximately 300 miles of territory in southern Panama and northern Colombia are still only semi-explored.

The South American section of the Pan-American Highway between La Guaira, Venezuela, and Rio de Janeiro, Brazil, is about 8200 miles long, following for the most part the Pacific Coast through Colombia, Ecuador, and Peru, and continuing southeast through Bolivia and Argentina and thence northward along the Atlantic Coast through Uruguay and Brazil.

The Pan-American Highway's completed and projected routes are traced on the accompanying map. Reports reaching the Public Roads Administration as of August, 1941, indicated that the highway in South America was 76.1 percent finished for "all weather" driving—which means all-year 'round. An additional 20.3 percent is "dry weather" road, which can be used six months during the year, bringing the total of useful highway to 96.4 percent for at least six months in the year. During the past year additional construction and improvements probably have moved this last figure up to about 98 percent.

FROM April to November, in the 12,600-foot Uspallata Pass in the Andes Mountains, at the border of Chile and Argentina, winter snows accumulate and prevent normal movement of wheeled traffic between the two countries for about six months of the year. If increased traffic warrants it, snowplows could keep this road open all year. The map shows the alternate central route north of Buenos Aires, Argentina, to La Paz, Bolivia, connecting with the western branch of the Pan-American Highway to Vitor, Peru. This route could be utilized to service Argentina, Uruguay, Paraguay, Bolivia, and portions of southern Brazil during the winter months, so that there can be free movement of vehicles over the highway all during the year.

Truck transportation over the Pan-American Highway is expected to be a principal feature of future trade among the other Americas. Trade among the American republics is more important than ever before now that they are cut off from many foreign markets. Even if the present rate of shipping could be maintained, which is doubtful, normal requirements are not being met. A plan to supplement shipping by utilizing trucking over the highway for transportation to the United States of vital strategic supplies would be an important step in providing materials for urgent production of military weapons as well as maintaining South America's economy.

Recent reports from Peru indicate that plans are being considered to solve local transportation problems engendered through the shortage of shipping by using truck convoys over the Pan-American Highway to haul goods from southern to northern Peru, over a distance of about 1000 miles. These plans propose to accumulate cargoes in northern Peru and thus save a thousand miles of ship movements.

The question may be raised as to whether necessary supplies and service facilities exist in South America to provide for a large-scale, long-haul trucking movement. There is oil in Venezuela, Colombia, Peru, and Argentina; Venezuela is the second largest oil producer in the world.

There is rubber in Brazil, Colombia, Bolivia, Ecuador, Peru, and Venezuela. There are 12 tire factories in South America. Recently, United States government agencies have sent many technicians to South America to stimulate increased production. Forty thousand tons of crude rubber annually is expected to be produced in the other American republics by 1943, with progressive increases each year thereafter.

As to other facilities: Every part of the highway, where constructed, is now being used for inter- and intra-American trucking and bus travel, although up to the present it has not been used extensively for the transportation of strategic materials to the United States, except for limited quantities coming from Mexico. The Mexican section of the Pan-American Highway and other Mexican national and auxiliary highways provide a continuous system of about 2000 miles of surfaced roads directly connected with those of the United States.

Even though we assume that motor transport costs exceed wartime shipping costs by a considerable margin, the fact that we have at present insufficient shipping at any cost to fulfill our needs should eliminate this factor as a basic consideration. Such cost differences as exist, when measured by United States prices, may be substantially reduced by the lower wage scales prevailing in most South American countries and the added economy of operation of Diesel-motored trucks.

As a proposed partial solution, a general movement of critical and strategic materials could emanate from Argentina and southern Brazil and accumulate westward through Chile, and northward through Bolivia, Peru, Ecuador, Colombia, and Venezuela, toward seaports situated on the Caribbean Sea and the port of Buenaventura on the west coast of Colombia, on the Pacific Ocean.

Secondary roads, airports, and railways are built in and adjacent to this region and around the ports of Maracaibo and Puerto Cabello in Venezuela, and Barranquilla, Cartagena, and Santa Marta in Colombia. At these "ports of accumulation" there already are storage warehouse facilities and more could quickly be built. Colombia's own road program includes improvement and extension of secondary roads in this area. Another important link, which is nearing completion, is a new highway which will connect Cali and Palmira, Colombia, on the Pan-American Highway, with the port of Buenaventura on the West Coast.

Progress on a road construction project in Costa Rica

Peru and Bolivia, too, are stepping up auxiliary road construction. Nearing completion is a 350-mile highway which will eventually link Lima, Peru, with its eastern empire across the Andes to Tingo Maria, site of a new agricultural experiment station.

From the South American Caribbean ports shipments could be made to the United States. This routing would reduce the ocean distance to passage over the Caribbean-Gulf region only. Allied vessels also could make pickups for British, Chinese, and Russian distribution. This would eliminate thousands of miles of precarious ocean travel by British and other Allied shipping. This routing would avoid voyaging north or south along the east and west coasts of South America.

Ships crossing the Gulf of Mexico from the "ports of accumulation" could be docked in the United States at Houston, Texas; New Orleans, Louisiana; Mobile, Alabama; at Tampico and Vera Cruz, Mexico (highways and standard gage railways to the United States border run from these Mexican ports; or at other United States ports adjacent to manufacturing centers or strategically close to Army and Navy establishments, railheads, or inland waterways, or river systems. From these ports rail, river, plane, or truck transportation could assume the final task of domestic distribution of goods.

Another alternate shipping route is that from the oil center and port of Talara, Peru, or from the port of Buenaventura, Colombia, northward up the Pacific Coast to the port of Acapulco, Mexico (a surfaced highway connects with the Pan-American Highway at Mexico City, leading to the United States border), or the ports of Mazatlan, Manzanillo, and Salina Cruz, which are connected with the United States by standard gage railways, or ships can sail directly to United States west coast ports. There have been very few ships sunk off the Pacific Coast of North and South America by the Japanese and the smashing attacks made by the United States Navy against the Japanese Navy in the Battles of Midway and the Solomons bodes ill for raiders in this area.

The Pan-American Highway could compensate in part when the enormous tonnage, and practically the entire convoying strength of the United States and our allies, may be mobilized for shipping troops and supplies to open new fronts. With new battlefronts rapidly developing, inter-American supply lines may have little or no protection against undersea attack. Every mile of highway built and used now may mean the saving of lives, ships, and vital cargoes of strategic materials for our war industries. Development of the Pan-American Highway as the "Lifeline of the Americas" should prove of inestimable value in the international effort to maintain a continuous flow of raw materials to United States war industries, and a return flow of essential goods to the other Americas.

OUR *Point* OF VIEW

BEYOND THE HORIZON

EMINENTLY realistic and practical is the view which a group of New York business men and technologists are taking of the post-war industrial world. In the days to come, they argue with irrefutable logic, those industries which have prepared for the inevitable transition from war production to peace-time activities will be the ones which will prosper; others will languish and possibly fail.

The well-known path toward such preparedness for peace is research, applied now to future problems. Through research it becomes possible to plan new civilian uses for military products, to determine means for machinery and product conversion, to take out insurance, so to speak, on what lies as yet beyond the horizon. But many important industries today lack research facilities, do not have the manpower to establish planning departments, perhaps do not have personnel with the depth of vision needful for peering into the as yet unknown.

It is to aid just such industries that the aforementioned business men and technologists have banded together in a post-war planning board. The members of this board, selected from a number of fields of endeavor in which they hold outstanding positions, represent a sum-total of talent the equal of which could be employed, if available, only by the largest of industrial organizations.

Yet the services of this planning group are now at the disposal of the smaller manufacturer, whose specific or general problems will be considered by specialists. Recommendations will then be made for changes, developments, or what ever, in the opinion of the experts, may be necessary to fit the machine, the product, or perhaps the manufacturer's organization itself to the needs of the future.

By such an approach the smaller, and many a larger, manufacturer will be relieved of his worries about the problems of tomorrow. With these worries poured into a pool of experts, he can concentrate more completely, and successfully, on the business of the moment. Out of the pool, in due time, will flow the answers, unless, indeed, the problem proves to be completely unsolvable.

Such a realistic approach to post-war industrial activities is highly encouraging, showing as it does that some people are doing more than talking about the future. The foresighted are planning for it.—*A.P.P.*

SECRECY VERSUS PATENTS

WARNING that emasculation of our patent system is a danger even closer today than ever before, Dr. Robert E. Wilson, president of the Pan American Petroleum and Transport Company, recently told members of the American Chemical Society, and others, that there is a definite possibility that such emasculation would result in a reversion to the dark ages of secret processes.

"Our patent system is in real jeopardy," said Dr. Wilson. "This jeopardy is due to public misunderstanding which in turn is largely due to deliberate misrepresentations as to the nature of the patent monopoly and the part which patents play in encouraging invention and the prompt disclosure of discoveries and inventions to the public. The inevitable alternative of secrecy would tremendously retard the progress of both science and industry in this country.

"It is high time for scientists to join the patent bar and trade organizations which have heretofore borne the brunt of combatting the threat of our patent system which jeopardizes the whole future of industrial research. Unless our scientists help to educate the lay public as to the facts of the situation, ill-considered legislation may be adopted which would hamper all research, prevent the prompt and free exchange of information, destroy the market of the independent inventor, and discourage the continuance of American industrial research, of which we are so justly proud.

"Probably the most serious effect that emasculation of our patent system would have on the future of research would be to encourage the use of secret processes. This would be highly unfortunate, since one of the principal reasons for the rapid advance of science and technology in the past 30 years has been the practical elimination of the secret process in favor of full disclosure and patenting as the preferable method of protecting one's rights and interests in his invention.

"If we take away a large part of the reward for disclosure, the tendency to revert to the dark ages of secret processes will be inescapable. The loss to our country would not be merely that due to the absence of competitive use of the process but even more in the slowing down of the exchange of basic information and new ideas.

"Inter-company research conferences and reports on new lines of development would practically cease and early publication of research work would seldom be permitted. Industrial espionage would rear its ugly head, and efforts to prevent it would force the elimination of the 'open door' policy of most of our industrial laboratories.

"Even though the attempt at secrecy might usually fail within a few years, the cumulative effect of the loss of time between successive improvements would tremendously retard our progress. Under present conditions new discoveries are frequently published long before the patent is actually issued, and the effect on the whole tempo of industrial progress is tremendous because so little time elapses between the discovery and the general availability of the information to stimulate new researches in a variety of fields not originally dreamed of by the original discoverer.

"We must also not overlook the effect of a drastic weakening of our patent system on our future ability to get information from abroad," Dr. Wilson said in summation. "Manufacturing conditions aboard are usually better adapted to protecting the secrecy of processes than in this country, and it is only the liberality of our patent system and the existence of a real market for worthwhile patents which has led most foreign patentees to make early application for a patent in this country."

None of what Dr. Wilson has to say in any way militates against revisions of our patent system to meet changing times; it cannot be too strongly emphasized, however, that the system itself is basically sound and should not be tampered with to meet crackpot or political or other selfish ends.—*O.D.M.*

Water and You

In Many Ways that Are Commonly Overlooked, Water is Involved in our Physiologic Processes

ARTHUR L. MEYER, M.D.
Formerly on the Staff of the Rockefeller Institute for Medical Research, and Associate Professor of Physiology in The Johns Hopkins University

A QUIZZICAL old gentleman once remarked that, in his opinion, the oceans were greatly overdone. I think that most of us, however, will easily appreciate the wisdom that prompted so wide a distribution of water over the face of the earth. Without water, life would be as non-existent as it is on the Moon. If, then, our planet is to continue as a habitat for living things, there must never be the slightest danger of a general and thoroughgoing drought.

It's really amazing how largely the human anatomy is composed of water. If a cadaver, weighing 170 pounds, and free from abnormal accumulations of water during its lifetime, were thoroughly descicated, it would weigh only about 50 to 60 pounds. We are, therefore, in very large part nothing more than animated masses of water. What is true of man is also true, of course, of all the representatives of the plant and animal kingdoms. The further fact that the youngest, the most actively growing forms of protoplasm, are highest in their water content indicates that water must have been very intimately concerned with the origin of life itself. And it is precisely by this token that the shrinkage of the senescent frame is prophetic of impending death.

It might seem that living matter, with its remarkable capacity for growth and reproduction, mental and spiritual achievement, would require something vastly more mysterious than water as its major ingredient. But strange to say, it is one of the characteristics of life to use only the most commonplace material in its structural organization. It shuns radium, gold, and platinum, but it does seize upon such things as carbon, oxygen, nitrogen, hydrogen, sodium, calcium, magnesium, sulfur, and iron; that is to say, elements which are among the most abundant in Nature.

Some of the reasons for the indispensable place that water occupies in the scheme of life are easy to understand. Water is an ideal solvent. I can think of no beverage adapted to human consumption, having a solvent other than water, and I am not forgetting milk. Even the most bibulous among us prefer to take their spirits in aqueous solution. And there is something about water which makes it the most acceptable of solvents to oxygen, so generously provided by the atmospheric ocean in which we live. Before satisfying their innate affinity for the iron of hemoglobin, the molecules of oxygen are jostled about in the watery plasma of the blood. They seem to like this. Otherwise they would not so willingly become disengaged from the hemoglobin, and submit to another jostling in a watery medium before their final union with certain tissue elements. The tissues, however, are calling for other things besides oxygen. They need fuel. It would be hard to imagine how a dish of salmagundi could provide sustenance to hungry cells if, after suitable preparation in the central cuisine of the body, it weren't given transportation to places where it was most needed. The reason that this is accomplished so effectively is partly because the vehicle of transportation is water.

THE living furnace, unlike the household furnace, is obliged constantly to attend to the removal of its own waste products. Oxygen burns carbohydrates and fats into carbon dioxide and water as completely within the body as it would in a bomb calorimeter. Since water isn't really a waste product, it is retained so far as possible, but carbon dioxide is carried into the lungs, where it finds an easy exit by passing up the flue, so to speak. Things are very different in the case of proteins, however. Proteins are only partly burned in the body. The residue, which is known as urea, appears as one of the constituents of urine.

The digestive juices which are daily poured into the alimentary tract contain about four quarts of water. In a less economical system all of this water would be cast off with the indigestible remnants of food. But our bodies think highly of this water, and return most of it to the circulation. Since the volume returned is about four times the amount that the average person drinks each day, our intake of water would have to be considerably greater than it is, were it not for this provision of Nature.

Though every effort is made to conserve the body's water supply, certain loses are unavoidable. The water in the solid excreta serves as a lubricant. The urinary output carries with it the refuse of general metabolism. The water which is constantly evaporating from the lungs and skin surface is known as insensible perspiration, and, because of its cooling power, is one of the factors regulating body temperature, thus reminding one of the hot desert custom of cooling water by placing it in earthenware jars. On occasion the body dilates its peripheral blood vessels and brings into action innumerable miniature geysers, called sweat glands. But for this, and a sufficiently dry atmosphere, a thermometer rising to uncomfortable heights would be rather enervating during a stiff bout of tennis.

BEVERAGES are by no means the only source of our water supply. Every portion of fruit or vegetable or meat contains water, and every bit of carbohydrate, fat, and protein that we burn within our bodies is actually converted partly into water. Furthermore, the body has a commendable habit of storing water against a temporary shortage. Whenever the reserves in the skin and muscles run low, we are promptly informed by a signal which we recognize as thirst. In the simple act of satisfying our thirst, we are adequately safeguarding our water balance. This thought should be a comfort to those who are given to fretting overmuch about their water intake.

When we drink "plain water," we are not drinking water in a state of unmixed purity, to be sure. There is no such thing in Nature. What we drink is always a mixture of the molecules of ordinary and "heavy" water plus something else—a solution, in other words; for even rain-water, product of a gigantic distillery, contains a dash of ammonium salts and certain gases to give it a tang, presumably lest plants should otherwise find it too insipid. On issuing from our springs, having percolated all manner of soil, it has become "hard," or chalybeate, or sulfurous, or radioactive, or what not. One sometimes marvels that its further exposure to such things as chlorine, copper sulfate, alum, and calcium hydrate, during the rites of chemical purification by our sanitary experts, should still leave it potable, not to say wholesome, when it comes from our hydrants.

But long experience has made life a connoisseur of solutions. The blood plasma, tissue fluids, lymph, and cell-sap are all watery solutions of sugar, salts, and albuminous materials. Though an exchange is constantly going on between them through partitions of delicate fabric, they are always kept in a state of "osmotic" balance. What passes from one to the other depends on the kind of specialization achieved by the partition itself. Some of these living membranes are permeable to water only. Most of them permit the diffusion of water and crystalloids, and many of these also allow proteins to pass, while others have denied a free thoroughfare to the protein molecule.

We'll assume that on a hot summer's day your sweat glands pour out four pounds of water in an orgy of libation to the goddess of badminton. You make good the loss by drinking water, and your kidneys, always on sentinel duty, prepare a urine containing sufficiently less salt to compensate for what is lost in the sweat; for the body, you see, conserves salt as well as water. Should you, by any chance, over-indulge in water, the kidneys would simply get rid of the excess, except for a portion which might be held for storage.

When the body cells live together in peace and comfort, the disposition they make of their water supply is very different from what we see in times of stress, or under conditions which alter the vital fabric.

Abdominal cramps and an intense feeling of fatigue and depression may sometimes be met in stokers, miners, steel workers, and others engaged in extremely hard work in extremely hot places. The overtaxed muscles and sweat glands of these men are so greedy in their demands on the circulation that the kidneys for the time being are out of action. In these circumstances, a heavy drain on the salt reserve, uncompensated by a corresponding intake, and a gulping thirst, over weeks and months, can do little else than produce a state of chloride shortage.

In the under-world the Danaides, you may recall, were assigned the task of forever lifting water in sieves. The story comes to mind as I think of diabetes insipidus. In this disease the kidneys have become profligate, for some strange reason, of the body's water, and permit as much as 40 pints to pass, as through an ordinary filter, in a single day. As the sieves of the daughters of Danaus probably retained things other than water, so the kidneys in this disease retain sugar and proteins. Except for its watery color and enormous volume, the urine is fairly normal. Persons with diabetes insipidus are therefore not diabetics in the ordinary sense of the term.

