SCIENTIFIC AMERICAN

DECEMBER • 1942

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WEARING new battle helmets, members of the merchant crew and Navy armed guard aboard ship practice operating a 20 millimeter gun. The crew member in the center of the picture is removing an empty magazine from the gun; the one at the right is prepared to hand over a new one. The canvas bag beneath the magazine catches the empty shells. U. S. Navy Official Photo.

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SCIENTIFIC AMERICAN

Owned and published by Munn & Company, Inc., Orson D. Munn, President; I. Sheldon Tilney, Vice-President; John P. Davis, Secretary-Treasurer; all at 24 West 40th Street, New York, N. Y.

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

DECEMBER • 1942

SCIENTIFIC AMERICAN December, 1942, Vol. 167, No. 6. Entered at the New York, New York Post Office as second class matter June 28, 1879, under the act of March 3, 1879; additional entry at Orange, Connecticut. Published monthly by Munn & Co., Inc., 24 West 40th Street, New York City.

Subscription rate $4.00 per year. Canada and foreign $5.00.

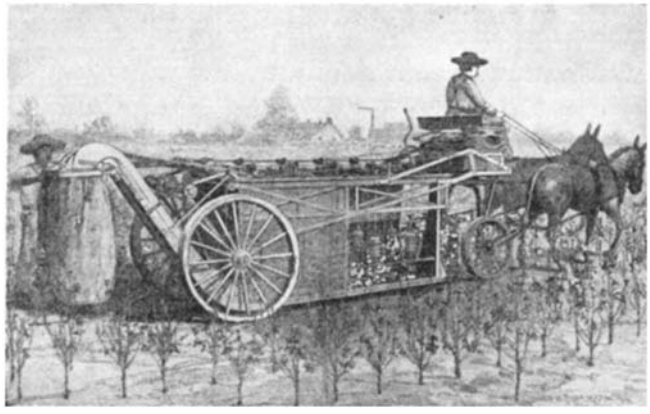
50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed From Issues of December, 1892)

CANAL—"At a recent New Orleans convention, which was attended by prominent business men from many sections of the country, the main effort was to bring to bear upon Congress sufficient influence to secure government aid in building the Nicaragua Canal."

STILL BAFFLING—"One of the subjects of invention which seem to have baffled inventors for many years is a practical cotton harvester. . . To a large extent, cotton planters in the South have been hampered by the difficulty in obtaining labor at the right time, and, as a result, serious losses have followed; but at length a machine has been perfected which may reduce cotton harvesting to a certainty. To run this machine, two men and a single team are required. It will harvest from 5,000 to 6,000 pounds of cotton per day at a cost of $3 to $4, as against forty men picking not over 150 pounds each per day at a cost of $30. . . The machine consists of a frame suspended on ordinary



wagon gear and inclosed in wire cloth. Within the frame are journaled two series of vertical shafts, upon which are placed beaters having spring arms. Through the bottom of the frame extends a slot, through which the stalks of the cotton plants pass. In the bottom of the frame are arranged conveyors which carry the cotton beaten from the plant rearwardly and upwardly, and deliver it to bags attached to the elevators at the rear of the machine. . . One of these machines has been in operation this season in Alabama, yielding the results we have described above."

INFUSIBLE—"Magnesia, formerly chiefly valued on account of its medicinal properties, has recently risen into great commercial importance, owing to its infusibility and its employment as a lining for converters used in the basic process of steel manufacture."

FALLING—"A fall, as a rule, injures a drunken man much less than a sober one, because, the controlling power of the mind being rendered nil through intoxication, the body falls as an inert mass, and thus the chances of injury are lessened, for, strange though it may appear, it is no less a fact that the most numerous cases of injury arising from a fall are caused by the effort, voluntary or otherwise, to avert the consequences, thus straining the muscles and tendons."

BALLOONING—"A very interesting balloon ascension took place at the end of the month of October. Mr. Mallet started at 6 o'clock in the evening of Sunday, October 23, in a balloon of 28,660 cubic feet capacity. . . . The balloon touched earth in the midst of a snow storm at half past 6 o'clock in the morning of Tuesday, October 25. The trip lasted 36 h. 30 m. No balloon has, up to the present, remained so long in the air."

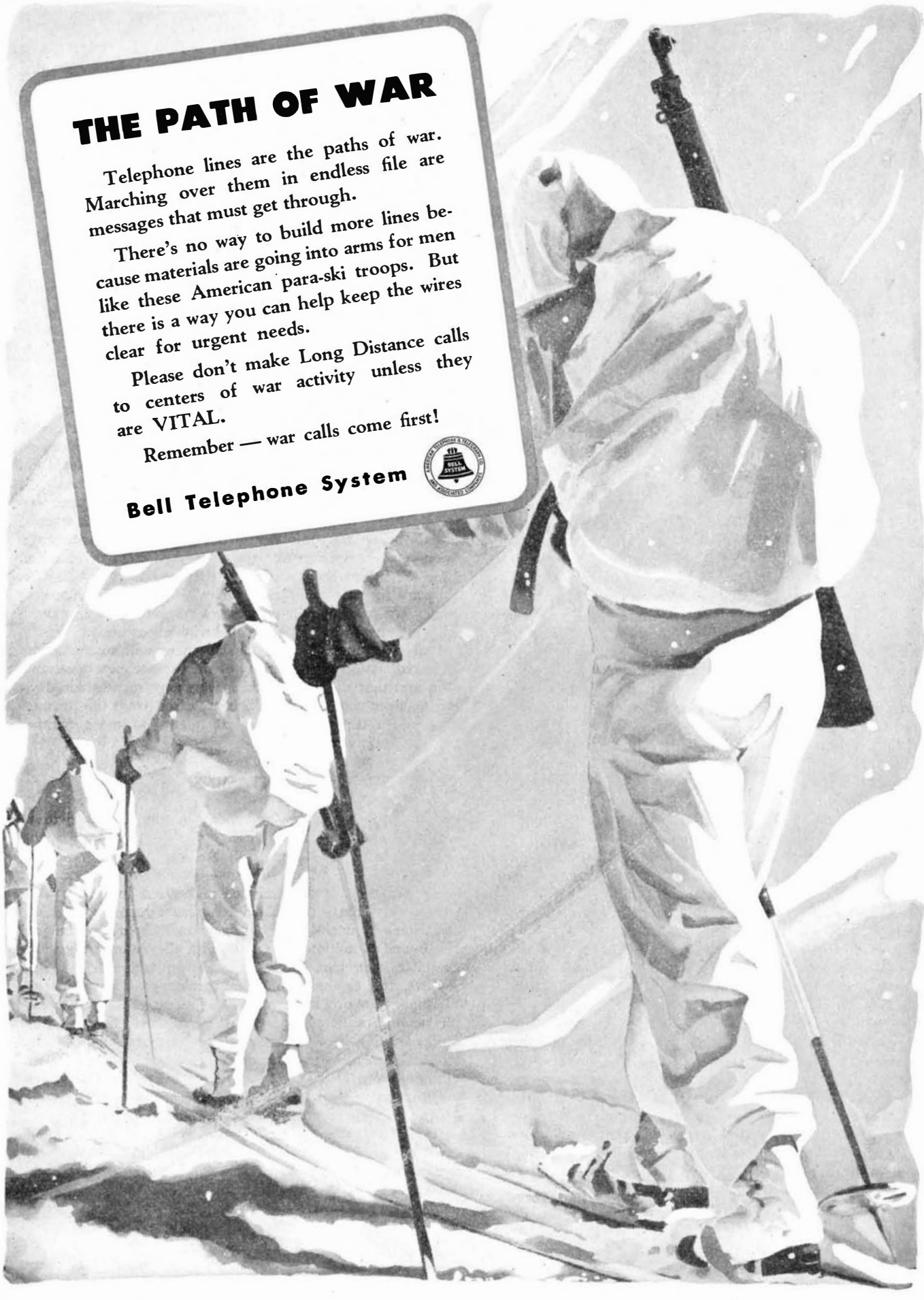
YESTERYEAR—"The National Association of Carriage Builders held their 20th anniversary recently in Buffalo, New York. Among the subjects treated a particularly important one, and interesting in view of the general movement for the advance of technical education, related to the establishment of a carriage builders' technical school. . . Carriage building is rapidly developing and bids fair to become a true profession. The past year has witnessed remarkable results obtained by the introduction of ball bearings and pneumatic tires on racing wagons, and it is hard to believe that the day is not near at hand when vehicles of luxury will be thus equipped."