An extraordinary loss of water is again prominent in the foreground of cholera; this time from the bowel. Water passes into the bowel from the blood stream against the usual traffic signals, as if in a desperate effort to flush out the invading germs. Water entering the body in abatement of a burning thirst fails to negotiate the barriers temporarily set up between bowel and circulation. Hence the blood becomes viscous, and more viscous, until at last we have a condition resembling a plumbing system filled with molasses. And yet, mirabile dictu, in some instances, the diarrhea vanishes, the body warmth returns, the kidneys again function, and the patient recovers.

Though water is one of the simplest of substances, the mechanism of its physiological behavior is not so simple. At this point, therefore, rather than yield to the temptation of discussing the physical forces of solution, ionization, diffusion, and osmosis, let me conclude with a word of assurance. To those who harbor a fear of nausea, dizziness, and motor incoördination from too liberal an intake of water, it may be said that, while "water intoxication" is an entity experimentally demonstrable in some animals, the possibility of its occurence in human beings is quite remote. Too little water is far more likely to be disturbing than too much water. And finally, if there are those who suspect water of being a causative agent of their obesity, let me remind them that by no alchemy has water ever been transformed into fat. It may add to one's weight, but not to one's embonpoint.

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ULTRA-SONIC

Focused Ultra-Sound Waves From Curved Crystals

Ultra-sonic waves, which are intense sounds of such short wavelength that they are far beyond human hearing, have been produced in a focused beam in the laboratories of the College of Physicians and Surgeons, Columbia University. Turned on liver and other animal tissues, they have a destructive, "cooking" effect in the spots where they were focused. They also throw water upward in a mound-like jet, melt holes in paraffin blocks, and have other striking physical effects.

The new work with ultra-sonics is being done by a three-man research team, John G. Lynn, Dr. Raymund L. Zwemer, and Arthur J. Chick.

Ultra-sonic waves are produced by specially cut pieces of rock crystal—piezo-electric crystals—which vibrate tens or hundreds of thousands of times a second when stimulated by high-frequency electric currents. (Human auditory range stops at about 20,000 cycles a second.)

Biological effects of ultra-sonics were first studied about 15 years ago by Prof. R. W. Wood of the Johns Hopkins University, Prof. E. Newton Harvey of Princeton University, and Dr. Alfred L. Loomis of Tuxedo Park, New York, in the latter's private laboratory. At that time, the crystals used were flat, so that the "beams" of ultra-sonic waves went out in straight or somewhat spreading lines. In the new experiments at Columbia, curved crystals are used, which have the effect of focusing the waves at a point, like the concentrated light beams passing through a lens. Their effects are thus at once localized and intensified.

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INSECT SIGHT—Experiments indicate that honey bees and fruit flies can see ultra-violet light, which is invisible to human eyes, reports the Better Vision Institute.

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PISTON STUDY

Facilitated by New Photographic Development

Automotive engineers have put photography on the job of ascertaining how well lubricating oils meet the severe requirements of actual service. The camera is built into what they call a "piston-photographing machine," which produces an image of the entire piston surface upon a single plane with practically no distortion. In use, a test piston is slowly rolled and revolved at constant speed along an arc. It presents each point of its circumference equidistant from the center of the arc for photographic exposure through a ¼-inch slot, which moves with the piston and is in line with the point of contact and with the camera lens. The resulting picture clearly reveals all marks, such as those of the original finish, scuffs, scratches, carbon deposits, varnish, and so on.

A Dream Almost Attained

A New Success Seems to Bring Astrophysics Still Nearer to the Rounded Solution of a Major Problem

HENRY NORRIS RUSSELL, Ph.D.

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

THE EARLIER history of astronomy fell into two stages: first, that of observation in which the orbits of the planets and their laws of motion were determined, and their distances and dimensions approximately found; and second, that of theory and observation combined, when these empirical laws were shown to be consequences of the principles of dynamics and gravitation. It then became possible to determine quantities—such as the masses of the Sun and the planets—which had previously been outside even the range of speculation, and to predict all the possible kinds of orbit which a body moving near the Sun could have, and to explain the motions of comets, and by other applications to account for such things as the tides.

A similar advance in the newer science of astrophysics has taken place in our times. Forty-two years ago (when the writer began his contributions to this journal), though much fewer observations were available than now, it was possible to find the distances, luminosities, masses, diameters, and so on, of enough stars to give us a fair idea of their properties. The spectroscope gave us extensive knowledge of the composition of their atmospheres, and revealed the existence of a long series of inter-grading types. We knew a great deal; but we had little or no idea of what a star ought to be like, on general principles, or of the real significance of such things as the spectral sequence.

The great awakening came this time with the discovery and development of the principles of atomic physics, which have done as much for astrophysics as those of gravitation did long ago for astronomy.

Knowledge which once seemed beyond even the dream of attainment is now in our grasp and we are far toward a solution of the deductive problem: Given a large quantity of matter, of known composition, isolated in space: Into what configurations can it settle down for a long-enduring career? Will it be self-luminous? If so, how big, bright, and hot will it be? And what will be the spectrum of its light?

We need only recall in a few words how Eddington showed that any large mass—more than a tenth of the Sun's—would be so hot inside that it would be hot outside and self-luminous, and that the brightness would increase rapidly with increasing mass and slowly with diminishing diameter. This explained why a star of the Sun's mass should be of about the Sun's brightness, but not why it should be of the Sun's size. Later, Bethe found a set of reactions between atomic nuclei which accounted for the gradual and self-regulating production of enough heat to keep the stars shining for billions of years; and this indicated that a star of the Sun's mass and brightness should be also of about the Sun's size and therefore of the Sun's surface temperature and color. To fit the Sun exactly, the mass would have to be composed mainly of hydrogen and helium, with a small percentage of heavy elements.

WE HAVE, therefore, a reasonable explanation, on general principles, why stars like the Sun are what they are—and likewise brighter and hotter stars like Sirius and Procyon, and cooler, fainter ones like 61 Cygni. What happens inside the great red giants like Arcturus and Antares we do not know yet.

Passing from the general properties of the stars to their spectra, reasoning along the lines initiated by the Indian physicist, Saha, shows that in the atmosphere of a star of the Sun's temperature some elements, like helium and neon, would not have their atoms stirred up enough to fit them to absorb lines in the observable part of the spectrum, while others, like potassium, are so easily affected that few atoms remain in condition to produce observable lines. This explained not merely why the solar spectrum looks as it does, but why some lines get stronger and others weaker in the spectra of the hotter stars, while other changes happen for the cooler ones. The whole sequence of spectra was thus explained at one sweep, and refinements such as the differences in finer detail between the spectra of giant and dwarf stars of the same temperature soon yielded to the analysis.

At the same time another riddle was solved—why the surface of the Sun, which is far too hot to contain any solid particles or liquid drops, looked like a sheet of incandescent cloud, with markings on it such as sunspots. The medium is purely gaseous; but it is full of free electrons, and the interaction between these, the light-waves, and the charged atoms from which the electrons have been lost, make the gas hazy, so that we can not see very deep into it and it looks substantially like patches of ground-fog seen from a height.

ONLY the atoms or molecules in the atmsophere above this fog can absorb the spectral lines that we observe. To be more precise, the fog thickens gradually downward, and we must count the atoms which lie above a certain average level where it is already pretty thick.

On these principles it has been possible to make a surprisingly good quantitative analysis of the atmospheres of the Sun and of many stars. They are found to be composed mainly of hydrogen and helium with only a whiff of atoms of other kinds; but the relative abundance of these heavier atoms is remarkably similar from star to star, and remarkably similar in general to that in the surface crust of the Earth.

With all this long list of successes, the theory failed in one point until recently. It indicated that the lines in stellar spectra, and in the solar spectrum in particular, should be much wider and darker than they are actually observed to be. The Sun's atmosphere, down to the impenetrable haze, is surprisingly shallow. The first to realize this fact, long before its full implications could be realized, was that great pioneer in astrophysics, Sir Norman Lockyer. Sixty years ago, he exhibited to a scientific audience in London the sodium lines in the Sun's spectrum, and the same lines as absorbed from white light by passing through a salted Bunsen flame an inch thick. The latter were the stronger—and so, said he, we know that there is less sodium per square inch in the Sun's atmosphere than in this flame.

It was more than 40 years before this half-forgotten remark was fully appreciated. Now we know that Lockyer was entirely right; but why the solar lines of sodium, and other elements, should be so faint began to be explained only three years ago.

Qualitatively, we understood perfectly well that, when an electron passes close to a charged atom and changes its "orbit," or when one is captured by an atom and later knocked off, light is emitted or absorbed in such a way that the gas, as a whole, scatters light of all colors, and behaves like a thin fog. But when the theory was developed far enough to permit of fairly accurate calculation of this scattering, it was found to be much too small. We should see deep enough down into the photospheric fog to leave at least ten times as many atoms working above it as are required to produce the observed spectral lines. Evidently there was some additional, and powerful, source of haziness in the atmosphere.

A SIMILAR situation was found in the cooler stars in general. In the A-stars, like Sirius, where the very numerous hydrogen atoms are split up, the calculated scattering agreed tolerably with observation.

In 1939, Wildt, who knows more modern chemistry than most other astrophysicists, saw where the answer was. The Sun's atmosphere contains an overwhelming proportion of hydrogen. The molecules are all dissociated into atoms, but hardly any of these are ionized—it is too hard to get an electron off one at that temperature. It had been supposed that these hydrogen atoms were practically inert as regards visible light, but Wildt found in the chemical literature evidence that the *neutral* hydrogen atom has a certain tendency to attract a free electron, and build up a negatively charged atom. It had long been known that electronegative atoms, such as chlorine and oxygen, had this "electron affinity;" but the fact that hydrogen possessed it was less familiar. This affinity is small for hydrogen (0.7 volts on the usual scale), but is sufficient to cause a certain fraction of the hydrogen atoms in the Sun's atmosphere to capture electrons. This proportion is very small, only one in 10,000,000, according to Wildt's calculations; but these atoms are continually losing their loosely bound electrons, while others pick electrons up, maintaining the average, and this process produces a very considerable scattering of light. Only rough calculations of this could be made three years ago. They showed that the total scattering effect produced by this process should greatly exceed that resulting from the interaction of electrons and charged metallic atoms—which has much less influence per encounter.

To proceed further was heavy work. It is not possible to get enough atomic hydrogen in the laboratory to observe this scattering. It must be calculated, by the laborious processes of wave-mechanics. This was done by Massey and Bates in London, just before the war, and it then appeared that the slight scattering due to the new process far exceeded that arising from all those previously known, and accounted for the main part, at least, of the unexplained haziness of the Sun's atmosphere. Strömgren, extending it to the stars, found it equally valuable there.

ONE DETAIL, however, remained to be cleared up. The calculated scattering was strongest in the violet at 4000A, and fell off considerably toward the red. In a star like the Sun, where most of the haziness comes from it, red light, having to pass through less haze, should come, on the average, from deeper and hotter layers than violet light. In consequence, the continuous background of the spectrum should be stronger in the red than it would be if the haziness were the same for all colors. That is, the Sun's light, on the average, would be redder.

The color-temperature, measured by the proportion of red to violet light, would then come out lower than the effective temperature, calculated from the total amount of radiation per unit area. This is not the case: the Sun's light is actually strong in the blue, and its color temperature is higher than the effective temperature. This could be met by theory either by diminishing the calculated haziness in the blue or increasing it in the red. Very recently a new calculation has been made by Williamson, at the Yerkes Observatory, using a much more accurate, and of course more complicated, set of formulas—such that the equation expressing the *results* of a long set of calculations itself occupies half a page of print. This new and precise calculation gives just about the same absorption (haziness) as the old for the ultra-violet, but a good deal more in the visible spectrum, with a maximum in the green at 5000. This is just what is required to clear up the discrepancy. Further laborious calculations are required before it can be applied to the stars; but the outstanding discordance will surely be much smaller, and may be entirely removed, in which case we shall be at last in a position to predict what the Sun should be like from pure theory—given its composition and mass, but having never seen it.

WHILE we speak of the solar spectrum, we may note a recent advance in its observation. In the remote infra-red the spectrum can be detected only by the energy which the waves carry, and very delicate heat-measuring devices are necessary. The rays must be focused by mirrors, and dispersed into a spectrum by a suitable prism. Up to wave-lengths of about 13 microns, or 20 times the wave-length of red light, rock-salt is transparent, and forms excellent prism material, since large transparent pieces can be found in nature. Beyond this, it grows opaque, and compounds containing heavier atoms must be used. Potassium bromide serves very well: but the crystal from which the prism is to be cut must be grown artificially—and to get a large, flawless transparent crystal demands great skill. Worse than this, the earth's atmosphere absorbs certain of these long waves very heavily. An enormous absorption band due to carbon dioxide and beginning near 14 microns has, up till now, blocked all efforts to get beyond it; but, with very sensitive apparatus, and a potassium bromide prism, Adel, at the Lowell Observatory, has passed the barrier. The automatic records of his spectrometer show strong evidence of radiation beginning at 16 microns, beyond the great absorption band, and extending almost to 24 microns. This new limit is 50 times the wave-length of blue light.

The records show numerous absorption bands—cutting off part, though not all, of the solar energy—which, from their great width, evidently arise in the earth's atmosphere. It is probable that many of these arise from water vapor, for their intensity varies with the humidity. If their effect can be eliminated sufficiently to find how strong the Sun's radiation would be without them, it may be possible some day to test theories of the intensity of the Sun's continuous spectrum over more than 20 times as great a range as is available at present.

Adel has shown that certain faint bands are absorbed by nitrous oxide, N_2O, and another by nitrogen pentoxide, N_2O_5. These must be produced at the top of the atmosphere by the action of ultra-violet light. If they occurred at low altitudes, their psychological effects would be conspicuous.—*Princeton University Observatory, Dec. 22, 1942.*

Pseudo-Fossil Man

Not All Human Skulls that Look Primitive Are Those of Ancient Primitive Man, and Why

LOREN C. EISELEY
Associate Professor of Anthropology, University of Kansas

SOME years ago, when the writer was engaged in archeological work near a small western town, a villager drew him aside and said: "You should see Mrs. Jones. She is the widow of a doctor who used to collect fossils all over this country. She has some very wonderful things, and probably would be glad to dispose of them now."

Seeking out the woman, I was led into a parlor ornamented, in the fashion of the '90's, with the usual array of sea-shells, baskets, and other odd items. Following a proper interval of small talk we came around to the subject of the interview—her husband's collection. After I had examined and made notes upon some items of local interest, a pause fell. Looking carefully about, and lowering her voice, the woman said: "This is not all. I have something very, very valuable. I have part of the skull of a primitive man."

Now, though extinct types of man have never been recovered in the New World, and the likelihood is that they never will be, it is not the business of science to make snap judgments. Mentally expecting no more than some odd and misinterpreted fossil, I waited while the doctor's widow eagerly uncovered her prize.

As the last wrapping fell away, there was dropped into my hand what I had least expected: a human frontal or forehead bone which, without doubt, carried an extremely massive supra-orbital torus, or ridge of bone above the eyes, such as is commonly found upon the skulls of the fossil men of the Ice Age. The rest of the skull was missing. Only this massive fragment of the skull remained.

"Where," said I, my pulse rising a point or two, "did your husband get this?"

"Oh," said the woman eagerly, "he found it buried with that other skull you've been looking at, in the Indian village up the road."

At this remark my heart quickly subsided to normal, if not below. No fossil man was going to get himself buried in a mere 500-year old Indian village. I had been digging there myself, and I knew. Moreover, fossil men are not laid out in Indian cemeteries along with the bones of the existing species of man. I tried, gently, to explain this to the widow.

"But," she exclaimed triumphantly, "look at that forehead. It's not modern.

Photos by Dr. G. Ekholm, courtesy American Museum of Natural History

This skull suggests incipient acromegaly. Notice particularly the helmet-like protrusion of the brow beyond the root of the nose, and the massive character of the zygomatic arch (the slender, constricted part of the cheek bone just forward of the ear)

My husband said it wasn't. He was a doctor, and he knew. That piece of bone is worth a lot of money."

The talk shifted. We exchanged some pleasantries and I left, albeit wishing I might have carried away with me that intriguing fragment of frontal bone. I knew by then what it represented, but it still appealed to me.

At rare intervals these fragments persist in turning up. To some laymen they are extremely attractive and, forgetting that a fossil type of man is a much more complicated structure than an individual possessing a supra-orbital torus, or brow ridge, of unusual size, the finder generally visualizes in them the primitive European "cave men" about whom he has read. So scarce are these objects and so infrequent is their complete preservation that it is very easy to be deceived by them, particularly at a time when the discovery of the late glacial Folsom culture in the United States has made us extremely conscious of the possible antiquity of man in the New World. If his find is not primitive—the layman is likely to insist vociferously—what in heaven's name *can* it be?

Such specimens of pseudo-fossil men can be classified into two general types: first, the "normal" individual who represents, in one or another feature, a more primitive appearance than the average for his group; and, second, the individual who, through a glandular disorder, has suffered a marked thickening of the bony structure.

IN CONNECTION with the first, or "normal," type, we may say that in no human population are the individuals exactly alike. Each person varies in his features from what we may term the ultra-human or vanguard types, to those who, in one or another characteristics, have retained some indication of the more primeval features of the earlier men. As Dr. Franz Weidenreich, distinguished authority on fossil man, has pointed out, "within each group . . . we may be confronted with specimens seemingly anticipating future development, while primitive features are retained in others." These by no means necessarily imply intellectual inferiority, but may include an odd array of little skeletal variations of which only the anatomist has knowledge. Occasionally, however, out of so many thousands of individuals, one may show unusually pronounced brow ridges or some other feature noticeably striking to the untrained eye.