MATCHES—"If the worthy gentlemen who control a monopoly of the trade in matches in the United States will give ear to reason, they will improve the quality of their product, even if in so doing they have to sacrifice a tithe of their present profits. Some of the matches now sold are a nuisance because of their unreliability, while others are a constant source of danger to property, if not to life, even in the hands of careful people. A portion of these latter drop a portion of the inflammable composition invariably, and if it happens to light on combustible material, a fire is pretty sure to result."

BRITISH NAVY—"By the launch of the Revenge from the works of Messrs. Palmer's Shipbuilding and Iron Company, Jarrow, on the 3d of November, and the floating of the Royal Oak from her building dock at Messrs. Laird's establishment, Birkenhead, the fighting strength of the British navy has been materially increased. These vessels belong to a class of eight, provision for the construction of which was made in the Hamilton Defense act of 1889, and they are considered on all hands to be, as regards strength and power for battle, superior to any first-class battle ships possessed by foreign powers."

ELEVATED—"In the early days of New York elevated railways the man who appears to have most highly appreciated their value and foresaw their great future was Mr. Jay Gould, a Wall Street broker. He bought out the Tilden and Field interests and so gained control of the works. The roads are admirably managed, and their extension in various directions would greatly add to the public convenience."

COLOR PHOTOGRAPHY—"M. Lippmann has been pursuing with energy his investigations into color photography. He says that 'on the layers of albumino-bromide of silver rendered orthochromatic by azaline and cyanina, I obtained very brilliant photographs of spectra. All the colors came out at once, even the red, without the interposition of colored screens, and after an exposure of from five to thirty seconds.' He submitted photographs of stained glass windows, draperies, oranges, and a parrot, taken by electric light with five to ten minutes' exposure, in which the color is noticeable as well as the form."



U. S. PARA-SKI TROOPS

OUR *Point* OF VIEW

CENSORSHIP

To THE foreign readers of SCIENTIFIC AMERICAN there is due an explanation of certain oddities which they have recently seen in these pages; to our domestic reader group there is inherent interest in this explanation regarding one of the many difficulties which war places on the publication of a magazine. The oddities referred to consisted of blank spaces in the editorial content of the magazine, sometimes only a few lines in extent, sometimes full pages and more. In these spaces, from which certain articles had been deleted, there appeared a statement to the effect that the material originally scheduled for these spaces was not approved for export by the Office of Censorship.

Compulsory censorship? Restriction of the freedom of the press? Not exactly, in this case, but, rather, a censorship set up for a war purpose and being carried on by a group of men who are doing it with a commendable sense of the responsibility which has been vested in them.

After the editor has made his selection of articles, and has carefully combed it for possible offending material, it is submitted to the Technical Data Division of the Board of Economic Warfare. In this division there has been set up a staff of experts in various fields whose job it is to go over the submitted material and to judge whether or not it complies with the general rules. If it does, these experts pass it on to the Office of Censorship where the material is once more reviewed. If it again passes the official scrutiny, a license is issued to the publisher and he is permitted to export the material—to send it out to his foreign subscribers.

But suppose the two groups of governmental officials mentioned above do not agree with the editor's selection? Then the license is issued with restrictions: The offending material must be "excised" from all copies that are to be mailed abroad. How to excise it is left up to the publisher's judgment. In the cases with which SCIENTIFIC AMERICAN has been specifically concerned, the directive for excision was not received until nearly press time. Thus the decision was made to run the material in those copies intended for domestic consumption and to lift the type and run blank spaces, with the notice mentioned above, in those copies to be sent out of the country. So far this has been done in two issues.

That, in essence, is the mechanics of the only compulsory censorship which has so far been placed on the press of the United States. It concerns only export copies, and therein lies the obvious futility of it all. We have not been reading too many spy stories or seeing too many movies when we state that it is our belief that every copy of SCIENTIFIC AMERICAN and of every other semi-technical and technical publication in the United States is carefully scanned, *in this country,* by foreign agents. This they do regularly, regardless of whether or not a single copy of a single informative publication is ever placed in the foreign mails by its publisher.

We are not alone in our opinion regarding the efficiency of the enemies' information collection systems. We have talked to many men directly concerned with the problems of censorship and, almost without exception, they agree that technical information originating in the United States could possibly reach enemy hands long before it could ever get there as a result of copies of magazines being mailed to foreign addresses. (The reader should bear in mind, of course, that no magazines can be transmitted to enemy countries, to enemy occupied or controlled territory, or even to certain countries contiguous to enemy nations.)

Yet these men of the Board of Economic Warfare are carrying on faithfully in a thankless job. They are constantly at swords' points with publishers; they are always open to the suspicion that they are playing favorites. Yet they discharge their duties as they see them. Although they are the men who "make holes" in our copies intended for export, we have the greatest of respect and the greatest of sympathy for them in an unenviable position.

Our only hope is that someday there will come a complete realization of the futility of the present export censorship and that these technicians who now spend their days poring over page proofs will be released from this tedious process, to turn their technical talents to more fruitful fields of endeavor.—*A.P.P.*

WHERE STAND THE VITAMINS?

WHERE do vitamins stand today in sound, conservative scientific and medical circles?

Now and then the American Medical Association issues official reports in which subjects—some of them not necessarily brand new—are weighed and sifted just as if they were new. That is, detachedly. A recent report of the Association's Councils on Pharmacy and Chemistry and on Foods and Nutrition thus deals with the vitamin mixtures available in prepared form—capsules or tablets.

First, the Councils find that prolonged deprivation of vitamins does produce a variety of diseases. Advice to the physician dwells on treating these diseases first with a food diet rich in vitamins, but does not condemn or even look askance at supplementing the diet with appropriate vitamin preparations.

Still unremedied, the Councils find, is the fact that some of the vitamin mixtures are badly balanced—enormous doses of Vitamins A and D and relatively insignificant amounts of riboflavin (B_2). For the adult, the minimum daily requirement of vitamins it recommends is: Vitamin A, 4000 U. S. P. units; B_1, 1 mg.; riboflavin, 2 mg.; C, 30 mg.; D, 400 U. S. P. units. It also asks for more informative labeling and for restrictions of advertising claims.