The writer can testify that he long coveted the skull of an unsuspecting colleague who approached close to the Neanderthal type in one or two characteristics of the skull. I say one or two advisedly. Viewed in its entirety, my good friend's cranium would have deceived no competent anatomist into imagining him to be one of our early forerunners. If, however, the right fragment of his skull—the "primitive" part—had been recovered from an archeological deposit of some antiquity, discussion might have arisen. Such instances are not unknown here in America, and more than one well-intentioned student has gone off the deep end in favor of some very ancient form of man having existed in the New World, only to suffer humiliation later.

The second type of pseudo-fossil man

—the glandular disorder type—represents an anatomical condition which may also contrive to trick the unwary archeologist. In this case we are dealing with a glandular disorder of the pituitary, a small gland at the base of the brain whose secretions control the course of human growth. This disease, known as acromegaly, overstimulates bone growth and, over a period of years, causes a great coarsening and thickening of the bones of the skull, particularly in the region of the brow ridges, cheek bones, and other portions of the facial structure. The result is to lend the face a somewhat bestial and primitive appearance which is even more pronounced in the skull.

There are degrees of intensity of affliction with this disease, and variation in its anatomical effects. In general, however, it has long been recognized that the skull, under this unusual stimulation, tends in a certain degree to simulate, in portions of its structure, anatomical traits of the primitive past of mankind. Indeed, so distinguished an anatomist as Sir Arthur Keith has suggested that man still carries within his body, and ordinarily regulated by a well-controlled pituitary, the biological mechanism which produced the physical structure of his early forerunners.

BE THAT as it may, however, this rare disease, scarcely ever identified archeologically, is well worth considering as a possible explanation for unusual skulls from recent deposits. Moreover, in its milder stages, it may be difficult to distinguish skeletally from a case of extreme normal variation.

The skull featured in the first photograph was collected from an early site in the Southwest, along with many other perfectly normal individuals. There is nothing mysterious about it. It is something over a thousand years old, and its associates were all perfectly normal Indians of that place and time. Yet this skull in many of its features is a remarkably rugged and "stone age" specimen of man to be encountered among American Indians; most of whom, incidentally, are by no means effeminate in skeletal structure.

Unfortunately, the bones of the body of this specimen are gone, so that we do not have them as an added check on the pathological nature of the skull. The latter has been slightly crushed. Because of the fragile nature of the bone, complete restoration has not been attempted. Nevertheless the general effect is plain; great size, ruggedness, and measurements which are very large. This skull was found in an area now being combed for traces of late glacial man, and I shudder to think what extensive essays might have been written upon that porching frontal bone if it had ever washed out of some convenient river bed or gravel deposit.

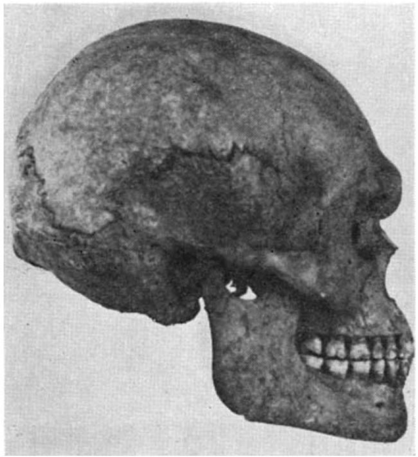
The skull is still not in what might be termed an advanced state of the disease. Nevertheless an excessive heaping up of porous vascular bone on the edges of the tooth-bearing portion of the upper jaw, and a chalky and spongy bony texture, are very suggestive of acromegaly. The brows contain huge air sinuses and the condition of the sutures of the skull suggests unusually early closure. Notable, too, is the bicanine index of this specimen.

This index, expressed as a percentage, indicates the width between the two canine, or "eye teeth," as compared to the width as measured across the maximum expanse between the molars.

A high index is a sign of primitiveness because the primitive or anthropoid jaw is more U-shaped or rectangular, and hence the canine teeth are almost as far apart as the molars. On the other hand, due to the more retracted and curving palate of modern man the index is much less in the latter. In the anthropoid apes, the index ranges in the high nineties, or even to 100 or over. In modern Europeans, it ranges in the low sixties. In the powerful and anthropoidal Rhodesian man, the index is 68 percent. Our specimen has an index of 68.5, indicating a wide primitive muzzle. As a matter of fact, the bicanine width is 48 mm., which is much beyond the average. It is interesting in this connection to note that in acromegaly there is sometimes a tendency for the "eye" teeth to advance slightly in position and be more directly in line with the incisors, thus creating a wider, more primitive arch.

If, however, one has access to the whole skull, as in this unusual specimen, there should be nothing deceptive to the trained eye. It is not really primitive. The brain case is capacious, and the face, though formidable in its ruggedness, is that of our own species.

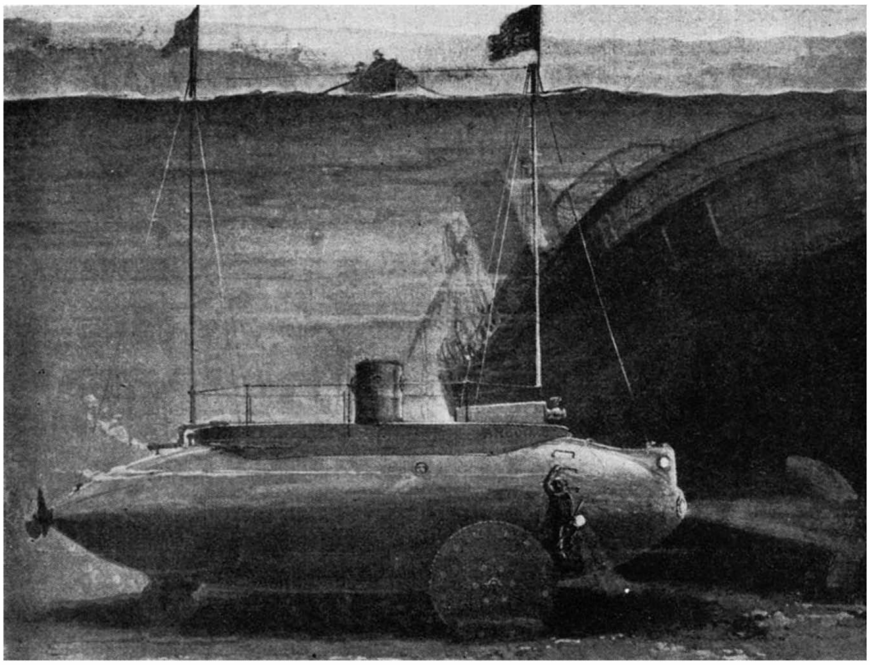
It is important to remember that none of our human forerunners is ever completely imitated by either pathological or normal variation. In the case of disease, the bone betrays evidence, not of primitive strength, but of ab-



Left and above: **Front and side view of the skull of a native of New Britain (northwest of the Solomon Islands). This individual is markedly variant toward the primitive, but not in a pathological manner. Note heavy development of the brow ridge, which is striking, even when it is seen in this somewhat archaic group of people**

normality. Moreover, the spurious primitiveness will tend to be localized and asymmetrical. One never gets, for example, the lack of the chin eminence so characteristic of the subhuman remains. On the contrary, in acromegaly the chin eminence may be pronounced. In the case of extreme normal variation of an atavistic nature the duplication is also not complete, but generally confined to a single character.

Such specimens as we have discussed remain as an emphatic scientific warning against easy and popular supposition. This is not to say, when you remove a curious and exciting skeletal fragment from its ancient resting place, that it should be casually dismissed. But before letters are written to authorities or dramatic announcements made to the newspapers, make sure that your prized, and in any case interesting, specimen is not that of a forgotten acromegalic, or an extreme case of normal variation toward the primitive. The search for fossil man is more, far more, than a search for skulls with big brow ridges.



A wash-drawing, reproduced from Scientific American for January 1898, showing the *Argonaut* on ocean bottom. Note diver, searchlights, masts

Simon Lake, Submarine Genius

The Early Struggles of the Man Who Laid the Foundation for the Science of Underwater Travel

HARLAND MANCHESTER

ABOUT 45 years ago a wild-eyed fisherman staggered into a Virginia country store shouting that the Devil was after him: he had been peacefully fishing on the Rappahannock River when he saw what appeared to be a buoy, floating upstream against the laws of Nature. Then with a clap of thunder and a smell of brimstone, a bearded, red-capped Lucifer rose up from the waves.

The quaking man went home and the hamlet's theological experts gathered around the cracker barrel to debate the revelation. Then the door opened and in came Simon Lake, intent on stocking the larder of his newest submarine, the *Argonaut I.* Hearing the story, he returned to his boat and quickly submerged. Some of those river men are good shots.

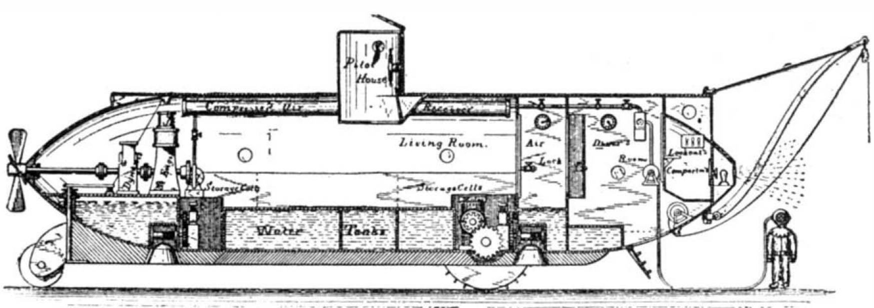
It didn't surprise Simon Lake to be mistaken for the Devil. He was accustomed to the superstitions and prejudices he has been combatting all his life. People in his home town in New Jersey smiled and made circles at their heads when he passed, and Washington naval experts bluntly told him that the ocean-bed trips he was making every day simply could not be done. They cited facts to prove it. But he went ahead doing the impossible, and, to make himself even more ridiculous, he claimed that these crackpot craft of his would be a major weapon in future wars, that you could blockade coastlines with them and sink shipping, that one of them could knock out a battleship!

As a red-headed, 14-year-old boy of Pleasantville, New Jersey, with little schooling and a hearty dislike for classroom discipline, Simon Lake read Jules Verne's *Twenty Thousand Leagues Under the Sea.* It kept him up all night and launched him upon his career. He immediately began planning a boat that would realize Verne's dream, and ever since that day in 1880 he has been constantly designing submarines and devices to improve them.

All the Lakes were inventors. Grandfather Lake invented a seed-planting machine, Father Lake a window-shade roller, Cousin Vincent a typewriter, Cousin Isaac Risley a printing device, and Ira a telephone. Uncle Ezra, a minister, built a flying machine and tried, without success, to fly it from one gallery of his church to the other. None of these New Jersey Lakes was dismayed by the unknown, or cared a rap if the neighbors thought him crazy. They were as ready to build an airplane or a submarine as they were to fix a door-latch, and if Simon had planned a rocket ship to fly to the moon, they would have listened with respect.

When the town fathers voted to build a road across the marshes to Atlantic City, then virgin terrain, the horses got mired to their bellies, and it seemed impossible to continue. But Uncle Jesse Lake took an old-fashioned horse treadmill, turned it upside down, mounted an engine on it, and thus created an endless-tread tractor to do the job. He later refused a large sum for his patent. Money never meant much to the Lakes. Jesse also invented a mowing machine which he sold to McCormick, a whistling buoy, and practical joke gadgets. Taking a fancy to Simon, Uncle Jesse brought him into his foundry and taught him to use tools. That shop was Simon Lake's university.

Bushnell, Fulton, Holland, and others had built under-water boats of sorts, but they were unreliable affairs that killed many of their crews, and Lake



A sectional view of the *Argonaut,* also from Scientific American, showing engines, cabin, storage batteries, wheel-operating mechanism, and the air lock for divers

was convinced that they were wrong in principle. Most of them dove head first. This often piled the crew up in the prow of the boat; it made navigation a matter of chance; sometimes the boat stuck its nose in the bottom and remained there permanently. Lake planned an "even-keel submersible," one which, by means of projecting vanes fore and aft, would retain its horizontal position while submerging and while submerged. This principle is now used on all submarines.

THAT was only one of the problems which this boy in his teens solved in the years of hard work before he actually built his first submersible boat. Science in those days could throw little light on the things Lake needed to know. For instance, how much air does a man need to live on? Lake asked university professors, but no one could give him the answer. So he built a large, air-tight, wooden box and cooped himself up, watch in hand, to find out how long he could stand it. From these tests he found that he needed 15 cubic feet of air per hour, and he has used that figure ever since.

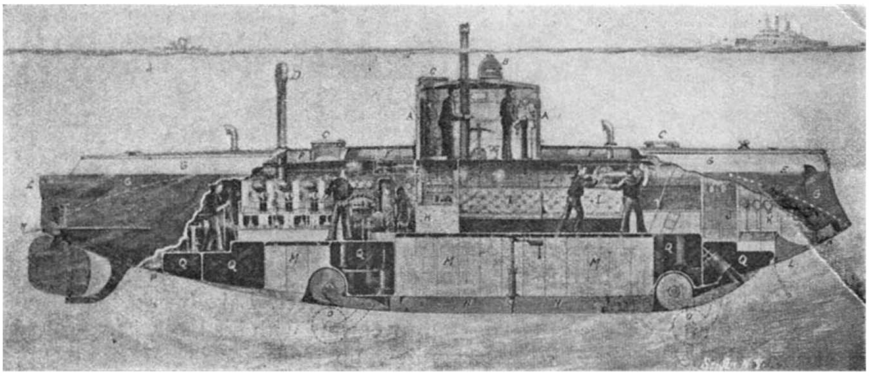
He heard that at Johns Hopkins Hospital bad air was exhausted from the contagious ward through little holes in the floor. This must mean that bad air is heavier than good air, he decided, and again shut himself up in his box to prove it. He lit matches, raised and lowered them, and as the minutes ticked by, noted the heights at which the flame was smothered by the rising level of exhaled carbon dioxide. As a result, his plans provided for the forced exhaustion of bad air through the floor of his submarine compartments.

In Jules Verne's fictional *Nautilus* there was a compartment through which divers could emerge to investigate the ocean bed. Lake decided that he needed an under-water exit in his submarine. It was a little matter of opening a door on the sea and at the same time keeping the water out. Lake was thinking it over one evening when his eyes fell on an old powder horn left by a pioneer ancestor. The horn had a small measuring compartment near the tip. When this space was full of powder, an inner valve closed, and the outer one could be opened to pour the correct charge into the musket barrel. Lake saw the answer to his problem in a flash, and hastily blocked out plans for his submarine "air lock." It was a small, air-tight room with two doors, one opening into the interior of the boat; the other, a trap door, opening to the sea. He could enter the room, release compressed air until the pressure was high enough to keep the water out, then open the sea door. Crews could collect oysters and crabs through the open door, or don diving suits to salvage wrecks or look for mineral deposits. To Lake, this sea-bed exit was one of the most important features of a submarine, for he planned the boat for peacetime commercial use, not as an engine of destruction.

For 12 years Simon Lake put in his evenings and odd moments planning his submarine. Meanwhile he earned an ample living working in the family foundry, and from inventions that were more immediately remunerative. For example, his safety device for windlasses on oyster boats, which prevented the crank handle from spinning backward and killing the operator, sold well. In 1892 the Navy, aroused at last to the value of the submarine, advertised for bids. Here, Lake thought, was a chance that the *Argonaut,* the name which he had given to his "paper" submersible, would be built.

In high spirits he took his plans to Washington. But he had never heard of scheming lobbyists and indifference in high office. They let him cool his heels for two days, then curtly dismissed him after a brief interview. On his second try, the Naval Board of Construction approved his plans, but in those days the final decision concerning types of vessels to be built lay with Congress. Lake's rivals had money, influence, and political acumen. Lake lost out, and $200,000 was spent in building a Holland "diving-type" submarine which never performed satisfactorily.

Determined to build his submarine and prove his case, Lake went to Wall Street in search of a backer. But a crank had just tried to kill Russell Sage, and when the shock-headed stranger talked about a boat that would roll on the bottom of the sea like a tricycle, the men of money turned pale and called their secretaries. Lake went home empty-handed.

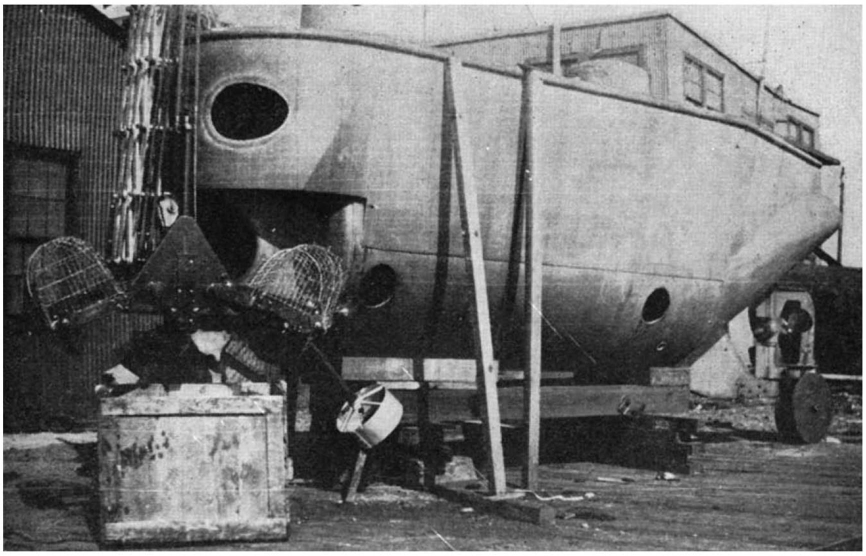


The *Protector,* Scientific American, December 1903. She passed gruelling tests for the United States, but was rejected. Russia bought her for use in harbor defense

No one understood his ideas but the other Lakes, and it was a member of the family who came to his rescue in the fall of '94. His Aunt Annie Champion, who had some money put away, asked him how much it would cost to build a kind of small "sample" submarine, and his cousin, Bart Champion, said he would help him build it.