These are total vitamin intake requirements. If the layman who is not under a doctor's care can obtain all of these direct from his diet, we shall not become a nation of pill gulpers.—*A.G.I.*

Personalities in Industry

EDGAR STALEY GORRELL

By the time he was 21 years old Edgar Staley Gorrell had accumulated a diploma from Baltimore City College, a B.Sc. and a lieutenancy from West Point, and an insatiable desire to learn all there was to know about aviation. During the next eight years of his extremely active life, the young officer not only satisfied his appetite for knowledge of flying, but he also acquired an M.Sc. from Massachusetts Institute of Technology, a colonel's commission in the Army, the Mexican Punitive Expedition medal, the British D.S.O., the French Legion of Honor, and the Victory and Distinguished Service medals from his own country.

These awards are readily understandable when it is known that after two years in the infantry, the youthful lieutenant transferred to the Aviation Section, Signal Corps (now the Army Air Corps) as early as 1914, went with Pershing into Mexico, and was sent to Europe in 1917 as a member of the Bolling Commission to help determine what aerial material should be produced in the United States and what produced abroad. From that start he moved to Chief Engineer Officer of Air Service of the A.E.F., and in the course of serving on all five fronts he became successively Assistant Chief of Staff and Chief of Staff of our expeditionary air forces.

In 1920, at the ripe old age of 29, he resigned from the Army with the rank of Colonel, and for the next 15 years the automotive industry claimed his close attention. However, in 1936 the scheduled airlines agreed that their industry needed as a "czar" a man with practical flying experience, executive and diplomatic ability, scientific background, and general knowledge of aviation. Colonel Gorrell was chosen for this position and became president of the newly organized Air Transport Association of America.

Since then the head of the Air Transport Association has been a busy man. He averages 100,000 miles a year on the airlines, writes one or more dynamic pamphlets or speeches a week. When he is in his Chicago office—and that has totaled as little as 65 days out of a year—his rapid-fire dictation keeps two, sometimes three stenographers well occupied. His is a powerful, constructive force in public relations, and his absolute fetish toward safety and accuracy has been successfully transmitted to every member of the industry, as attested by the records.

Now past the half-century mark, whatever the Colonel does, he still does with all his might, be it work, swimming, collecting odd bits of Lake Michigan driftwood, or gardening at his home in Lake Forest, Illinois. In the latter, Mrs. Gorrell, who is an aviator in her own right, joins in keen competition. There is a third Gorrell, 11-year old Peter, whose laudable ambition is to emulate his Dad, and who is the pride of the Colonel's little "regiment."

Probably the achievement of which he is most proud was his membership on the Army Air Service Investigating Committee of 1934, for it was from the deliberations of that body that the G.H.I. Air Force was created (the Colonel's idea), and from which much of a constructive nature with respect to military aviation has been accomplished. Add to this the fact that Colonel Gorrell's views and comments since his association with the Air Transport Association have contributed much to the background for legislative and administrative action in civil flying, and it is easy to see why he has been termed the "spark-plug" of our civil aviation industry.

98TH YEAR SCIENTIFIC AMERICAN DECEMBER 1942

NAVY SKY-FIGHTERS

Aircraft of the United States Navy

WALTON L. ROBINSON

MODERN naval warfare is three-dimensional; gone forever are the days when sea fighting was restricted to encounters between surface ships. The navies of today fight on the sea, in the air above, and in the waters beneath. Relative strength can no longer be calculated by the simple process of totaling tons and guns; new weapons—the mine, the torpedo, the submarine, and the airplane—have made their appearance, adding many complex and unpredictable factors to the art of sea warfare.

Latest of these weapons is the airplane, an American invention which appeared just after the turn of the century. A few years later in World War I, planes were employed with some effect in the military operations, but they had little influence on the war at sea. It was not until the years immediately following the 1914-18 conflict that the possibilities of naval aviation began to be fully realized, and then only by the most rabid air enthusiasts. Like most pleaders for some special weapon, however, they overstated the case for the plane, blandly declaring that it had made battleships obsolete and would even abolish navies altogether. Actually, the plane has done nothing of the sort, but it has quite definitely established itself as another and absolutely essential weapon of naval warfare.

The United States Navy was one of the first to recognize the potential value of aircraft and today possesses what is generally conceded to be the finest air service of its kind in the world. Our naval planes are as good as or better than those of any other nation, while the training and morale of our fliers are unsurpassed. This very satisfactory state of affairs is no matter of luck; rather, it is the result of a long and painstaking development which really began in July, 1921, with the creation by Congress of the Navy's Bureau of Aeronautics. Rear Admiral William A. Moffett was the first Chief of this bureau; he remained in office until his untimely death April 4, 1933, in the crash of the rigid airship *Akron*. Under his direction our naval air arm developed rapidly and established many speed and altitude records. Three aircraft carriers were also commissioned—the old *Langley*, formerly a navy collier, and the *Lexington* and *Saratoga*, converted during construction from their original battle cruiser design. The U.S.S. *Ranger*, our first ship laid down as an aircraft carrier, was launched a few weeks before Admiral Moffett's death.

● Following the series of five analytical articles on battleships, aircraft carriers, cruisers, destroyers, and submarines of the United States Navy is this clear and concise description of our naval aircraft. We propose to follow these six inter-related Navy features with a comprehensive article on the tactical usage of each branch of our naval fighting forces, as soon as it is approved for publication by the proper authorities. The previous articles appeared in our issues for May, August, September, October, and November of this year.—*The Editor.* ●

THE various types of planes used by the Navy are officially designated by a system of letters and numerals. An initial letter or letters indicate the function or class of the plane; a following numeral, if present, indicates the model; and a final letter, the manufacturer. Following this group and set off by a dash is a numeral indicating the series or modifications of the model. Thus the designation PBY-1 indicates that the plane is a P (Patrol) B (Bomber) Y (Consolidated) -1 (First model). Any minor alterations to this basic design, such as slight changes in structure or armament, would make the new model a PBY-2. An entirely new patrol-bomber model built by the same manufacturer would, on the other hand, be designated a PB2Y-1. A modification of this model would be a PB2Y-2.

The letter "X" preceding a designation indicates that the model is experimental. This "X" is discarded when the plane goes into production. The letter "V," indicating "heavier-than-air" craft (as distinct from "Z," employed to designate "lighter-than-air" craft—blimps and rigid airships), is placed before the functional letter or letters when referring to classes of planes or abbreviating the names of air squadrons, but is omitted from the designations of individual models, as in the examples given above. Thus patrol-bombers in general are spoken of as VPB's, while "Patrol Squadron Eleven," for example, is rendered VP-11, the second functional name and its corresponding letter being dropped.

ON October 1, 1941, two months before Pearl Harbor, the United States Navy had on hand a grand total of 4862 aircraft. An additional 5832 planes were on order under the Expansion Acts of 1940-41, which had authorized a strength of 16,000 aircraft. This total was subsequently increased to 27,000 planes, while the Emergency War Program, which followed our entry into hostilities, provided for some 60,000 naval aircraft of all types. Only combatant aircraft—fighting, scouting, bombing, torpedo, observation, and patrol planes—will be discussed, however, as they are the ones which exercise a direct influence on and actively participate in naval operations.

These aircraft are of three very distinct types: landplanes, which operate

from aircraft carriers or land bases; seaplanes, which are carried by battleships and cruisers, being flown off from them by means of catapults; and flying boats, operating from coastal bases, advanced shore bases, or tenders. Carrier-based aircraft are the fighting (VF), scout-bombing (VSB), and torpedo-bombing (VTB) planes. Seaplanes are mostly of the scout-observation (VSO and VOS) type, while the big flying boats are all of the patrol-bomber (VPB) type.

The VF's, or fighting planes, are the Navy's smallest and speediest combatant aircraft. These single-seaters have two distinct missions, one defensive and the other offensive. Their primary mission is defensive: to secure control of the air above combat areas and to protect friendly planes and ships by destroying hostile fighters, bombers, torpedo planes, and other aircraft. Their secondary and offensive duties consist of attacking enemy surface warships, submarines, shore installations, and their exposed personnel with machine-gun fire, small cannon, and light bombs.

Our fighting planes in service are the products of three well-known aircraft manufacturers: the Brewster Aeronautical Corporation, the Grumman Aircraft Engineering Corporation, and the United Aircraft Corporation. Their respective identification letters are A, F, and U. All of the Navy's fighting planes, as well as most of its other combatant aircraft, are powered by either Pratt & Whitney or Wright radial air-cooled engines developing from 450 to 2000 horsepower on the take-off. A few scout-observation models, however, have a Ranger in-line air-cooled engine.

DURING 1937-40 three improved models of the Grumman F2F-1 biplane, the F3F-1, F3F-2, and F3F-3 entered service. The F3F-2 and F3F-3 models, fastest of the group, have a top speed of only 270 miles per hour. The last two-winged fighters built for the Navy, all of these planes are now obsolete and mostly employed as combat trainers.

In 1940 Grumman delivered its first monoplane fighter—the twin-engined experimental Skyrocket or XF5F-1, which is powered by two 1200-horsepower Wright Cyclone engines. The greatest secrecy surrounds this plane, but it is known to be in the 400 miles per hour class. The Navy has not announced production contracts for the model, which, as a result of exhaustive tests, is believed to be undergoing considerable modification.

U. S. Navy Official Photo

Grumman Wildcat Fighter (XF4F-3) above the clouds

Other fighters delivered in 1940 were the Brewster F2A-1's or Buffaloes. Powered by a 950-horsepower Wright, they have a top speed of 330 miles per hour and a cruising range of 1000 miles. Forty-two of them were released to Finland in 1940, being replaced by an equal number of improved F2A-2's.

In 1941 Grumman delivered its F4F-3's and F4F-3A's (Wildcats), while Brewster completed its F2A-2's and F2A-3's (Buffaloes). The Wildcats are powered by a 1200-horsepower Pratt & Whitney Twin-Wasp engine for a top speed of about 350 miles per hour. They have a cruising range of about 1150 miles and a service ceiling of 28,000 feet. Their equipment includes bullet-proof gas tanks and armor protection for the pilot.

The Buffaloes have a 1200-horsepower Wright engine for a maximum speed of 360 miles per hour. They are credited with a range of over 1400 miles and a 30,000-foot ceiling. Armament comprises four .50-caliber machine guns and two 100-pound bombs. The F2A-3's are generally similar to the F2A-2's except for their folding wings. Several hundred of them were supplied to Britain and the Netherland East Indies during 1940-41.

Latest Navy fighters, delivered this year, are Grumman's F4F-4's and F4F-4B's and the Vought-Sikorsky (United) F4U-1's. All data regarding the new Wildcats are restricted, but some details of the F4U-1's (Corsairs) have been released. These planes, specially designed for carrier use, have an 18-cylinder Pratt & Whitney Double-Wasp engine rated at 2000 horsepower on the take-off and giving a top speed of around 400 m.p.h. at 35,000 feet. They are generally considered to be the Navy's best fighting planes, particularly for high altitude work.

SCOUT-BOMBING planes (VSB's) are the most numerous carrier-based type. As their designation implies, these two-seaters are intended for either scouting or bombing duties. As scouts they carry additional fuel in auxiliary tanks hung from their bomb racks, while as bombers some of them can carry a ton of high explosives. In recent years the VSB's have been built by Brewster, Vought-Sikorsky, the Curtiss-Wright Corporation, the Douglas Aircraft Company, Incorporated, and the Naval Aircraft Factory. Identification letters of the last three builders are C, D, and N respectively.

In 1938 Chance-Vought completed a number of monoplane scout-bombers —the SB2U-1's. Two more series of the model, the SB2U-2 and SB2U-3, were delivered in 1939-41. Named Vindicators, all three groups are powered by an 825-horsepower Pratt & Whitney Twin-Wasp Junior giving a speed of 257 miles per hour. Their cruising range is 700 miles. Further details have not been released for publication.

In 1938-39 Curtiss delivered two series of biplanes—the SBC-3's and SBC-4's. The former have a maximum speed of 220 miles per hour, while the latter can do 235 miles per hour. Both groups are now obsolete and mainly employed for combat training. The newest Curtiss scout-bombers and the best the Navy has, are the

U. S. Navy Official Photo

Curtiss Helldiver diver bomber (XSB2C-1) in flight

SB2C-1's (Helldivers), very fast and heavily armed monoplanes specially designed for dive-bombing attacks. Few details concerning them have been released, but it is understood that they are powered by a 1750-horsepower Wright Double Row 14-cylinder engine giving a speed in excess of 300 miles per hour. They are equipped with internal bomb stowage.

FOUR series of Douglas Dauntless scout-bombers (SBD-1, -2, -3, and 3A) were delivered in 1941. All of them are monoplanes of very similar design. Powered by a 950-horsepower Wright, they have a top speed of 260 miles per hour and a cruising range of about 1000 miles. Their armament includes two .50-caliber machine guns and several 500-pound bombs.

The Naval Aircraft Factory also completed a number of VSB's during 1941. Designated the SBN-1's, they are generally similar to the old Brewster SBA-1's, now out of service. Their maximum speed is 285 miles per hour. Although built and classed as scout-bombers, they have served on occasions as carried-based VTB's (torpedo-bombers).

THE only Brewster scout-bombers at present in service are the SB2A-1 Buccaneers, the first of which were delivered this year. As in the case of the latest Curtiss VSB's, details concerning the Buccaneers are restricted. It is believed, however, that they have very similar characteristics to the Helldivers.

Some of the Navy's older bombing planes, designed primarily for dive-bombing attacks, are classed simply as VB's (bombers). In recent years these planes have gradually merged into the scout-bomber type described above. Torpedo-bombing planes (VTB's) are the Navy's heaviest carrier-borne aircraft and probably its most effective weapon for striking heavy aerial blows at the enemy's large naval units. Whenever possible, they make their torpedo attacks from low altitudes and close to the target. On bombing missions they remain at high altitude and drop armor-piercing or demolition bombs on warships and shore objectives.

The Douglas TBD-1's (Devastators), the first of which entered service in 1938, are three-seat monoplanes with an 850-horsepower Pratt & Whitney Engine. Their top speed is 225 miles per hour and their cruising range 1000 miles. They can carry either a torpedo or a ton of bombs

Newest torpedo-bombers are the Grumman TBF-1's (Avengers). which have a speed of 270 miles per hour, a cruising range of 1400 miles. and a ceiling of 20,000 feet. They dealt the Japanese Navy some very hard blows at Midway.