Lake accepted Aunt Annie's offer, and he and his cousin spent a happy winter building a tiny submarine out of "spit and string." He has turned out many powerful sea monsters since that time, but the building of the 14-foot *Argonaut, Jr.* was the greatest adventure of his life. She was a stubby, box-like craft covered with two layers of pitch-pine, with canvas between, but, because of the limitations imposed, she lacked many of the refinements of Lake's planned submersible. She had tanks which could be flooded with water to offset her buoyancy so that she would sink. There were three wooden wheels on the bottom; a front one for steering, and two rear ones driven by a crank inside which was turned by manpower. Lake's cherished idea, the air-lock, with its trap door opening to the sea, was built into her stern. There was an old soda fountain tank for compressed air to hold back the water when the sea door was open; this was filled by a second-hand plumber's pump. Air for breathing came through a pipe from a buoy on the surface, and as a final touch, there was a small gasoline stove for cooking fish speared through the trap door.

THE launching of the *Argonaut, Jr.,* in 1895, was an event comparable to the Wright brothers' first flight, yet the world gave no heed when the two men trundled the crude ark to the Shrewsbury River and wagered their lives on Simon Lake's calculations. Everything worked according to plan. They screwed down the hatch, flooded the tanks and sank to the bottom, then cranked the machine across the river



A later Lake invention. The *Explorer,* 1932, a commercial submarine designed for salvage operations. She was equipped with grab buckets on the end of lazy tongs

bed and back to the starting point.

That summer they had more fun than Huckleberry Finn with his raft. They poked around the bed of New York Bay for sea food, and Lake went through the sea door in a home-made diving suit to explore the bottom. They gave an exhibition for the town fathers, who couldn't quite believe that they actually gathered oysters from below. So the dignitaries signed their names to a weighted shingle and threw it in the river, and the submarine pioneers went down and retrieved it.

ALTHOUGH the little *Argonaut, Jr.* was a practical submarine, few people took it seriously, the press viewed it with amusement, and Washington remained officially incognizant. But a few informed people came to Lake's aid with funds to build an all-metal, gasoline powered boat, launched in 1897. This was America's first successful full-sized submarine. It went through its trial runs with flying colors, and rode out the roughest of storms. It attracted attention all over the world, and was the precursor of today's powerful submarine cruiser.

During the Spanish-American War, Lake had taken the *Argonaut* to Newport News and had easily located the harbor mines. He told a naval authority what he had done, and showed how easy it would be for a submarine like his to put mines out of action and cut telegraph cables. He was told that what he said he had done was impossible, and that if he did it again he would be thrown in jail! Lake declared that he would never go to Washington again until they called him, and turned the *Argonaut* over to commercial work in salvaging sunken cargoes.

Fully aware that his boat was by no means perfect, Lake worked out improvements with his limited funds, and drew up plans for larger and better submarines. Working at his Bridgeport plant in 1900, he quickly saw what other experimenters were discovering, that a submarine must be able to see above the surface while submerged. He went to optical firms and asked them to make some sort of tube with lenses which would serve the purpose. They declared flatly that it was impossible. Lake had heard that word so many times that it had no meaning, so he bought a miscellaneous assortment of lenses, found a craftsman who could make optical equipment to his order, and began to experiment. He built a tube-like box and stuck the end out of his office window, then adjusted the lenses in various positions in an attempt to get a view of the street. It was no mere matter of bending light around a corner. Lenses of the correct focal lengths had to be fixed at precise points in the tube to relay the image to the eyepiece. His chance of success was little better than that of the fabled monkey of writing a book by hitting typewriter keys at random, but after several months and hundreds of experiments, he finally looked in the tube and saw a clear view of the street. Then he went to lunch, it started raining, and the office boy pulled in the tube and jumbled up the lenses. Despairing of ever passing another miracle, Lake went to a Johns Hopkins expert and posed his problem. The expert said it was impossible.

"But I've already done it," said Lake.

"In that case," said the professor, "give me all the data you have and I'll see what I can do."

In about a week he found the answer and Lake had his periscope.

Meanwhile, the government was awakening to the need for submarines and, in 1901, Lake was called to Washington. High officers in the Navy, scornful of the Holland vessel that Congress had paid for, urged him to build a better one. There was no appropriation, but the officers promised to do their best to secure adoption. Lake raised money from his stockholders to build the 65-foot *Protector,* designed for coast defense. Work was stopped when a rival firm sued him for libel and attached his plant, but he hacked his way out of the difficulty and finished the boat. He called on William Howard Taft, Secretary of War, and Taft promptly sent three Army officers to see the boat in action. The *Protector* passed gruelling tests. She submerged for ten hours, she navigated under the ice, and she simulated the laying of mines. The investigating board made an enthusiastic report but the bill was killed in Congressional conference.

RUSSIA and Japan, then at war, were both interested. A patriotic man, Lake did not wish to sell the weapon to a foreign power, but it was the only alternative to financial ruin. He chose Russia, and the *Protector,* hoisted to the deck of a freighter and covered with tarpaulins, was quietly shipped abroad. Her inventor followed, and spent seven years building submarines for the Russian government.

Lake's stay abroad shaped history in a manner that he could not foresee. Krupp, the German arms firm, examined Lake's plans and offered him a fat contract. Then they discovered that Lake's patents were not protected in Germany, and tore up the contract. Admiral von Tirpitz had talked with Lake and conceived a plan for offensive submarine warfare, and Lake's patents were legally stolen to build Germany's U-boat fleet.

By this time Lake's fame as a submarine builder was international, and he thought that his own country would finally recognize his ability. He had plans for an improved submarine, and built it at Newport News with some Navy encouragement. But the answer was still "No." England and Russia fought for the boat, and Russia won. Lake then promised the United States Navy the fastest and most powerful submarine in the world. He would built it with his own money, and if it didn't make good on all his claims, the Government could have it for nothing. The 161-foot *Seal,* launched in 1911, quickly made world records. The ice was broken at last, and Lake was given contracts for five more boats. With World War I, he came into his own. In his shipyards at Bridgeport and Long Beach, California, he built more than 40 submarines for the government which had so long rejected him.

Simon Lake has excited public imagination for almost five decades, and many people will be surprised to learn that he is still alive. He is as full of ideas as ever. A great-grandfather at 76, he is hard at work on an experimental project vital to the war. One eye is habitually closed, the result of years of squinting through periscopes, and he takes his time climbing stairs, but after a day at the plant and a half-hour for dinner, he fortifies himself with a handful of cigars—his only indulgence—and works over plans until midnight.

This obsession with machines persists in his progeny. A son, Thomas Alva Edison Lake—named for an old friend—and three grandsons carry on the Lake tradition as engineers. They have all had more technical training than the patriarch, but they have great respect for his way of cutting through a problem.

There is a common impression that the submarine has reached its peak. but Lake shakes his gray shock and declares that the boat is in its infancy. He still preaches commercial submarines, and will not consider his life work complete until he has proved their value to the world. Recently he proposed a fleet of cargo submarines of 7500-ton capacity as a means of solving the shipping shortage. He says they can be built as cheaply as tankers, will cost less to operate because of elimination of wind resistance and the buoyant effect of the water, and can easily escape raiders by submerging.

In his early days, Lake used the *Argonaut* to recover coal and other cargoes from sunken vessels at a profit, and later he built equipment to recover the gold of the sunken *Lutine* in the English channel, a project which was shelved in favor of building the *Seal.* He has maritime charts on which black dots marking sunken ships turn the ocean into caviar, and predicts that much of this vast store of lost wealth will sometime be redeemed by underwater wrecking boats and that rich undersea deposits of gold, platinum, and radium will be mined by submarine. Underwater oil wells have already been drilled off the California coast. Lake has a plan for recovering ocean-bed petroleum by submarine, and declares that as oil becomes scarcer, his method will be adopted.

Of course there are experts who will call these things impossible, but Simon Lake never understood that word.

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TENT

With Floor For Maximum Protection

A SPECIAL pup tent equipped with a built-in floor has been developed for mountain troops. It will offer protection against mosquitoes and other insects and furnishes ample protection against rain, blizzards, and wind velocities up to 75 miles an hour. Whereas the regulation pup weight 14 to 15 pounds and is made of canvas, the newcomer, complete with poles and pins weighs only seven pounds and is made of a featherweight nylon cloth. Two men can sleep with ample room, and in an emergency, three soldiers can be bedded down for the night.—*The Army Officer.*

TELEPHONE ALARM

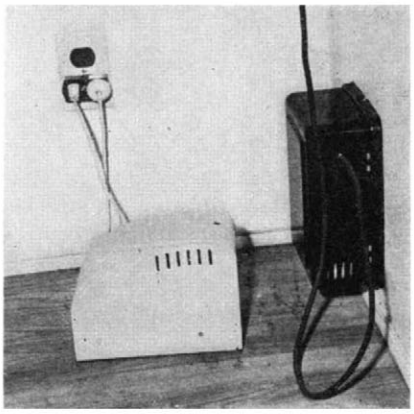
Used to Summon Air-Raid Warden from Workshop

AN "Electric Sentry" is now on air-raid service in at least one home, that of Mr. F. Dickie, of Los Angeles, to bring warning of phone calls, which might be in connection with air-raid duties.

Mr. Dickie, as an air-raid warden, is subject to call at any time. He is also an enthusiastic home workshop fan given to spending most of his evening hours in his shop, which is to the rear and quite remote from his home. His was a problem of having phone calls come to his attention in his shop when other members of the family are absent from the house.

An ever-ready sentinel for the warden

The problem was solved by installing the transmitting end of a Zenith Electric Sentry in front of the phone bell and by plugging in the receiver end in the workshop. Now, when the phone



Transmitter at the bell-box

rings, Mr. Dickie immediately hears it and can hasten to the house to take the call. Also, when he goes to visit his next door neighbors he need only take the receiver end along and he can keep an ear on his phone bell the whole evening long.

No wiring is required with the Electric Sentry, it only being necessary to plug the units into the house light sockets for satisfactory operation.

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DOPE—The same chemical, cellulose acetate, which, used as a "dope," gave tautness, resiliency, and strength to wing fabric on comparatively flimsy airplanes of World War I, now is the transparent plastic which affords protection and clarity of vision to flyers in their sturdy training planes and gliders of 1943.

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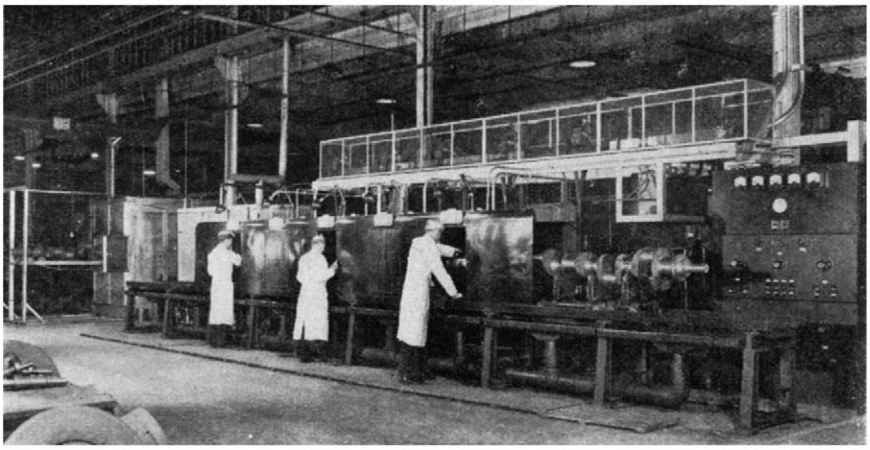
DIESEL CRANKSHAFT

Induction Hardened, Sets Remarkable Record for Wear Resistance

AN example of the value of hardening metal by electrical induction was recently demonstrated when the vital parts of one of the world's fastest "streamliners" were inspected after the locomotive had piled up a million miles of service.

In checking the engine parts, the wear on the crankpins was found to be only .001 inch, even though the train had traveled a distance equivalent to forty times around the world. According to metallurgical experts, this unusual record was made possible because the crankshafts of the engine



A huge Diesel crankshaft set up for induction hardening

were hardened by an electrical induction process introduced by The Ohio Crankshaft Company of Cleveland.

In order that the crankshaft may stand up under the tremendous pressure exerted by the locomotive's 12 cylinder, V-type, Diesel engine, the surfaces of the bearings and crankpins were selectively hardened by the Tocco process, providing accurate control of depth, width, and structure of the hardened area.

INDISSOLUBLE

Plastic Developed, Has High Abrasion Resistance

DEVELOPMENT of an entirely new transparent plastic having many times the abrasion resistance of other clear plastics was announced recently, but, because of priorities and other restrictions, this new plastic is not yet in commercial production, and is not expected to be available for any but experimental purposes for months.

The new plastic, called C. R. 39, is one of a group of resins resulting from many years of research activity by the Columbia Chemical Division of the Pittsburgh Plate Glass Company. Its properties are such that it is in numerous ways far superior to similar products now in use. It does not dissolve in acetone, benzene, toluene, alcohol, gasoline, or any of the common solvents.

Its resistance to abrasion is 10 to 30 times greater than other clear plastics. It retains its shape even when exposed to high atmospheric temperatures and can be formed into large sheets, either clear or laminated, by the application of extremely low pressures. In transparent sheets its strength, weight, clarity, and impact resistance are comparable with other transparent resins.

In its primary form C. R. 39 is a clear, low-viscosity liquid which, in the presence of a catalyst and heat, hardens into a crystal-clear solid. Layers of fabric, paper, and the like can be impregnated with the liquid material and cured under low pressure to form sheets or shaped objects with a minimum of expense for tooling. Ordinary plastics used in this way require pressures of from 50 pounds per square inch to many tons to produce a suitable laminated material.

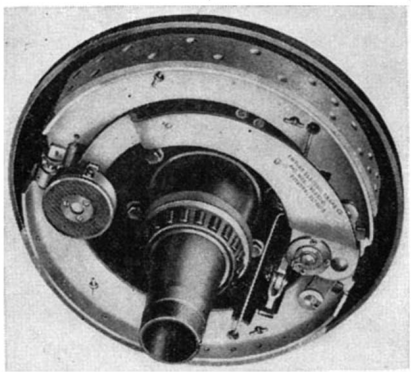
Since C. R. 39 is thermosetting and releases no gaseous or liquid by-products when curing, it opens up a broad new field of plastic applications not satisfied by any other resin. Large flat sheets and intricate three-dimensional shapes can be made with ease.

ELECTRIC BRAKE

Now Used on Guns, Tractors, Machines

AN ELECTRIC friction brake came into being just before the rumble of war in Europe; it was just arousing interest among technicians when the demands of war put it to an even more severe test than anything that would have been accomplished in civilian life.

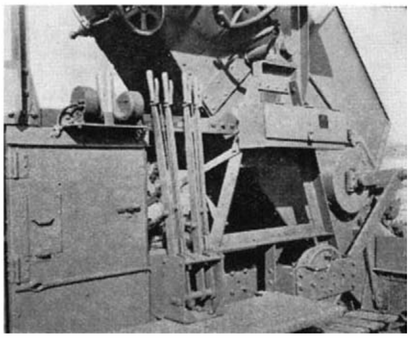
Present and continuing research with this brake is showing its value in many ways. It is being used on large anti-aircraft gun carriages, on self-powered ditch diggers which run on tractor treads, and on injection plastic molding machines. On the anti-aircraft gun carriage it makes the carriage independent of its towing tractor or truck for breaking power; on the ditch digger steering is by means of breaking the treads and, with the electric brake, is accomplished with no physical effort on the part of the operator; on the injection molding machine the brake holds the plunger against 50,000 pounds of pressure where other brakes have failed.



Interior of electric brake. End of magnet shows as a disk at left center

The simplicity and effectiveness of this new electric brake, called the magdraulic brake, is due to the design of the operating magnet, a unit so carefully conceived that only a small amount of current is needed to operate the brake.

Functioning of the magdraulic brake is simple. When the magnet, shown in one of our photographs, is energized, it tends to draw itself toward an armature plate fastened rigidly to the brake drum, and the drum tends to drag the magnet with it. The resulting movement operates a cam which expands the self-energizing brake shoes. Control of the amount of braking is through a simple manual or foot operated rheostat.



Electric brake on ditch digger. Drum at lower right, controls left center

The amount of current drawn by the electric brake is on the order of one ampere for installations such as would be used on the average passenger car; for heavy trucks and trailers up to two amperes are used.

CREEP

Of Metals Measured by Electronics

AN ELECTRONIC robot, including a photoelectric cell, now measures the rate at which metals flow when heated and stressed in the General Electric Research Laboratory. Not only does this release for other important work the attention of a man who formerly watched the metal sample through a microscope; it also is more sensitive

What did *you* do today ... for Freedom?

Today, at the front, he died . . . Today, what did *you* do?
Next time you see a list of dead and wounded, ask yourself:
"What have *I* done today for freedom?
What can I do tomorrow that will *save* the lives of
men like this and help them win the war?"

To help you to do your share, the Government has organized the Citizens Service Corps as a part of local Defense Councils, with some war task or responsibility for every man, woman and child. Probably such a Corps is already at work in your community. If not, help to start one. A free booklet available through this magazine will tell you what to do and how to do it. Go into action today, and get the satisfaction of doing a needed war job well!

EVERY CIVILIAN A FIGHTER

CONTRIBUTED BY THE MAGAZINE PUBLISHERS OF AMERICA.

For Flying Fortress flyers. Complete, even to sail

than any human observer and more reliable. It watches all day without ever getting tired.

These measurements of the "creep" or flow of materials are being made by Dr. Saul Dushman, assistant director of the Laboratory. Since a steam turbine, for example, operates with greater efficiency the higher the temperature, metallurgists try to create alloys for parts which will hold their shape under high stress and the greatest possible operating temperatures.

Some time ago Dr. Dushman described an accelerated method for making creep tests. The usual tests use a bar of the sample metal, which is heated in a special furnace to the range of operating temperatures, or 800 to 1400 degrees, Fahrenheit. Such tests may require months to complete. The new method uses a thin wire of the metal, and passes an electric current through, to heat it to perhaps 2000 degrees, Fahrenheit. This wire is enclosed in a glass cylinder, which protects it from air currents, and even permits the tests to be made in an atmosphere of nitrogen, thus preventing rusting from the oxygen in the open air. A weight is attached to the wire. Through a microscope focused on the lower end the observer formerly watched and measured the slow stretching, as much as one half of one percent an hour. Data are obtained much more rapidly by this method than formerly.

To make the measurements automatically, J. T. Mireles Malpica devised the robot, and the apparatus now used was constructed by Eric T. Asp, of the Research Laboratory.

The principle may be demonstrated with a flashlight and two combs. Hold one comb over the lens of the flashlight, and you can shine a spot of light on a nearby wall. Now hold the other comb over the first, close to it with the teeth parallel, and move the second comb very slowly. When the teeth of one cover the openings of the other, the light is cut off. But when the second comb moves the width of a tooth, the clear spaces are lined up and light passes through. If the flashlight and first comb were firmly fixed, and the width of the teeth and openings were known, it would easily be possible to measure the movement of the second comb merely by counting the alternations of light and dark.

This is exactly what Mr. Malpica did. A light shines through a glass grid, ruled with horizontal black lines, each 1/250 of an inch wide and the same distance apart. Attached to the bottom of the test wire is another such grid, nearly in contact with the first. A lens forms an enlarged image of these grids on the surface of the photocell. A very sensitive meter, in which electronic tubes are used, makes in ink on a moving strip of paper a record of the changes in current from the photocell, hence in the changes in brightness or the movement of the second grid. In this way it is possible to measure accurately an extension of the wire as small as 1/10,000th inch.

FORTRESS RAFT

Provides Safety Equipment For Forced-Down Flyers

An improved seven-man rubber life raft which will give aviators forced down at sea greatly added protection and comfort, including a square rigged sail, was designed by the Equipment Laboratory of the A.A.F. Materiel Center, Wright Field, working in collaboration with the United States Rubber Company, will be put into use on our Flying Fortresses.

Numerous improvements, both in construction and equipment, grew out of the experience of those who have been rescued at sea after spending weeks in inflatable boats. The new design not only gives more space, but makes the boat less tippable and more sea-worthy. A fabric sea anchor will be used to keep the nose of the boat into the wind and thus reduce the possibility of tipping caused by heavy seas.

Two ten-foot lengths of rope are tied on opposite sides of the boat to aid in "righting" the raft if it inflates wrong side up or is overturned. A horizontal bulkhead divides the boat into upper and lower chambers so that the entire boat will remain inflated though pierced by a shark or other object from the bottom. A sail is provided as well as a tarpaulin with which the crew can protect itself from the elements.

Beside the sail and wooden oars on which the sail may be rigged, equipment includes a fishing kit, emergency repair and signal kits, and first aid equipment. These items, together with concentrated rations for 30 days, and, in some boats, a radio sending set, supplied by the Army Air Corps, will be placed in a special waterproof container secured to the floor of the boat. Thus they cannot be lost when launching the boat or in case it is overturned.

Dimensions are approximately 12 feet long and 5 feet 8 inches wide, and weight, complete with equipment, is only 70 pounds. The boat deflated with equipment rolls into a carrying case 3 feet long by 1½ feet in diameter. Like all Army boats for rescue at sea, the top is orange-yellow for quick visibility and the bottom is blue to avoid attracting sharks.

GOGGLES

Of Various Types for Army and Navy Uses

New types of eye-protection goggles, one of which permits naval observers to look directly at blinding sun and spot dive-bombers, are now reported to be conserving and sharpening the eyesight of America's embattled soldiers, sailors, and fliers. Designed at the request of the Army and Navy, hundreds of thousands of the new war goggles are being produced by the American Optical Company, special lenses in the goggles making them suitable for different military purposes.

One of the goggles, equipped with glare-reducing lenses that absorb invisible ultra-violet (sunburn) and infra-red (heat) rays, is used by the Navy for observation purposes and to spot planes, especially dive bombers obscured by the sun's rays. Another type is fitted with special lenses which, in addition to blotting out reflected glare, can be rotated by hand to exclude as much light as desired.

Another goggle is made with clear unbreakable plastic lenses and these are worn by sailors exposed to cold weather, wind, and flying spray. A fourth type, for ski troops, is fitted with lenses that screen out reflected glare—and also the ultra-violet rays which may cause snow blindness.

For mechanized troops, goggles with unbreakable plastic lenses have been designed, and these protect eyes against dust, wind, and glare. A sixth type for Army and Navy fliers has precision-ground absorptive glass lenses which permit accurate flying, bombing, and sighting.

Lenses of most of these goggles are inserted into soft rubber cushions that fit exactly around the eyes. These rubber masks protect eyes against dust, wind, or water.

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PAINT AND WAR—The inside of a combat tank is painted white to help the crew see better, bombs and shells are finished in different colors for instant identification, and zinc yellow priming coat is used instead of red lead on aluminum alloy metal surfaces, particularly those coming in contact with salt water, such as seaplane pontoons.

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CIVILIZATION'S END

Seen If Spirit Fails to Keep Pace With Science

"UNLESS man uses his reasoning power to keep pace spiritually with mechanical developments, our civilization can disappear as other civilizations have," James F. Lincoln, President of The Lincoln Electric Company, said in a recent address.

"We all recognize that technological advance has had a profound effect on the life of every individual," Mr. Lincoln continued. "The thing we do not recognize is that this same technological advance has taken place also in the art of war. War is not the comfortable, short, decisive thing of 130 years ago or even of our own Civil War. It is, instead, unthinkable destruction from which no generation fighting it ever recovers.

"War is still in its infancy. It is a perfectly safe thing to say that if the creative genius of the research workers now in the laboratories of the United States should be directed completely to the arts of war that the tools which they could develop within the next few years would be capable of killing every person in the world in a week. It is because of the fact that this imaginative genius has been used in the arts of peace that civilization has not already been destroyed in this war. War as a means of settling disputes between nations must be outmoded or this civilization will disappear.

"The experience of all business in settling disputes has demonstrated the fundamental fallacy of fighting as a means of reaching a tenable agreement. Industry always, therefore, sidesteps conflict. We must learn the same methods as nations.

"There are two courses open to us—one is to follow the brave but silly goat bucking a grindstone swinging on a rope till he kills himself—the other is to learn by mutual understanding to live at peace.

"A great philosopher two thousand years ago outlined the principle which can permanently settle all disputes between people or nations—The Sermon on the Mount. This is not the principle of the weakling; it is the principle of the strong and stalwart man. It is not only just a way out, it is the only way that nations can live with each other. It is not new. We have had endless experience with it in the family, in our contact with our friends and in our industrial activity. It is not an experiment, it is a fundamental fact. War as we know it now is outmoded because it is no longer war—it is suicide."

• • •

KILLER—Cockroaches can swallow phenothiazine without harm, but if this chemical touches the outside of their bodies it kills the pests. The phenothiazine passes through the shells of the roaches, and is apparently converted into another compound which really does the killing.

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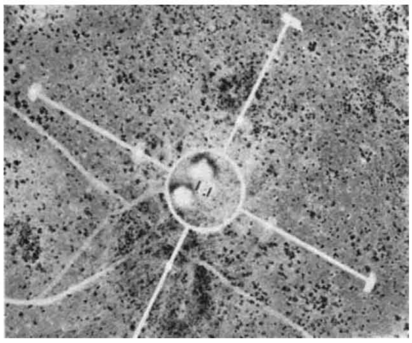
BOMB SCORING

Made More Accurate by Microphone Method

A NEW method of automatic and instantaneous scoring of bombing accuracy which enables officers at the world's largest bombardier college to check the accuracy of bombs dropped by cadets on targets 20 to 60 miles distant has been perfected and has been installed at the Midland AAF Bombardier School in Texas.



As the bombardier sees new target

The new "sonic method" which was developed under the supervision of Capt. Edward Peter McKaba, Experimental Projects Officer, utilizes methods originally devised for exploring new deposits of oil.

Concrete housing for bomb microphone

In addition to speeding up the scoring of each cadet's bombing proficiency, which now requires a large staff of officers and men, the new method will bring about a substantial saving in such scarce commodities as rubber, gasoline, and motion picture film. It will not only be less expensive but will be more accurate than past methods.

The new "sonic method" was developed by Capt. McKaba from the seismographic method used for locating oil deposits. In this work, an explosive is set off on the surface of the ground. The sound is reflected by the sub-surface layers and picked up on the surface by a row of geophones which are like microphones. These sounds are recorded on photo-paper and can then be interpreted to plot the contours of the sub-surface layers.

The problem of bomb scoring is very similar. Four microphones are placed in a square pattern about the target center, each 500 feet from the center. By recording the time of arrival of the sound waves from the bomb explosion at each of these microphones, the bomb's position can be plotted. For instance, the sound wave from a bomb in the target center will arrive at each microphone at the same time. If the bomb is off the center, then the sound will arrive at the microphone nearest it first and at the other microphones in the order of its distances from each. These values as recorded can be applied to a unique hyperbolic plotting board devised for this purpose by Capt. McKaba, and the bomb's position determined.

Heretofore, the explosion of each of the 200 bombs dropped by every cadet during his 12 weeks of training here has been photographed by a camera from the bombing airplane. With planes aloft an average of 20 hours a day, the developing of this film has assumed proportions which rival those of the largest Hollywood studios. Adoption of the "sonic method" will eliminate the need for these expensive cameras and this great quantity of film, plus the labor and materials required to process it.

Another great advantage of this new system is that it may be wired back to the home base through leased telephone lines so that the bomb-scoring crew may score each bomb the instant that it hits.

WAR MEDICINE

New Knowledge Can Stem Epidemics

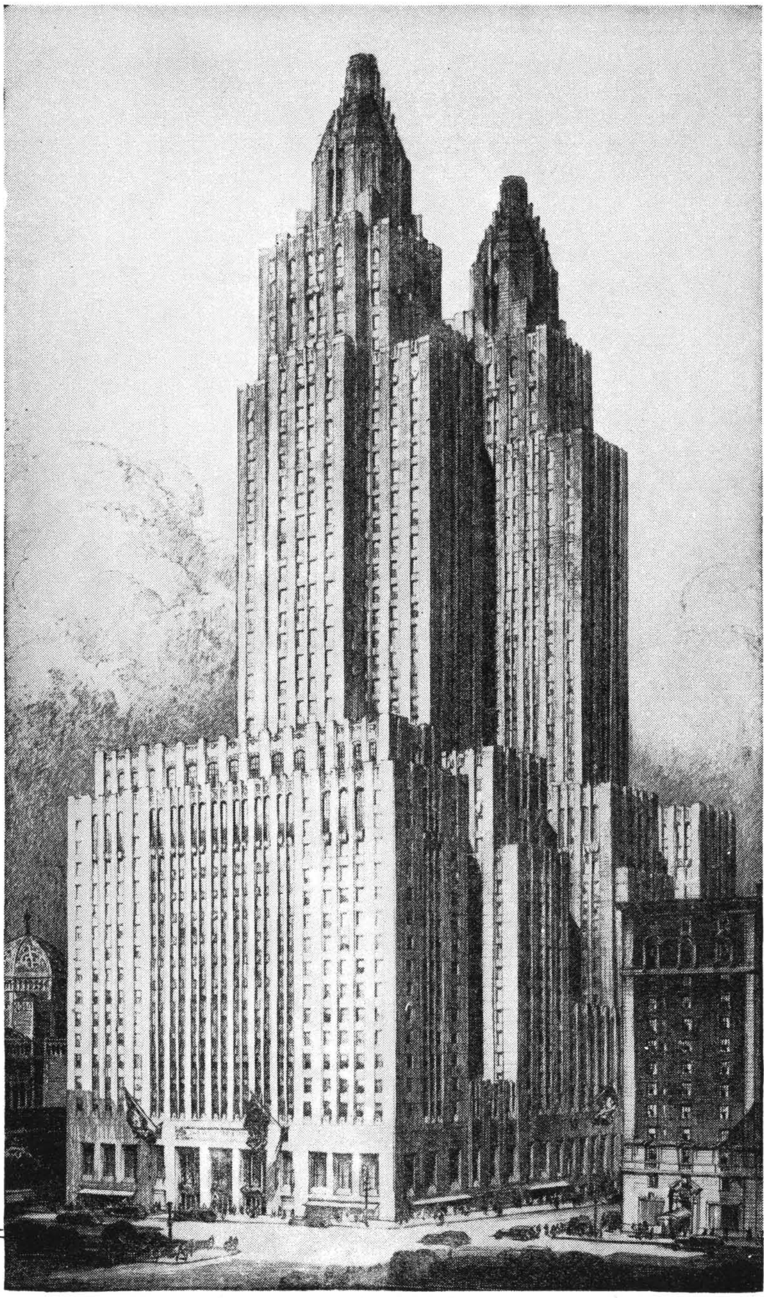
ONE of the greatest questions of the present war is whether modern science is capable of preventing the recurrence of epidemics which in all past wars cost more lives than were lost in battle, according to Dr. Bernhard J. Stern, in a paper prepared for a Cooper Union symposium on "Medicine in Wartime".

The influenza epidemic that followed World War I killed more victims in a few months than all the armies in four years, it is pointed out by Dr. Stern, who is a Columbia University sociologist and author of "Society and Medical Progress." In the United States alone perhaps half a million died; the worldwide mortality is estimated at from ten to twenty-one million.

There have been prodigious advances in epidemology since the last war, and there are elements of hope in the global conflict now raging if the resources of medicine are utilized to the full, Dr. Stern believes. "In World War I soldiers got vaccines to protect them from typhoid fever, paratyphoid, and smallpox," he says. "This time, in addition they get shots to ward off tetanus, which is lockjaw that results from contaminated wounds, and yellow fever. If they are going to North Africa they get added protection against typhus. If they are on the way to India they get vaccines for plague and cholera. New yellow fever vaccine promises to be of special importance.

"The results of advanced knowledge of immunology are already apparent. During the Spanish-American War one out of every twenty soldiers contracted typhoid fever. Ten percent of these died. During the first half of 1941 there were only three cases in the entire army, and no deaths."

The developments in the field of sulfa drugs mark one of the most brilliant chapters in the history of medicine. These drugs have already proved their value in armies of the world in preventing gas gangrene, the ailment once more dangerous than bullets. In World War I the loss of arms and legs from infection was frequent and eighty per-

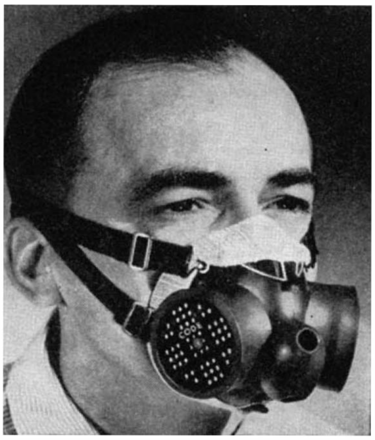


cent of the soldiers with perforated abdominal wounds died. Following the attack on Pearl Harbor not a man lost an arm or leg from infection and virtually all who survived shock recovered.

RESPIRATOR

Cartridge Type for Nuisance Gases

COMPLETE protection against paint and lacquer sprays, chemical fumes, smoke, and so on is afforded by a new car-



Cartridges come in colors

tridge-type respirator known as Dupor No. 10. Different types of cartridges, for differing filter purpose, are available for this mask. The cartridges are easily distinguishable by their color so that the workmen can always select the correct cartridge for the job.

The molded rubber face piece gives air-tight fit while the adjustable head band holds the respirator firmly in place.

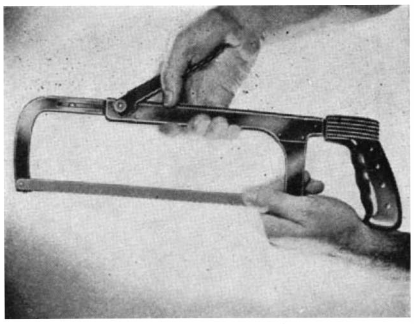
HACK SAW

Has Quick-Action Lever Lock

A CAM-ACTION lever-lock sets up and releases the blade in a new type of hack saw frame, in which loose blade studs and threaded tension devices have been completely eliminated with the result that blades can be replaced or repositioned in a fraction of the time required with frames of conventional design.

Straighter cuts and reduced blade breakage are claimed to result from the extremely high tension which this new Star frame puts on the blade. This high tension is possible because the frame is made of heat-treated spring steel. A gun-metal finish insures high resistance to rust and all other forms of corrosion.

The frame may be adjusted for 8-,



The lever locks the saw blade

10-, or 12-inch blades by pulling out a single pivot pin to its open position, sliding the frame forearm in or out to desired length, and snapping the pin back into place. Blade may be re-positioned to face in any of four directions by placing it over either of two sets of fixed pins which are integral with frame.

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PAY—The median annual income of members of the chemical profession in 1941 was $3,364, it is disclosed by a survey just completed by a committee of the American Chemical Society. Fifty percent of the profession earned more than this figure and 50 percent less.

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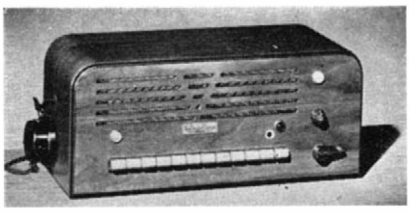
CONFERENCE CONTROL

Made Possible by New Intercommunication System

An intercommunication system which provides many new features not available in any other one system is known as the Super-Chief. With an installation of these units, it is possible for any number of stations to hold a private conference without interruption or eavesdropping from other stations outside of the conference group. Also, by means of ingenious control switches, it is possible to maintain one-way automatic transmission which



Intercommunication station unit

is especially effective for dictation and for recording of conferences.