SCOUT-OBSERVATION planes are officially divided into two types: VSO and VOS. When ship-based, both types are fitted with landing floats. but these can be quickly replaced by wheel gear when desired. The VSO's are primarily scouts, operate from cruisers, and have folding wings to facilitate their stowage in hangars aboard ship. The VOS planes have rigid wings and are carried by battle ships, whose gunfire they observe or "spot," thereby increasing both the accuracy and range of the big guns All of our battleships carry three VOS (observation) planes, while most of our cruisers accommodate four to six VSO (scouting) planes.

Curtiss, Vought-Sikorsky, and the Naval Aircraft Factory are the builders of our VSO-VOS planes at present in service. In 1937-39 Curtiss delivered three scout-observation models SOC-1, -2 and -3. A fourth model. SOC-4, was delivered to the Coast Guard. Biplanes with a speed of about 165 miles per hour, they are now obsolete. Latest Curtiss scout-observa-

U. S. Navy Official Photo

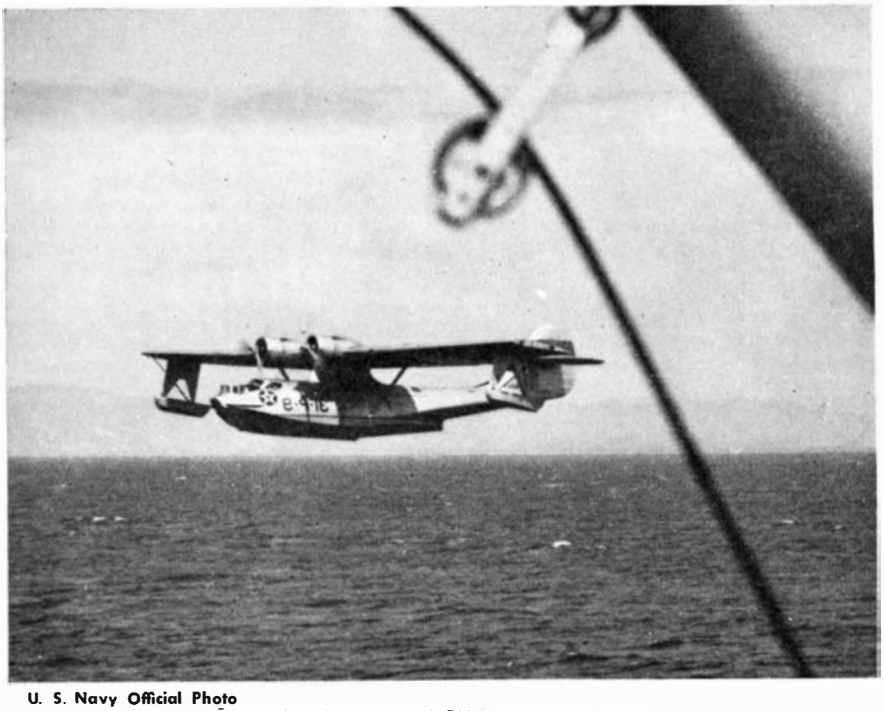
Vought-Sikorsky training ship (OS2U-1) about to take off

tion plane is the SO3C-1 (Seagull), a two-seat monoplane powered by a 520-horsepower Ranger inverted Vee air-cooled engine giving a top speed of 200 miles per hour.

Vought-Sikorsky recently delivered three VOS models: the OS2U-1 and OS2U-2 in 1941, and the OS2U-3 this year. These planes, known as Kingfishers, have a 450-horsepower Pratt & Whitney Wasp-Junior engine giving them a 200 miles per hour speed. They are the Navy's standard observation planes.

The Naval Aircraft Factory in 1940 completed a VSO model, the SON-1, and this year delivered its OS2N-1 observation plane. The former, a low speed biplane, is now obsolete. The latter, however, is practically a duplicate of the Vought-Sikorsky Kingfishers described above.

Patrol-bombing planes (VPB's) are the largest aircraft in the naval service. Known as the "Eyes of the Fleet," their primary mission is long-range reconnaissance from shore bases or aircraft tenders and the protection of convoys from submarine attack. Their secondary mission is to operate against enemy ships or shore establishments, in which case they carry bombs, torpedoes, or mines instead of maximum fuel load. Fitted with bunks and cooking facilities, they can operate for extended periods from small tenders or advanced bases. All of them are flying boats and some have reversible-pitch propellers for maneuvering afloat.



U. S. Navy Official Photo

Consolidated Catalina (PBY-2) patrols the coast

Most of our patrol-bombers have been built by the Consolidated Aircraft Corporation and the Glenn L. Martin Company. The former's PBY-1 Catalina monoplanes date from 1937. Weighing nearly 14 tons, they are powered by two Pratt & Whitney 1050-horsepower engines for a speed of 200 miles per hour. Their cuising range is about 4000 miles and their ceiling 25,000 feet. They can carry two torpedoes or two tons of bombs and require a crew of seven. Four improved series, the PBY-2 through PBY-5, were delivered during 1938-41. The last two models weigh 15 tons and have 1200-horsepower engines. This year a number of PBY-5A amphibians, designed to alight on land or in the water, were delivered.

In 1938 Consolidated completed its first four-engined plane, the XPB2Y-1. After exhaustive tests, this experimental type passed into production as the PB2Y-2. First delivered last year, these giant Coronado aircraft weigh 30 tons, are powered by four 1200-horsepower Pratt & Whitneys, and have a range of some 5000 miles. They carry six or more tons of bombs and a crew of nine.

The Martin company delivered its first patrol-bombers in 1941. These planes, the PBM-1's (Mariners), weigh 20 tons and have a pair of Wright Cyclone 1200-horsepower engines for a speed of 225 miles per hour. A crew of seven and two 21-inch torpedoes or several tons of bombs are carried.

This year Martin completed the huge Mars or XPB2M-1, a 70-ton patrol-bomber with four 2000-horsepower 18-cylinder Wright Duplex Cyclone engines. This great flying boat has a range of over 7000 miles, requires a crew of 11, and can carry four torpedoes or a very heavy bomb load. As a transport she can accommodate 150 fully equipped soldiers. Some observers regard the Mars, which is still very much in the experimental stage, as ideally fitted for the regular bombing of Japan.

These, then, are our Navy's combatant aircraft in service or in production. Upon them we must depend for some time to come. New and greatly improved models will doubtlessly appear in due course, but for the present such excellent aircraft as the Wildcat and Corsair fighters, the Helldiver and Buccaneer scout-bombers, the Devastator and Avenger torpedo-bombers, the Seagull and Kingfisher scout-observation planes, and the Catalina, Coronado, and Mariner patrol-bombers must form the backbone of our hard-hitting Naval Aviation.

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HIGH-OUTPUT ENGINE

Liquid-Cooled, For Use by Navy

In an announcement foretelling a revolutionary change in naval aircraft design, the Navy disclosed recently the development of a huge new liquid-cooled aviation engine approaching 2000 horsepower.

If the Navy's use of this extraordinary powerplant, developed by the Lycoming Division of The Aviation Corporation, follows the same general line of airplane construction adopted by the Army with liquid-cooled engines, then a new series of naval fighter craft, faster and more powerful than any now on first-line duty, is in the making.