The units of this intercommunication system are provided with amplifiers of sufficient power to permit operation without a falling off in efficiency with the units as far as 3000 feet from each other. Each station is equipped with individual volume control and optional equipment includes an earphone for use where privacy is essential.

Industrial Growth

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

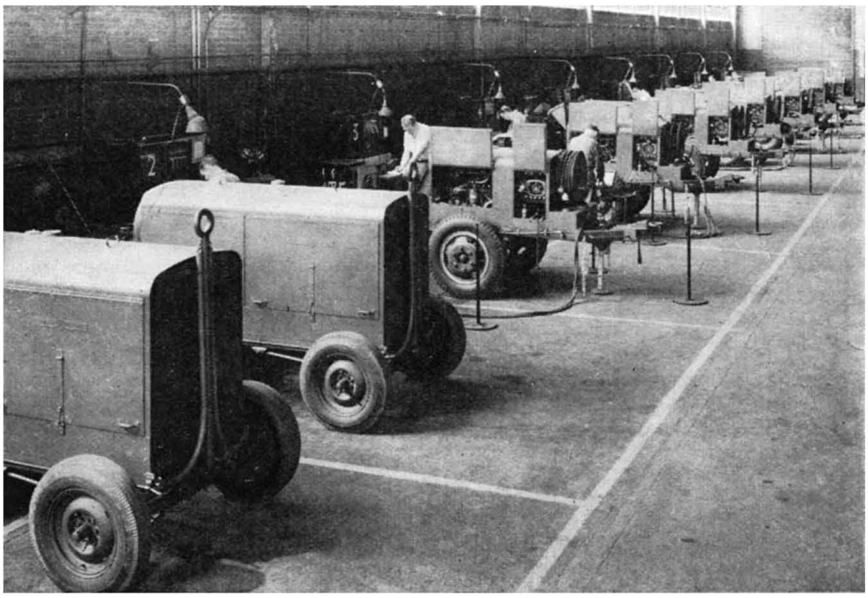
SIGNAL LIQUID
Hardens to a Surface That Melts Sharply

For use in any application where fairly accurate determinations must be made of temperatures, a new liquid material has been developed which is applied to any surface by a brush. This liquid dries quickly to form a smear on the surface that melts sharply when the temperature of the surface reaches the rated temperature of the material. After cooling, the smear forms a glossy mark, different in appearance from the original, which indicates that the signal is no longer operative. This mark can be wiped off the work surface.

This liquid material, known as Tempilaq, is available for signal temperatures in 25 degree steps from 125 to 350 degrees, Fahrenheit, and in 50 degree steps from 350 to 1600 degrees, Fahrenheit.

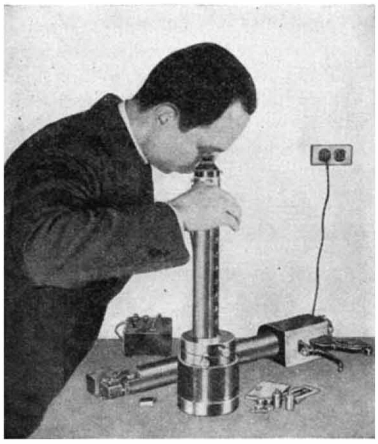
POWER PLANTS
Searchlight Equipment Undergoes Test

Before portable power plants for the operation of United States Army searchlights are sent out into the field, they are rigidly tested in the factories which produce them. Shown under such test in an accompanying illustration are a group of such power plants in one of the General Electric factories. Most of those shown are designed to supply current in the field for the operation of 60-inch, 800-million candle anti-aircraft searchlights.


Soon to be furnishing power for anti-aircraft searchlights

WEAR GAGE
Makes Indentation Which is Measured Microscopically

An optical instrument, which can be used on internal or external flat or curved surfaces to measure wear, employs a microscope to make comparison measurements of diamond-shaped indentations. After these indentations are


Wear gage of many uses

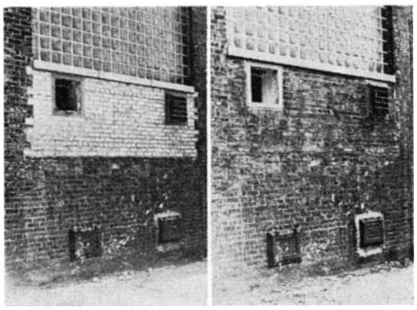
made with a special indenter, the base length of them will change as the surface wears. Measurement of this change by means of the microscope makes it possible to detect a minimum wear of 000015 of an inch, or a maximum of 0014 of an inch.

This new gage can be used on cylinders, spheres, or flat surfaces. Typical applications are measuring the wear in engine cylinders and on pistons, crankshafts, and other similar parts where accurate wear determinations are essential to research.

BRICK AGER

Solution Colors Brick to Camouflage New Work

THE UNSIGHTLY appearance of new brick work, when it is combined with old work as in a repair or rebuilding job, can be quickly and easily masked by the application of an aging solution. This solution, mixed with water, is sprayed or brushed over the surface. The two accompanying illustrations are from photographs made only a few minutes apart. Between the two exposure times a coating of Justrite brick aging solution was applied to the repaired surface, effectively "camouflaging" it to blend with the older surface.



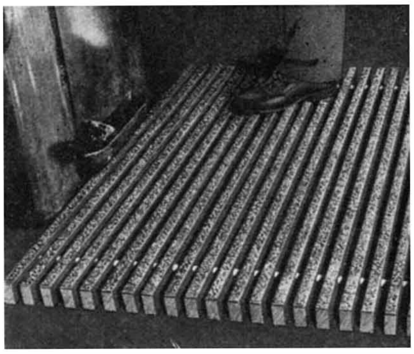
Before and after applying camouflage

NON-SLIP

Grid Gives Protection Against Falls

DESIGNED to eliminate hazardous conditions under foot in places where excessive water, oils, or other liquids make floor surfaces slippery and unsafe, a new wooden grid is giving satisfactory service. Made of oak, the non-slip feature of Orco-Grid is obtained by bonding alundum abrasive aggregate to the walking surface of the grid pieces.

A composition known as "Valim" is used to bond the aggregate to the surface of the grids. The abrasive aggregate and the bonding composition are not affected by alcohol, gasoline, creosote, S.A.E. 10 oil, water, and other commonly used solvents. Temperatures ranging from 55 degrees below zero to 300 degrees above zero, Fahrenheit, do not affect the aggregate or the bond.



Abrasive insures sure footing

FUEL METER

Uses Synthetic Rubber as Shaft Protection

SYNTHETIC rubber has solved a major problem in helping to assure the safety of Army and Navy fliers; Chemigum is being used in the rotors within fuel lines of war planes to show each pilot how fast his fuel is being consumed. This is important in order that each pilot may balance his rate of usage against his supply.

The fuel-meter rotor is mounted directly in the center of a plane's major fuel line, with the center shaft parallel to the flow of the gasoline. The stainless-steel shaft of the rotor is covered at each end with a sheath of Goodyear's Chemigum to resist the solvent action of the gasoline; natural rubber would swell and possibly clog the fuel line.

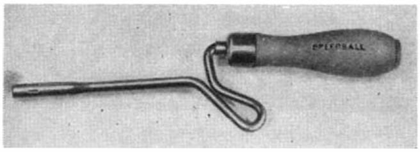
In the center of each rotor is a bushing of magnetized metal. Propeller blades on the outside of each rotor force the roller to revolve as the flow of gasoline strikes them. Thus the rotor, revolving inside the metal fuel line, acts in the same manner as an armature, generating electrical impulses which are transmitted by wires from the fuel line and the rotor's mountings to the airplane's instrument board.

Naturally, as the flow of fuel increases, the strength of the electrical impulses is raised, which, in turn, reflects on the calibrated dashboard dial that records the volume of fuel usage.

SPEED DRIVER

Can Speed Up Hand Assembly Jobs

A NEW high-speed ball bearing driving tool, known as the Aero Tool Speedball Driver, drives screws, countersinks, or removes burrs. Replaceable tips, conveniently stored in the recessed handle, gives the tool a wide variety of uses. It can be supplied in



A variety of tips are used

several shapes for special work with tips for Phillips screws, slotted-head screws, set screws, or for burring and countersinking jobs. A tapered shank on the tip allows for easy removal but will not permit the tip to turn in the tool.

GOLD ALLOY

For Use in Small Parts Manufacture

ELECTRIC contacts, instrument bearings, and so on can readily be made from a new precious-metal alloy containing gold, platinum, and palladium, recently announced by J. M. Ney Company. This new alloy, which can be drawn, rolled, machined, soldered, and welded, fuses at 1985 degrees, Fahrenheit, and has an annealed hardness of 180 Brinell.

FIBER CONDUIT

Is Replacing Metal in Many Applications

IN VIEW of the metal shortage, great interest has been shown in the possibilities of fiber conduit such as Bermico, in which wood cellulose fibers are scientifically built up and heat-treated to form rugged tubes with a solid, homogeneous wall structure. These tubes are then impregnated by a special process to produce a chemically inert, light weight pipe with high mechanical strength and water resistance.

Millions of feet of Bermico are put under ground each year for the installation of electrical cables. Lately Bermico fiber conduit has been used in place of critical metal conduit. Another new application is for inside drain pipe to carry off rain water. Bermico is also reported as being used as a protective jacket to prolong the life of metal pipe exposed to corrosive action of liquids or gases.

PAPER BURLAP

Has Similar Uses to Fabric Which It Simulates

AVAILABLE in rolls and measuring from 30 to 64 inches in width, a new woven paper burlap is being marketed for application in most of the services for which fabric burlap has been used. Bags, wrapping, backing for carpets and rugs, upholstery, and seat covers are a few representative examples of the possibilities of this new material made by the Matthias Paper Corporation.

INSULATOR-MARKER

Made of Plastic Tubing for Wire Terminals

SHORT lengths of extruded plastic tubing are clearly marked with letters and numerals to perform two jobs; they serve as insulators of terminal connections and as wire markers. Where lug insulation and wire identification are required, they speed assembly by eliminating other means of identification.

The tubing from which these new combination insulator-markers are made has high dielectric strength. Smooth inside surfaces permit quick application over wires and lugs. Legible numerals of the customer's choice are printed on the tubing with an ink that has resistance to chemicals, water, and oils equal to that of the tubing itself.

HAND WHEELS

Cast from Phenolic Resin, With Metal Inserts

CUSTOM fabricated to the user's requirements, a new line of plastic hand wheels for use on machinery of various kinds has been developed by the Colonial Kolonite Company. These wheels are cast from a phenolic resin; hence, priority ratings of A-1-K or better are necessary.

Metal inserts for these new hand wheels are shrunk in under heat after fabrication, the metal parts being supplied by the customer.

Most Powerful Dive-Bomber

New American Aircraft Excels in Every Respect Any Other Dive-Bomber Ever Built

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

So much has been written about the German Stukas that many have come to believe that the Germans not only invented dive-bombing, but that they excel at this effective fighting method. As a matter of fact, the American Navy originated dive-bombing and our dive-bombers are superior to anything built anywhere in this class of aircraft.

The latest, most powerful, and most ominous dive-bomber is the Curtiss-Wright XSB2C-I, which is a mid-wing design and which carries two men for its crew. Military necessity prevents much information being revealed, but we are glad to learn that the machine will be faster, will have a greater range, and will carry a greater load of bombs than any other craft of its type in the world. It is powered with a 1700-horsepower Wright Cyclone engine, the wings have either fixed or movable slots at the tips, and a three-bladed controllable pitch propeller will absorb the power of the Cyclone.

EXPERTS ABROAD

Promote Co-Operation in United Nations' Aircraft Production

From the point of view of our aircraft program, it is most encouraging to see how closely Americans and British are co-operating. A feature of such co-operation is the exchange of missions, whose personnel is composed of aircraft manufacturers—not politicians. When people like T. P. Wright, of the Aircraft Division of the War Production Board; Ken Ebel, chief engineer and test pilot of Glenn Martin's; Philip G. Johnson, the energetic president of Boeing Aircraft; J. Carlton Ward of Fairchild Aviation; and other equally well qualified experts visit the aircraft factories of Great Britain, they return with much useful information, both military and industrial. In turn, they serve to energize the English manufacturers.

Mr. Wright, on his recent return, reported impartially on the merits and demerits of British methods. Their factories are underground, in many cases, with a number of plants scattered in a given district to feed a central assembly plant. This makes for safety against bombing, but does not make for better volume. Again, English machine-tool equipment is more obsolescent than ours and single-purpose machines, which we take for granted, are less frequent in England. On the whole, productivity per man is less than in the United States.

But Mr. Wright did not give us superiority on all points. Thus, British working hours are about 15 percent longer than in the United States. Relationships between labor and management are more cordial. There are no material bottlenecks to be found. On the contrary, materials flow smoothly and their control is far more efficient than with us. When the Deputy Director of the Aircraft Division of the War Production Board is expert enough and broad-minded enough to make such observations, we can only compliment him on his wisdom, and ourselves on our good fortune in having such a man in this vital Washington post.—*A.K.*

• • •

LUMBER—Blue stain in sapwood lumber is caused by tiny threads of living organisms which permeate the wood cells. Although the threads within the wood are brown, they impart a blue to blue-gray color by refracted light.

• • •

TURNTABLE

Made in Portable Form, for Use on Any Airport

The activity of an airport, as far as ground movement of the airplane is concerned, is concentrated at the Arministration Building loading platform. And as plane traffic increases, so does congestion grow at the loading platform; the difficulty of finding space in which to turn planes around increases in like measure. In an attempt to meet this difficulty, fixed or permanent type turntables have been installed at Floyd Bennett Field, Long Island, and at the National Airport in Washington. These turntables require reinforcement in the concrete or pavement adjacent to the turntable pit, and also provision for draining the pit.

Now, the International Stacey Corporation, working under the sponsorship of the Civil Aeronautics Authority, has produced a portable turntable which can be moved about the airport as required (thus relieving congestion). This new unit needs no pavement reinforcement and is self draining.

The portable turntable is five feet six inches in diameter, and only two inches in height. Seals protect its huge steel ball bearings against dust and dirt. The whole unit weighs only 700 pounds and requires no anchorage to the pavement surface. This turntable has performed successfully under a single wheel load of 20,500 pounds with very little deflection of the top revolving plate, and it has already given excellent trial service at the Washington airport.

The handling of cargo for the airlines, the construction of suitable cargo terminals, the installations of hand-cart and conveyor systems, are all just in the offing. This portable turntable is but one of the many devices which airport engineers will develop and which will help to handle the commercial air cargo that all authorities so confidently expect to come after the war. For military purposes air cargo is already being carried on a vast scale.—*A.K.*

SCRAP SALVAGE

In Aircraft Industry is On Scientific Basis

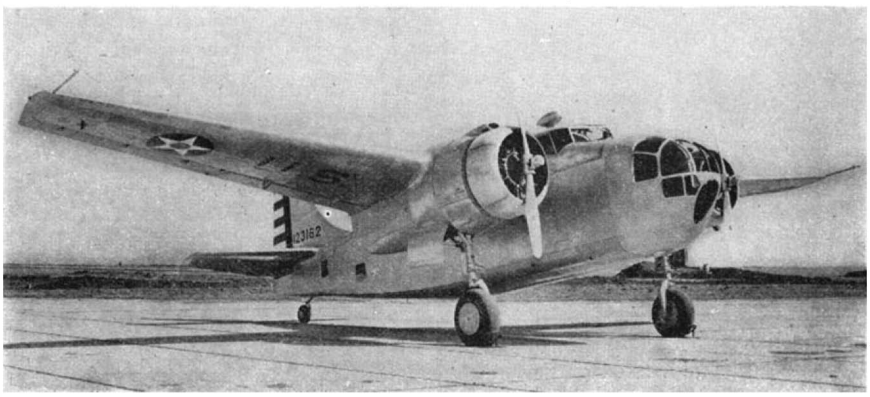
Great credit is due to the Wright Aeronautical Corporation for working out a complete plan for salvaging tons of vital scrap—steel, aluminum, and other high grade materials used in the construction of airplane engines. Moreover, this scrap is secured in such a condition that it can be quickly reapplied to the war effort, and is sent immediately to steel companies, shipyards, tank manufacturers, smelters, and the like.

The plan has the vital advantage of segregating the various metals just as fast as they are removed from forging or casting by lathe, drill, or milling machine. Machine tools, ranging from small boring machines to massive turrent lathes, have bins attached which catch and hold all shavings and chips or whatever waste is produced. Salvage collectors wheel large boxes up and down the factory aisles, gathering a special type of metal and, to make sure that there is no mix-up, the containers are identified with the corresponding machine tools by a foolproof color-marking system. Containers are marked with a specific color for each metal, the coloring being in the form of a large "V" painted on the side of the box. The men employed, some of whom have been appointed "monitors," give full co-operation.—*A.K.*

CREW TRAINER

Contains Major Aerodynamic Features of Combat Planes

It is an immense step from primary basic training to the piloting of a huge multi-engined bomber. There is another great step from the individual effort of the pilot to the coördinated team-work of the crew of a bomber. The Army Air Forces have taken due cognizance of these facts and met the situation by development of the AT (Advanced Training) Crew Trainers. Such an advanced crew trainer has been designed and built for the A. A. F. by the Boeing Airplane Company, and the Boeing AT-15 was probably the first training plane specifically designed and equipped for the integrated training of pilots, co-pilots, bombardiers, navigators, and gun crews. In reality, it is a small, perfectly equipped bomber, with everything provided to give members of the crew complete training in their duties as individuals and as members of a team.



Specifically designed and equipped for bomber crew training

All the military gear of a bomber is included—bomb racks, power-operated gun turrets, regulation bombardier's position in the plastic enclosed nose, and full radio and navigational facilities. The fuselage is constructed of mild steel tubing with wood fairing and fabric covering.

Wings and tail surfaces are of wood with plywood covering. The wing span is approximately 59 feet and the overall length is 42 feet. With two Pratt & Whitney engines of moderate power, the top speed is well over 200 miles an hour.