Official silence cloaks both the performance figures and future uses of the new engine. The formal announcement that it had been completed and placed on contract described it only as "considerably larger than any other liquid-cooled aircraft engine now in production," with power sufficiently great "as to compare favorably with that of the largest type aircraft engine presently in use."

The largest known air-cooled aircraft engines now used by the Navy are the 2000-horsepower units on the giant flying boat *Mars*.

A Chemist Looks At Research

Development Cost Comparisons Reveal the General Value of Research for Many and Varied Industries

EUGENE AYRES
Staff Chemist of the Gulf Research and Development Company

IT IS a curious circumstance that research, which is the most scientific of all pursuits, should be one of the most difficult to evaluate in dollars and cents. Those of us who are enthusiastic about research are apt to refer to its value in most general terms. We say it is valuable because of this and because of that—all abstract qualities—much as we would define the value of honesty as a business asset.

Lord Kelvin is often quoted as saying that "when you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be." Perhaps Lord Kelvin would say that, despite the eminently scientific nature of research, its appraisal for business purposes is only dimly understood.

It is natural that no generalizations can be made concerning the monetary value of research carried out by an individual. There are notorious cases of extraordinary returns from very little in research, and other more familiar cases in which research has continued year after year without tangible return. But in organized industrial research, the element of chance is less important for several obvious reasons, among which are the number and variety of technical viewpoints and, particularly, the character of the research problems. In general, there are two kinds of research problems. On the one hand there are problems that are fruitful only if we are fortunate enough or clever enough to get a particular kind of answer, and, on the other hand, there are research problems which are fruitful without regard to the answer.

A paper presented before the Division of Industrial and Engineering Chemistry at a meeting of the American Chemical Society.

Suppose we have reason to believe that a certain organic compound might have useful properties as an antioxidant. We do a lot of work to find out how to prepare this organic compound and then we test it to see if it has the desired antioxidant quality. If the answer is "yes," we may balance the cost of research work on this problem against the value of the antioxidant, but if the answer is "no," we may have no economic justification for this research expense. Here the value of the research depends upon the kind of result obtained. But suppose we

The author

undertake to determine the optimum conditions for a process in order that we may know how to design a commercial plant. Here the result has the same value regardless of the conditions which are found to be optimum. A considerable proportion of industrial research is concerned with this second type of problem, and from the voluminous experience of research laboratories in many industries, certain numerical criteria are beginning to emerge.

It is probable that no two research laboratories would agree in detail on the average relationship between the different elements of cost of development, but they would probably not be very far apart. These cost relationships have been formulated by economic studies of many different sorts. For example, a company found it necessary to go into the manufacture of a new chemical in a hurry. There were no large-scale precedents for this operation but two good process ideas were offered by the Research Department. Because of the emergency, it was decided to commercialize one idea without any research, while the second idea was carried in orderly fashion through laboratory and pilot plant. Despite the delay occasioned by months of research, the second idea resulted in a smoothly operating plant before the first and at much lower development cost. The first idea was then sent back to the Research Laboratory and a year later superseded the second.

In another case, illustrating another way of going about it, a new process was commercialized from laboratory data without pilot plant research. A few years later a new plant of the same size was designed and built from data secured from the first plant.

FROM these and dozens of other cases, it is possible to come to some general numerical conclusions which, being averages, apply to no specific case with any accuracy, but which may apportion development costs in the correct order of magnitude for a majority of industries and companies. Here are three generalized cases:

	Units of Cost		
1. Laboratory Research	1	1	0
2. Patent Prosecution	1	1	0
3. Pilot Plant Research	5	0	0
4. Excess Design and Construction	5	15	20
5. Getting Process in Operation	25	50	65
Total Development Cost	37	67	85

"Getting Process in Operation" is the part of development cost that comes after the commercial plant is built. There are some companies which always figure this cost because it is the largest element of development expense and because it affords one of the best measures of technical management. But some other companies permit this cost to be absorbed in operating expense and do not worry about it. This cost may be figured in many different ways but perhaps most conveniently by subtracting the operating profit for the first year of operation from the operating profit for the second year of operation, making indicated adjustments for proper comparison and including, of course, such items as structural changes and losses of materials.

"Excess Design and Construction"

cannot be figured so easily, but can be estimated by competent engineers. *Total* design and construction cost cannot be regarded as development expense because thoroughly commercialized plants also must be designed and built. But, because of technical uncertainties, it always costs more to design and to build a new process than an old one, and the difference is development expense. The more we know about a process before we start to build, the smaller this difference and also the smaller the cost of getting the plant into operation.

Every authorization for plant construction covers not only investment but also a proportion for development expense; but this proportion cannot be ear-marked as such for the very good reason that it cannot be predicted in advance.

The first column expresses the relationship between cost elements which perhaps may be regarded as ideal and, therefore, as showing a minimum total for the average research project. Laboratory research and patent prosecution are indicated as of the same order of magnitude. Pilot plant expense is five times as high as laboratory expense. "Excess Design and Construction" is made equal to pilot plant expense because experience indicates that this is about as low as competent research can bring it and "Getting Process in Operation" is five times as great for the same reason.

THE most significant comparison is between the columns. Without any research, the total development cost is about 2.3 times the total cost with adequate research. Laboratory research without pilot plant work figures 1.8 times the ideal.

It is interesting to apply these ratios to special cases. For example, a chemical company, during a certain period, spent on the average about $3,000,000 per year for process development. During that period this company did no laboratory or pilot plant research on these processes. The $3,000,000 was made up of "Excess Design and Construction" and "Getting Process in Operation." According to the table, if this company had done $175,000 of pilot plant work per annum, it could have reduced the total development expense for these processes from $3,000,000 to $1,300,000 per annum. This would have meant a saving of $1,700,000, or nearly 1000 percent profit from research investment.

This conclusion may well be absurd. The table can be very wrong in specific cases but, on the other hand, it can be wrong in either direction. The conclusion noted may very well be correct.

Regardless of accuracy of application, the generalized figures point toward some interesting conclusions:

(1) Patent prosecution and laboratory research are almost negligible portions of total development expense.

(2) Total research, including adequate pilot plant work under the most favorable conditions, figures around one-fifth of total development expense.

(3) The minimum development expense is associated with adequate research expenditures.

(4) Research is about the most profitable investment that can be made.

The question is sometimes raised: Can we avoid development expense by the installation of processes developed by others? The answer to this question is clear. We can avoid the small parts of development expense, but we usually cannot avoid the large ones. Many cases can be pointed out in which a company has had lower development expense on processes purchased from others, but there are many other cases in which the development expense has been actually greater. Unless a process has already been thoroughly commercialized, whether a purchased process costs more or less than an independently developed process depends primarily upon the quality of the pilot plant work. Certain purchased processes have cost a chemical company far more for development than if they had passed through the company's own laboratory and pilot plant because the preliminary work that had been done by others failed to provide sufficient data for economical design and construction. In general, the only cases in which we can avoid the major part of the normal development expense of new processes are those in which processes have been operated for a sufficient time to iron out all the kinks. But in such cases processes are likely to become obsolete about the time we get them into operation.