ELECTRIC EYE

Controls Warning Lights on Aviation Hazard

Some two miles from La Guardia Airport, an "electric eye" has been installed on a 125-foot standpipe. The

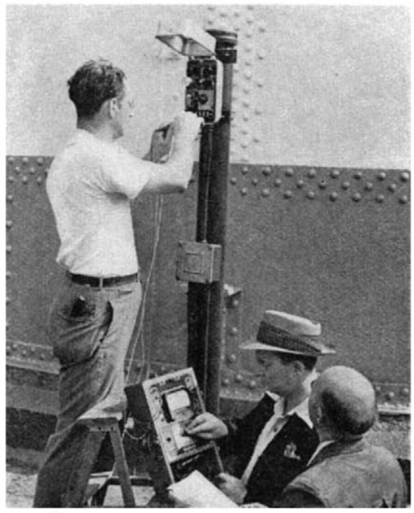


Photo-cell airport guardian

"electric eye," as the photoelectric device has been nicknamed, makes use of one phototube and three standard radio type vacuum tubes. At the approach of darkness or fog this device will turn on red warning lights.

Relays of this type are not new. They have been used for the control of street and highway lighting and for floodlighting and spectacular devices; it is their application to airport service that merits noting.—*A.K.*

ANTI-AIRCRAFT

Weapons, Both Secret and Announced

British merchant ships are reported to be using a rocket device that sends into the sky parachutes, which, when discharged from their small shells, dangle long wires and entangle attacking airplanes. The mere fact that the device has been allowed to pass the censor is, however, an indication that its efficiency is perhaps mediocre. Another, more powerful British anti-aircraft weapon has remained secret. The Government was about to describe it. A newspaper, *The Daily Mail,* pleaded for censorship, which constituted an analogy to the man-bites-dog story. *The Daily Mail* was perfectly right in insisting on secrecy, and the new weapon seems to be inspiring fear in attacking German raiders who often throw their bomb load down in open country and race back.—A.K.

NATIONAL DEFENSE

How A Naval Battle Is Fought

(*Continued from page* 103)

and beneath its surface, staging raids against enemy shore installations, and — most important of all — covering landing operations, such as in the Solomons, and such, again, as that in Northern Africa, in co-operation with the Army.

The third main engagement in the Solomons, the Battle of Cape Esperance, occurred the night of October 11-12. Under cover of darkness a strong Jap force tried to repeat the practice of landing reinforcements on Guadalcanal.

All classical standards aside, this battle was fought in the darkness of midnight and lasted for 27 minutes. It was a duel of guns and torpedoes, between almost equal opposing forces. It was a battle in which a trap was set by the United States force, including the now-famous cruiser *Boise,* of Captain E. J. "Mike" Moran. The Japs steamed straight into ambush.

THE *Boise* alone fired 1000 rounds of 5- and 6-inch shells, nearly 40 a minute for the 27 minutes. She shared in the sinking of three Jap cruisers and three Jap destroyers. She was hit below waterline, her fires were out, and flames leaped mast-high. She was given up by her sister ships, but the crew of the *Boise* plugged holes with bedding, and patched her and pumped her so that she amazed all by steaming back into line at 20 knots two hours later. And, despite her own loss of 107 officers and men, she continued operation.

The Japs fled.

With the coming of daylight our planes followed the Jap flight and inflicted further damage on Jap vessels. The Japs lost at least eight ships sunk and three damaged. We lost one destroyer.

In the Battle of Santa Cruz Islands, the fourth main sea engagement in the Solomons, we lost one carrier and one destroyer. The Japs in the same engagement lost one battleship, three carriers, five cruisers, along with 100 planes destroyed and 50 "probables." The battle centered around a United States carrier task force which exchanged air thrusts with a strong Jap group northeast of Guadalcanal.

The Battle of Guadalcanal (being the official title of the fifth main sea-engagement in the Solomons) occurred November 13-15. The Japs again attempted to dislodge our forces in the Solomons. The Jap preparations this time were larger than ever. For weeks they had been assembling ships, planes, and troops in New Guinea, in the Northwest Solomons region.

When the enemy had everything ready and assembled for the attack, three large forces moved in upon the Solomons. They were met by our ships just after midnight of the 13th. This was the battle wherein the Japs, in the darkness, got confused and fired on each other. This was the battle, too, wherein the *San Francisco,* by steaming between the enemy lines and adding more confusion to the Japs, so distinguished herself that she later received the accolade.

Our planes fought all next day, and a new sea-action took place on the second night. Warship slugged with warship. On the morning of the 15th the Japs fled. Or at least the survivors fled, for the Jap losses included 25 to 27 ships sunk and 10 ships damaged. The sinkings included one, and perhaps two, battleships. The United States lost two light cruisers and seven destroyers.

In theory, then, it would seem that individuality on the part of the commanders, along with surprises on not doing the expected as taught in school, have as much to do with winning sea-engagements today as they always have —despite all the war theories ever written or studied.

It was the same in the days of John Paul Jones and the *Bon Homme Richard.* It was the same when the *Boise,* given up for lost, steamed back into line still firing and her commander saying: "Go after the biggest ones first." It was the same when the *San Francisco* steamed directly between the enemy lines at night, causing the Japs to fire on each other. It will be the same when. . . .

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.

A MATHEMATICS REFRESHER

By A. Hooper

Another crutch book for the lame mathematician, and an excellent one—as proved by the fact that it has made learned mathematicians shudder (because it unbends and attempts to break down the usual barriers, and isn't conventional). Arithmetic, algebra, geometry, trigonometry, and a wee peek at calculus—these give the scope. After examining it, this reviewer sees no reason why a diligent student who never had previously studied mathematics could not derive much help from this book. It was prepared mainly to refresh aviation trainees whose high school mathematics was rusty. (342 pages, 5¼ by 7¾ inches, illustrated.)—$2.60 postpaid.—*A.G.I.*

NEW COMMERCIAL AND TECHNICAL DICTIONARY

Spanish—English. English—Spanish

In an attempt to set a standard of terminology for technical and commercial words in Spanish, 50,000 words have been chosen and defined. Many engineers, importers, technicians, and soldiers will find that the information presented here will be invaluable on many occasions. A supplement gives conversion tables of weights, measures, and monetary units. (600 pages, 6½ by 9½ inches, unillustrated, thumb-indexed.)—$10.20 postpaid. —*A.P.P.*

JEWELRY, GEM CUTTING, AND METALCRAFT

By William T. Baxter

Second edition of a book which has been well received. The section on jewelry making has been rewritten and new material added. This book tells how, gives addresses of dealers in material and equipment and, in general, emphasizes the practical. (287 pages, 5½ by 8 inches, 170 illustrations.)—$2.85 postpaid.—*A.G.I.*

UNITED STATES SERVICE SYMBOLS

By Cleveland H. Smith and Gertrude Taylor

The vastness and variety of war services and insignia are made simple, understandable, and far more interesting by use of this volume. To know the meanings and backgrounds of the symbols worn by American men and women fighting this war is to appreciate the whole picture far more thoroughly. The authentic information and hundreds of illustrations in color will identify members of the Army, the Navy, the Marine Corps, the Coast Guard, the Air Forces, the Women's Services, the U.S.O., Civilian Defense people, as well as medals, decorations, squadrons, regiments, and signal flags. (116 pages, 5 by 7¾ inches, lavishly illustrated in color.)—$1.60 postpaid.—*A.D.R., IV.*

THE STEAM LOCOMOTIVE

By R. P. Johnson, M. E.

Concise, technical treatise on locomotive theory, operation, and economics for (mechanical) engineers. Author is chief engineer of the Baldwin Locomotive Works. Typical chapters: Tractive Force; Counterbalancing; Torque Diagrams; Locomotive Testing; High Speed Service; Repair Costs. Plain, unadorned, thoroughly businesslike work (even the cover is black like a locomotive) which makes no concessions to popular appeal. (502 pages, 6 by 9¼ inches, illustrated.)—$3.60 postpaid.—*A.G.I.*

VOLES, MICE AND LEMMINGS

By Charles S. Elton

Ecological study of a problem in popular dynamics, by the Director of the Bureau of Animal Population at Oxford University. Fluctuations in vole, or meadow mouse, and other mouse population are studied in relation to those of their predators in both old and new worlds(especially in Labrador Peninsula, from the very old Hudson's Bay Company rceords). (496 pages, 6 by 9½ inches, 21 illustrations.)—$10.10 postpaid.—*A.G.I.*

SHIPBUILDING BLUEPRINT READING

By Joseph L. Tomlinson

Contending that skill, knowledge, and technique needed to *make* ship drawings are unnecessary to enable students to learn to read and interpret them, this author offers a practical home course on shipbuilding blueprint reading, minus close study of principles involved in marine construction. Thus he arrives at a simple explanation of skill in visualization, and understanding of symbols and abbreviations commonly found in ship prints. Preliminary sections are instructional, followed by test sheets in step-by-step fashion. Author has background as shipfitter instructor with shipbuilding companies and vocational schools. (208 pages, 8 by 11 inches; profuse with diagrams, drawings, blueprints.)—$3.10 postpaid.—*A.D.R., IV.*

STRUCTURAL GEOLOGY

By Marland P. Billings

SPECIALIZED textbook treatise, limited to that part of geologic science which deals with the principles, methods, and technique of determining and mapping local structural (three-dimensional) units. Adapted to readers who are already familiar with stratigraphy, paleontology, physiography. Author is associate professor of geology at Harvard. (473 pages, 6 by 8 inches, 336 illustrations.)—$4.60 postpaid.—*A.G.I.*

RULES OF THE ROAD

By Lt. Robert A. McCoy, USNR, and Lt Davis N. Lott, USNR

NAVY and reserve officers, midshipmen and enlisted men, merchant marine officers and seamen, sea scouts and private yachtsmen will find this thorough explanation of every combination of lights or signals required under both International and Inland Rules of the Road both timely and valuable. (121 pages, 6 by 9 inches, 45 full-page plates.) — $2.10 postpaid. — *A.D.R., IV.*

FOUNDATIONS OF ASTRONOMY

By W. M. Smart

PRACTICAL, rather than descriptive, astronomy is the main content of this work. Content: geometry of the sphere; celestial sphere; right ascension; mean time; solar system and law of gravitation; refraction; parallax; aberration, precession and nutation; determination of Earth's position; Moon; eclipses; stars; stellar motions; clusters and nebulae; telescopes. This book will repel readers who seek attractiveness, as it is bleak; but will attract those who prefer bleak, compact, mathematical treatment without concessions to interest or wordiness (it surely isn't garrulous!). It is the text used in first year astronomy in Britain. In mathematics it does not go beyond trigonometry. Author is Professor of Astronomy at Glasgow. (268 pages, 5½ by 8½ inches, 115 figures, no pictures.)—$4.30 postpaid.—*A. G. I.*

COME AND GET IT!

By George W. Martin

THE appeal of outdoor cooking and outdoor eating grew apace with America's automobile ownership—these rubber-less and gasless days the relegation of the art of outdoor culinary achievements to the back-yard hasn't lessened that appeal. Beginning with a comprehensive discussion of outdoor fireplaces, stoves, ovens, fuels, and personal equipment, the reader will learn much that is helpful about preparation of delicious meats, fowl, fish, shellfish, eggs, gravies and sauces, vegetables and cereals, soups, breads and flour foods, beverages, and even such luxuries as deserts. Packed with splendid recipes for picnickers, campers, hunters, and all out-of-door eating fans. (189 pages, 5¾ by 9 inches, many drawings, index.)—$2.10 postpaid.—*A. D. R., IV.*

WILLARD GIBBS

By Muriel Rukeyser

As the years move on, science steadily elevates the late Willard Gibbs higher and higher. An obscure, shy man, scarce known to his neighbors, likewise unknown to the world outside his quiet limited daily radius at Yale, performed mathematical miracles that have proved to be basic beneath chemistry, and physics, and biology and, beyond these, chemical industry. Gibbs, the almost unknown, is seen today to have been one of America's few really great scientists. Among his biographies the present one, widely acclaimed by reviewers, is turning out to be equally preeminent. (463 pages, 6 by 9 inches, 6 illustrations.)—$3.60 postpaid.—*A.G.I.*

MATHEMATICS FOR READY REFERENCE

By H. M. Phillips

Readers of this book can use it as a reference work as needed or as a text from which to glean a comprehensive knowledge of the whole subject of mathematics. The method in which the text is presented in numbered sections makes reference particularly easy. (224 pages, 5½ by 8 inches, a number of drawings, thoroughly indexed.)—$2.10 postpaid.—*A.P.P.*

WOODCRAFT

By Bernard S. Mason

Comprehensive, encylopedic on all phases of campcraft, woodcraft, and crafts of the woods. Excellent reference and guide to camp counselors, club leaders, and individual—old or young—who like life in the open. Author has had a lifetime of experience in his subject, is acknowledged by Ernest Thompson Seton as a "master." (580 pages, 5¾ by 9 inches, indexed, numerous photographs and drawings.)—$2.85 postpaid.—*A.D.R.*

HOW TO PLAN A HOUSE

By Townsend and Dalzell

Practical working manual from which the prospective—or today, at least, optimistic—house builder may gain access to the underlying principles of planning which architects know, but which so many amateurs, carpenters, builders do not know, or else ignore to the detriment of houses. This book gets right down to cases and gives tangible details—it isn't merely vague and general. After studying it thoroughly, the reader should emerge with an enhanced respect for architects—and in the end probably will hire one, but will understand, anyway. (525 pages, 5½ by 8¼ inches, heavily illustrated.)—$4.60 postpaid.—*A.G.I.*

CURRENT BULLETIN BRIEFS

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

PORTABLE ELECTRIC DRILL, ITS PROPER USE AND CARE is a handbook specifically aimed at operators of various types of hand drills. The text describes and illustrates the use and care of different types, showing many of the wrong methods which should be avoided for long and efficient drill life. *Black and Decker Manufacturing Company, Advertising Department, Towson, Maryland.—Gratis.*

INDUSTRIAL SUB-ZERO MACHINES is an eight-page illustrated folder which describes various types of refrigeration equipment for such industrial purposes as rivet storage, expansion fits, aging and processing, and testing. *Kold-Hold Manufacturing Company, 424 North Grand Avenue, Lansing, Michigan.—Gratis.*

HOW TO INCREASE TOOL LIFE is a 24-page illustrated booklet which describes a method of increasing the life of cutting tools by fine-finishing of the cutting faces during regrinding. By such methods it is claimed that production has been increased as much as 400 percent for milling cutters and 66 percent for punches and dies. *Norton Company, Worcester, Massachusetts—Gratis.*

RECTIFIERS FOR ELECTROPLATING, ANODIZING AND ELECTROTYPING is a bulletin which describes in detail a line of copper oxide rectifiers, their construction, operation, and operating characteristics. Profusely illustrated with photographs, charts, and diagrams. *Hanson-Van Winkle-Munning Company, Matawan, New Jersey.—Gratis.*

A. C. WELDERS is a 12-page booklet which compares the advantages of A.C. and D.C. welding and shows how welding speeds can be increased and power costs decreased. *Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.—Gratis.*

PORTABLE FLEXIBLE SHAFT MACHINES is a 30-page booklet which describes and illustrates a wide range of machines of this type. Also illustrated are some of the attachments and accessories which are available. *R. G. Haskins Company, 615 South California Avenue, Chicago, Illinois.—Gratis.*

WHAT OF TOMORROW? is a 26-page folder which is presented as an anlysis of the possible trend of future events as prepared by a philosophical and educational fraternity. *The Rosicrucian Order, Rosicrucian Park, San Jose, California.—Gratis.*

SOLDERLESS WIRING DEVICES is a 32-page catalog devoted entirely to illustrations, descriptions, and specification details of a group of wire terminals and connectors, together with their application tools. These devices have been developed specifically for aircraft usage, but are adaptable to many other electrical problems. *Aircraft-Marine Products Inc., 286 North Broad Street, Elizabeth, New Jersey—Gratis.*

THE EVOLUTION OF THE SCREW, by Herbert Manchester, is a 22-page booklet which describes the historical development of the screw thread from its earliest known form up to those of the present day. *Parker-Kalon Corporation, 200 Varick Street, New York, New York.—Gratis.*

THE STORY OF RESEARCH is a 20-page illustrated booklet which describes briefly but quite comprehensively the business of research as it is conducted by one of the largest industrial organizations in the country. *General Electric Company, Department 6-201, Schenectady, New York.—Gratis.*

HANDBOOK OF SPECIAL STEELS is a 128-page manual presenting in text and tabular form the purposes and uses of a wide variety of steels, including tool, Nitralloy, stainless, electrical, and carbon steels. *Clark W. Green, Allegheny Ludlum Steel Corporation, Brackenridge, Pennsylvania.—Gratis.*

PROTEKTOL is an eight-page pamphlet describing an industrial stripping lacquer which has been developed for use as a protective coating on polished metal, glass, or ceramic surfaces. This protective film, which prevents damage to surfaces during handling and fabricating, is easily removed. *Interchemical Corporation, 75 Varick Street, New York, New York.—Gratis.*

NEW FIELDS FOR AMERICAN AGRICULTURE is a 53-page pamphlet giving data on growing small items formerly imported but no longer available due to the war: lavender, paprika, pyrethrum, perilla, rape, eucalyptus, camphor, cinchona. *National Farm Chemurgic Council, 50 West Broad Tower, Columbus, Ohio.—50 cents.*

MICROMAX THERMOCOUPLE PYROMETERS is a 56-page illustrated catalog giving information about available instruments—indicators, recorders, and controllers—and about the thermocouples and accessories which are used with them. *Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania.—Gratis.*

AIR CLAMPS is a four-page illustrated folder describing a number of different types of air clamps for industrial machine tool use, ranging in size from a new midget type to larger models delivering pressures of from 80 to 1800 pounds on a line pressure of 100 pounds. *Mead Specialties Company, 15 South Market Street, Chicago, Illinois.—Gratis.*

HOW TO HARNESS A CONFERENCE, by Don Herold, is a humorous approach to an ever-present business problem. It gives suggestions as to how to call conferences and how to conduct them, using printed forms which keep the whole business "on the beam." Please request this booklet on your business letterhead. *Hammermill Paper Company, Erie, Pennsylvania.—Gratis.*

TELESCOPTICS

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

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

IDEAL hobby for elderly people is telescope making. Equally ideal for telescope making are elderly people, for these have long since discovered the necessary patience and tenacity. E. G. Richardson, 1238 Broadway, San Gabriel, California, is 79 years young and, in sending the photograph (Figure 1) of his 18", *f*/7 reflector, he says he has ridden the hobby for five or six years and made mirrors from 6" up, also a 5¼" refractor and seven 6" and two 12½" flats.

Asked to give further detail about the 18" telescope, which is mounted as proposed by Porter in "A.T.M.", page 139, he writes: "Most telescope drives shown in the "A.T.M." books show the motor on the foundation or the frame of the telescope. I have tried that and attempted to smother the vibration, or rather cut it off from the telescope, by various kinds of pads and vibration insulators, but always found an annoying slight vibration, especially in some positions of the telescope, that interfered with sharp vision. So I have put my synchronous motor in a little two-story 'dog house' located on one side of the telescope platform just visible at the right in the photograph. The motor is mounted on a block of concrete which sits on a hole filled with sand. It is belted to a reduction gear which is on its own separate foundation, and the gear to a shaft which runs through a conduit under the platform and is geared to the worm which drives the large worm gear at end of the polar axle. I have absolutely no trouble from motor vibration.

"The upper story of this little house opens onto the telescope platform and in it I keep star maps and the odds and ends that one uses about a telescope. The switch-controlling motor is also here.

"An accessory that is rather important with so large a telescope is the observing step platform, which the photograph shows beside the telescope. At first I used an ordinary 12' stepladder, but it is surprising to note the number of persons who are more or less timid when they climb a few feet off the ground, especially the ladies. So I built the step platform. The steps are 10" wide and there is a strong rail on each side. You stand on the step that suits your height, lean on or grasp the rail, and take a look. You are relaxed and comfortable. Much of the time you are looking downward, the most comfortable position, and the step is so solid that the most timid feel no fear. For convenience in moving around, the two legs are provided with large casters. You grasp the lower ends of the rails and push it around like a wheelbarrow.

"Are there any advantages in a large telescope? My experience is that when the seeing is good you get just that much more illumination and see better and more, but when the seeing is poor the big telescope gives no gain. Often, in fact, a smaller instrument will show more."

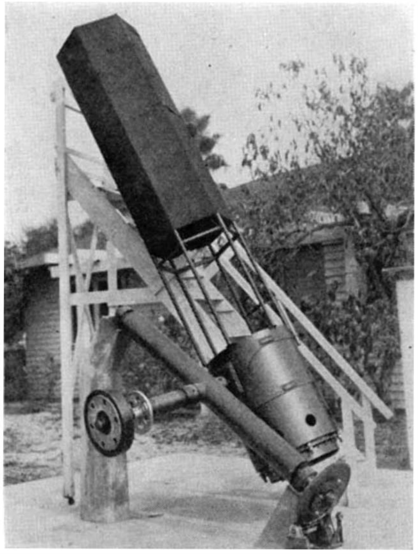


Figure 1: **Richardson's 18-inch**

THE LATE J. H. Hindle, of England, was one of a minority of amateur telescope makers who prefer machines to hand work. Figure 2 is a clean-cut machine he was building when the war intervened. It never was completed. Hindle sent no descriptive data, but a close study of the photograph will afford useful ideas.

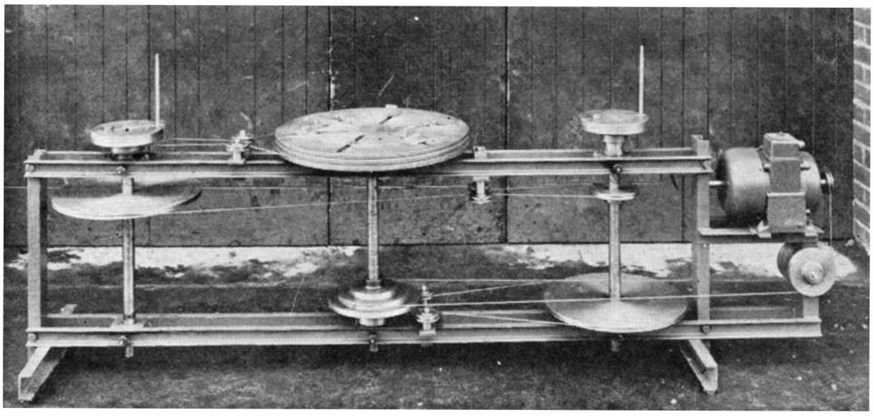


Figure 2: **Hindle's uncompleted machine with rope drive**

Hindle's machines for grinding and polishing embody a principle in which the mirror rides on top, just as in hand grinding, and is free to rotate of its own accord and does so rotate. Earliest origin of this idea, so far as is known, is the machine of Lord Rosse, described in Sir John Herschel's old volume, "The Telescope," dated 1861. Here it is the iron tool which rides on top (*KL,* Figure 3), mirror being beneath and immersed continually in water to within an inch of its surface. *M* is a round disk of wood connected with the polisher by strings hooked to it in six places, Sir John Herschel explains. "The bar *DG,*" he adds, "opens into a ring which fits the polisher nicely, but without tightness, so that the polisher turns freely around." Thus Hindle's machine traces pretty clearly to the younger Herschel's.

Figure 4 also might have been the inspiration of the drill-press grinding machine described by Hindle in "A.T.M.", page 219, and is the old Lassell machine described by Sir John Herschel in the book named above. Amateur telescope makers as a class are too mechanical to need all the lettered details of this old drawing explained, except possibly that the gear *O* is fixed and the sector *S* is concentric with the axle *P,* though in bad perspective in the odd old drawing. It is

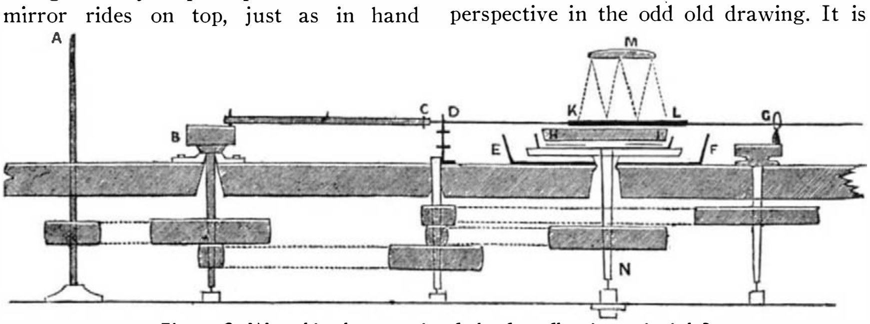


Figure 3: **Was this the genesis of the free-floating principle?**

hollow, and pinion T is adjustable anywhere along its groove. Hollow crank arm V is also adjustable. "By this mechanism," Herschel states, "it is evident that the pin [which drives the polisher J] will be carried circularly around a point which is itself maintained in circular motion."

Hindle's adaptation of this old principle was an improvement, in that he eliminated its rather Rube Goldbergish characteristics, and for them substituted more practical simplicity.

As ALL amateur telescope makers know, you can saw glass with wet Carbo and the edge of a strip of sheet metal. The same procedure works with stone. In

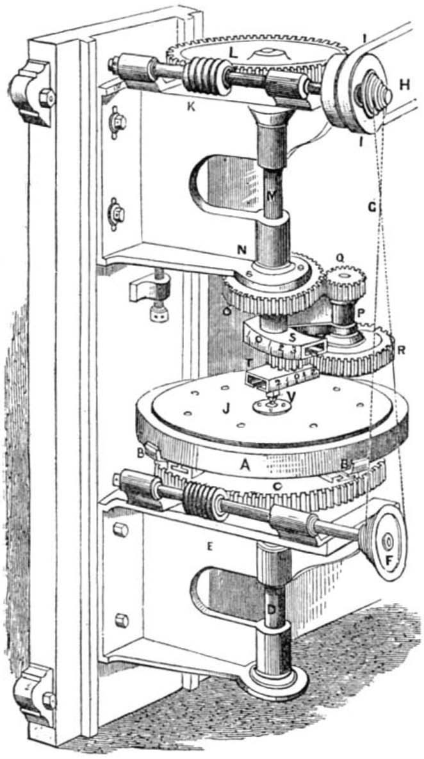


Figure 4: Lassell's machine

making the stone sundial shown in a temporary mock-up in Figure 5, your scribe sawed out its two 1" x 14" x 18" slabs of dense Devonian flagstone using No. 60 Carbo with the back of a one-man crosscut saw, each cut requiring about an hour. A drip-can was rigged up, a mound of Carbo was poured out near the cut, and this was fed in with the aid of a stick of wood as the right hand kept the saw moving. (In this instance, the owner of the saw, too distant to see clearly and ignorant of our familiar sawing technique, thought the stone was being sawed with the toothed side, and fainted.)

The uneven slabs were worked down with an old glass tool and coarse Carbo with ample elbow-grease, then fined with some of the familiar Carbo series.

The gnomon is a solid casting of bronze made and contributed by Fred. B. Ferson, Biloxi, Mississippi, author of the chapter on molding and casting in "A.T.M.A."

Diagonal lines for each 15-minute time interval from 7 to 11 A.M. were incised with the edge of a piece of sheet metal and Carbo. As they shallow up at the

TELESCOPTICS

ends, this gives a curved illusion due to the shadows of their own edges.

The larger letters were hogged out with an electrically driven "Handee Tool" and finished by hand with tools ground from old files and a knitting needle. The style of lettering was stolen from an inscription in England and it isn't orthodox (so says an engineering friend).

The left-hand stone carries a graph of the equation of time for the summer

Figure 5: **Stone sundial parts**

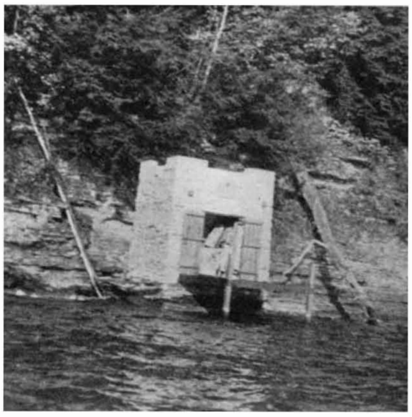


Figure 6: **Rock cabin, sundial**

months, also instructions for making the date corrections. By careful interpolation between the 15-minute lines of the dial, and addition or subtraction of date correction, it is always possible to set a watch and find it within two minutes (Sun's "time diameter") of correct time. Help from Mayall and Mayall, "Sundials," is gratefully acknowledged; also from Mayall and Mayall.

This is an east-facing, morning dial and it was built into the masonry over the door of a rock cabin (Figure 6) situated as per the legend carved on the dial: N. Lat. 42°29′40″; W. Long. 76°54′46″.

This cabin was begun 15 years ago and has provided a "piece of resistance" for annual two-week vacations. It was placed 4′ from the base of the 20′ vertical cliff shown (note ladder) and in 18″ of water. It therefore is an island. Some 56 cotton cement sacks were filled with mixed cement and aggregates and corded up on the solid rock bottom under water till they reached the surface. Into these, before the concrete set, was thumped the initial course of stone. The 12″ wall then was continued to 17′ above datum. Approximately 100 tons of 1½″ stone selected from the submerged talus by a submerged editor were brought in a rowboat and laid up in concrete mortar. No help was employed on this cabin—it was too much fun.

The flat, five-ply, pitch-and-felt, Barrett Specification roof proved to be the largest and liveliest job of pitch lap making this writer ever did, particularly when the pitch, which was being raised toward 400° F. in an iron washtub over an open fire, flared up in a roar just as both feet became stuck in the hot, soft, just-mopped-on pitch tanglefoot. Has any reader ever found out why two things pick one time to happen?

The castellated design is a perversion of one contributed by Russell Porter. The front porch shown is a temporary eyesore to be replaced by a proper stone stylobate, or basal surround, to give proportion. Porter calls this cabin "Karnac," others refer to it as a mausoleum.

Door hardware was forged from Swedish iron, to a tolerance of 10,000 wavelengths of the B line of sodium light.

Inside are a corner fireplace, Shipmate range, built-in table, a bunk 7′ overhead and a stone floor to fall out on.

The "Fisherman Good Luck" invocation relates to the small-mouth black bass that lurk in the foreground in 20′ of clear water and chuckle "they'll need it," as the optimists troll past.

This is a vacation hideout, and there's more than one way to hide out on a two-week vacation far from the madding crowd and the razor (Figure 7), while laying stone masonry.

•

¶ *The preceding 53 lines and Figures 5, 6, and 7, give some indication of the excessive mental strain under which Scribe Ingalls has been laboring these past 15 years. The purpose of this note is not only to disclaim all responsibility for the civil-life actions of our associate, and especially for this month's department, but also to warn all "Telescope Nuts" of what may be expected from Scribe Ingalls 15 years from now, when he will have "retired" and be living in his own "mausoleum" (Figure 6.)*—The Other Editors.

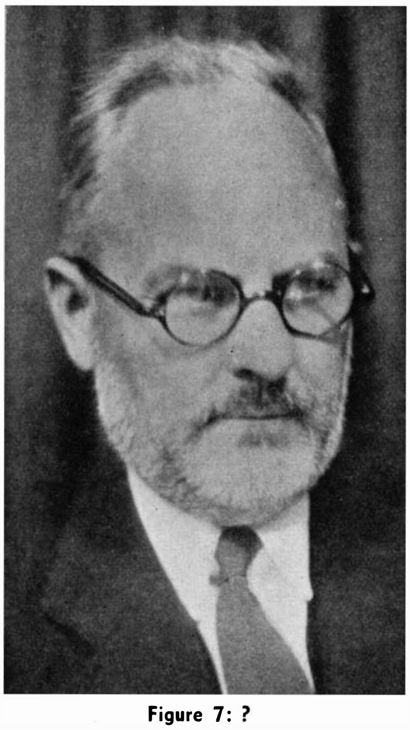
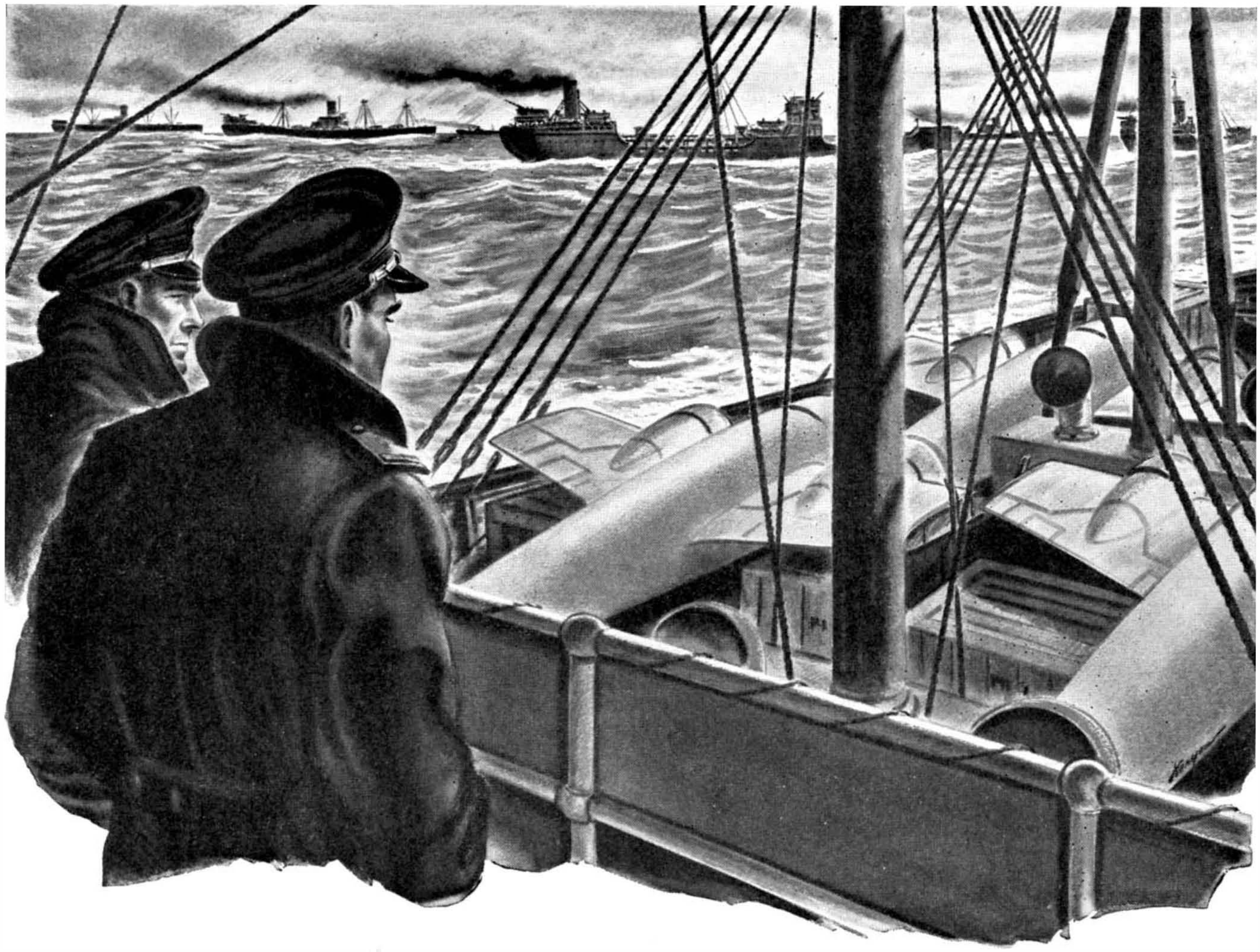


Figure 7: ?

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



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