TECHNICAL obsolescence must be regarded as of the utmost importance in the present argument. If we pay a million dollars as paid-up royalties for a certain process, this may not seem to be a serious expense if we can assume that this process will not become obsolete. But this is frequently not the case. By the time we get this process in operation, it will be somewhat obsolete, and by the time we install its successor and get it into operation this also is likely to be obsolete. Paid-up royalties cannot be regarded as nonrecurring expenses because technical obsolescence sees to it that such expenses recur with dismal regularity.

It appears that process research should be justified (1) by its saving of many times its cost by the reduction of the other greater development costs, and (2) by its effect upon the vital element of timing. Either one of these reasons is sufficient in itself and it is unnecessary to include the reason that research may enable us to charge royalties or to be immune from paying royalties. This last factor has to do not with the justification of research, but rather with the justification of patent prosecution. There is no reason to compare the cost of research with the cost of royalties. The comparison should be made between the cost of patent prosecution and the amount of royalties received plus the amount of royalties which otherwise we would have to pay.

ROYALTIES are normally set as high as the traffic will bear. The only reason royalties in general in the chemical industries are moderate is because competitive research has prevented any company from securing a monopoly on any important process. This makes the royalties themselves competitive and the company with the strongest patent position will either receive royalties or, if it does not wish to follow the necessary procedure for securing licensees, it will at least pay the minimum royalties. The royalties never seem very large when they are figured on a unit of material, but our competitive disadvantage is measured not by the amount of royalties, but by double this amount, for while we are paying the royalties, the other company is receiving them.

The royalties paid by companies who do little research are small compared with the cost of research that would have been required to provide immunity or to balance royalties paid with royalties received, but large compared with the cost of prosecution of patents to accomplish this result. Failure to protect inventions with patents means not the saving of patent prosecution expense, but the loss of many times this amount of money.

Companies differ widely in their patent policies. One company may not be concerned with the licensing of inventions to others for royalties, whereas another company may do this sort of thing on a large scale. The less aggressive company can defend itself only with patents, and its patent position must be made stronger than that of its more aggressive competitor. This

is merely another way of saying that its technical position must be stronger than that of its competitor; for patents are, after all, merely inexpensive handles with which to wield the technical weapons effectively.

Under some circumstances, product patents can be even more important than process patents. It happens that most product patents in the chemical industries now refer to relatively small volume products, but there are some important exceptions. Here again research is justified, not by immunity, but by getting products on the market before instead of after our competitors. If we grant that research expense can be justified in this way, it is proper to balance against royalties only the expense of patent prosecution.

Product patents are of more value to the company with the less aggressive patent policy than to the company with the more aggressive patent policy because it takes more good patents to defend than to attack. Furthermore, there are more offensive patent alliances than there are defensive ones.

The evaluation of research in accordance with the foregoing principles requires a certain measure of optimism, but this is, after all, the same sort of optimism that inspires a company owner to believe that his company can survive as a business enterprise. For only through successful research is ultimate survival possible.

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New Glass For Precision Optics

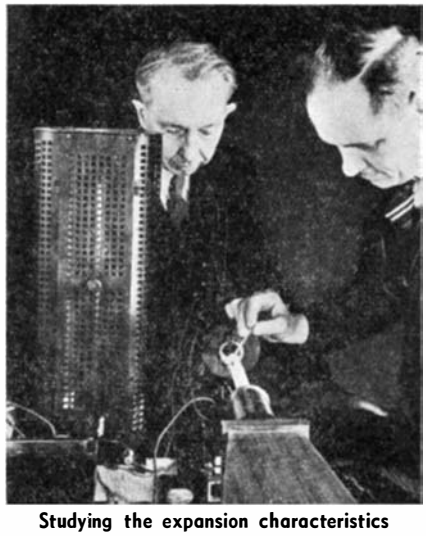
Compacted Glass, Made by a Secret Process, Makes Possible New Accuracy in Lens Manufacture

THROUGH the development of a new, scientifically controlled process of heat-treating optical glass, mass production of precision lenses—the "glass eyes" of microscopes, projectors, and other optical instruments—is now possible, according to Dr. E. D. Tillyer, research director of the American Optical Company.

The new technique, Dr. Tillyer declares, is significant because it eliminates production delays and many of the rejections which were previously encountered in manufacturing complex prisms and precision lens systems for which there is an urgent military demand. The process, he states, produces compacted glass — glass at maximum density and with maximum light-bending power—that is perfectly homogeneous throughout its entire structure. This optical uniformity simplifies the mass grinding and polishing of precision optics and prisms because their optical performance can now be made so accurate that reannealing or hand correcting is unnecessary. The process also stabilizes the glass so that future changes in its performance do not take place as the years roll by.

This stabilized glass, Dr. Tillyer reports, is definitely superior to that made previously, as shown by a precision laboratory test which determines the exact performance of an optical system. The new heat-treating technique is now being used by the optical concern's scientific instrument division, Spencer Lens Company, in the production of military optical instruments.

In explaining the process, Dr. Tillyer points out that glass can perform queer tricks. For example, a cut-glass goblet suddenly cracks for no apparent reason. Difficulties are encountered in matching the several glasses used in making bifocal lenses for near and distant seeing. The optical lens systems of precision scientific instruments may lose their accuracy after years of storage because a change of light-bending power (refractive index) takes place.

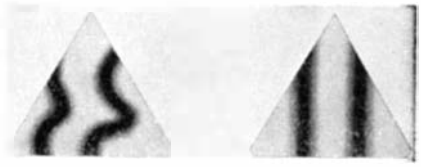


Studying the expansion characteristics of the new compacted glass by means of comparison with a standard alloy

To determine the reason for these imperfections, it was assumed that something was lacking in the glass-annealing picture. The commonly accepted practice was to bring glass to a certain temperature range, keep it constant for a specified time and then let it cool slowly. This procedure actually did eliminate mechanical strain—a condition that could be revealed by polarized light.

But in addition to removing strain, it was believed that the atomic structure of the glass should also be perfectly packed and perfectly settled during annealing so that the maximum light-bending power would be achieved. Tests showed that there were times when glass was not perfectly packed even when the strain had been eliminated. The production of a glass that was perfectly packed throughout its entirety seemed the answer to the problem.

Accordingly, Dr. Tillyer photographed the behavior of various specially treated sample glasses under heat in comparison with a standard metallic alloy of known thermal expansion. After a study of the film, a graph was plotted that not only showed the range commonly used in ordinary strain annealing, but another point which looked as if it might bear investigation. (The details of this new time-temperature cycle for annealing optical glass are a military secret and cannot be revealed.)



Typically poor glass result, often obtained with old forms of annealing, at left, compared with new glass at right. Lines indicate that refractive index is not constant throughout glass at left

To investigate the new critical point in actual practice, tiny glass specimens were placed in three electrically-heated "thimble" furnaces, so insulated that the temperature could be controlled closely.

Measurements showed that glass maintained at the temperature indicated by the new theory and selected from the graphs reached a maximum index of refraction (light-bending power) higher than that usually reached in the older accepted manner of annealing. The glass seemed to be perfectly packed — completely homogeneous. For comparison, these thoroughly compacted glass specimens

were held at temperatures above the new annealing range. These samples lost some of their compactness, and their refractive index was lowered.

Bolstered by this mass of pertinent information, the new annealing process went into actual production. Results were the same. The glass was perfectly homogeneous, as revealed by a prism interferometer test. This means, according to Dr. Tillyer, that the day of "hit or miss" annealing is over—that a regular time and temperature schedule can be set up and followed with the result always as anticipated.

Precision lens systems can accordingly be manufactured without glass production delay and with the certainty that the glass will remain homogeneous permanently.

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WORKERS—The number of research workers in the petroleum industry is now about 6000, of which about 45 percent are highly trained scientific men. There are 563 research workers for every 10,000 wage earners in the refining branch of the business, or almost twice the ratio in the chemical industry.

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RESEARCH CONTINUES

Machine-Gun Manufacturer

Invades Other Fields

WHEN, in 1941, J. Russell Maguire, President of the Auto-Ordnance Corporation, manufacturers of the Thompson Submachine Gun (the "Tommy Gun"), realized that there was a definite need for research in other and somewhat allied fields, he did something about it. This realization was the beginning of a systematic effort to assemble a staff of highly competent engineers, chemists, and physicists for the express purpose of conducting research along well defined lines that bear closely on many phases of our war activities.

Less than a year later the rapidly growing research staff was housed in permanent quarters in Connecticut where they are provided with every essential for the research and development work which they are doing in fields directly connected with the total war effort. Some of the endeavors include: improvement of the present submachine gun as well as the development of new types of guns; work on an asphalt process for speedy laying of airport runways and roads under severe conditions; perfection of methods of de-bulking dehydrated foods for economical shipment to distant points; research in the broad field of electronics.

That the manufacturing activities of the Corporation have been eminently successful is evidenced by the Army and Navy "E" Award recently received, of which Mr. Maguire and his staff are justly proud.

MAGNESIUM RECLAIMED

By New Welding Method

Using Helium

MUCH strategic magnesium metal, already fabricated but with small defects, now can be quickly and easily restored to usefulness, thanks to a new fusion method of welding which was brought about by the close wartime co-operation of two major American industries. This new method of fusion welding, which takes advantage of the peculiar properties of helium, an inert, non-explosive, non-flammable gas, is the result of joint development by The Dow Chemical Company and Northrop Aircraft, Inc. Of particular interest at this time of rush war production is the fact that vital aircraft sand castings, some of which were formerly discarded because they did not meet standard specifications, now can often be reclaimed by this advanced method.

As magnesium, lightest of all structural metals, is an essential material for the construction of airplanes and other military equipment, the new helium arc method for welding magnesium alloys has an important bearing on our war production progress, according to Dow spokesmen. Its advantages over other methods of joining are the elimination of rivets, ease of operation, and greater speed of production over a wider range of design. These results are possible because the electric arc applied to the parent metal is shielded by a blanket of inert helium gas which prevents oxidation of the molten weld metal. Oxygen cannot penetrate the helium "envelope."

SKIN HEATER

Solves Sheet Metal

Wrinkle Problem

HEAT therapy has moved out of the hospitals and into the aircraft industry through a recent development at The Glenn L. Martin Company. A major difficulty in the riveting of aluminum "skins" over spars and ribs to make wings has always been the unavoidable wrinkling and buckling of the skins under the pounding of riveting hammers. The wrinkling and buckling, even though slight, interfere with the smooth flow of air over and under the wing.

In the system of "heat therapy," devised by Harry F. Kniesche, Assistant Factory Manager at the Martin plant, the various sheets of aluminum that make up a skin are riveted together on a wood frame that has the shape of the wing. The skin, full now of unavoidable small buckles and wrinkles, is then laid on the wing of the ship. The skin heater, which might be described as an oversized version of the electric heating pad which people apply to a sore back, is laid on top of the skin. The heater fits snugly, for it has the exact contour of the wing.

The heat is turned on. In a few minutes the skin has a temperature of 140 degrees, which causes enough expansion to rid it of all wrinkles and buckles. While rheostats hold the temperature constant, the skin is quickly stitch-riveted round the edges and along the ribs. Then the heater is removed and the skin shrinks as taut and unwrinkled as a drum-head.

In ridding skins of wrinkles and buckles the "skin heater" has cleared up a troublesome problem of wing construction. At the same time, because it allows a whole skin to go on in one riveting operation, it has helped speed production.

SELFCONTRACTOR

Company Takes Over When

Subcontractor Fails

BY acting as "subcontractor to itself," the new Westinghouse Merchant Marine Division has slashed nearly a year from the tooling time required for quantity production of 30-ton gears to drive new war cargo ships. This situation was brought about by the fact that an over-burdened machine tool builder, although able to design the massive gear-cutting machines, lacked the plant capacity and manpower to finish and assemble them within 12 months of the time Westinghouse needed them. The machine tool builder was asked to send the large parts of the machines to Westinghouse, where they were assembled. As a result, production of ship gears was started nearly a year ahead of the time this would have been possible had not the company undertaken to become subcontractor to themselves.

Some of the "bull" gears that will be made on these machines — gears that are coupled directly to a ship's propeller shaft to drive the vessel — are more than 12 feet in diameter. Yet each of their 693 teeth must be

machined to an accuracy of three ten-thousandths of an inch. This means that the "hobbers" — the machines which rough and finish-cut, or "hob" the gear teeth — must be built to tolerances that are even finer. If even minute errors were allowed in the cutting of these teeth, they would make so much noise under the pressure of thousands of horsepower from

Air conditioned for accuracy

the ship's turbines that sound detecting devices on enemy submarines could locate the ship in the dark and from great distances. This gear-cutting is so precise that each gear hobber is enclosed in a special air-conditioned room in which temperature and humidity are rigidly controlled.

WORN-OUT TOOLS

Can be Salvaged and Put Back Into Service

With the huge production of war equipment causing a heavy drain on supplies of metals, automotive companies are greatly accelerating their salvage and conservation activities. For example, the shortage of cutting tools, which is far more serious than most people realize, has led to development of reclaiming methods that in peacetime would be prohibitive in cost.

An ordinary tap, of the type which you once could pick up at the five-and-ten-cent store, now takes two months to replace. It takes six months to get milling cutters today, and to get such a part as a taper reamer for one standard type machine tool requires three-quarters of a year.

Thus, the salvaging of tools now on hand becomes a definitely sound practice, for monetary savings are relatively unimportant, when values are measured in terms of life-and-death as they are in wartime.

A new method of restoring a worn-out forming tool, as a specific example, costs more than it would to replace with a new tool, but through use of such methods, thousands of pounds of cobalt steel are being saved. The worn-out tool which, in normal times, would be ready for discard, is first annealed and forged to restore size and shape. It is then machined, heated, and quenched to produce a new tool to which grinding, the final step, restores polished surfaces.

Along with the reclaiming processes, all plants are urging workers to use great care in handling precious tools. Broken tools are conspicuously displayed with dramatic explanations of the cost of such waste in terms of time and effort.

Time and labor are, of course, the chief values to be considered now, but waste can still be measured in monetary values. In such terms it costs $40 for tools to produce one airplane propeller. And for every airplane engine, which requires from 15 to 20 cutters alone, the tooling cost ranges between $800 and $1200.—*Automotive War Production.*

PIPE LINE

Pipe Protected from Corrosion by Asbestos Wrapping

The new 24-inch war emergency pipe line, now being constructed from Longview, Texas, to Salem, Illinois, is the largest-diameter line carrying crude oil ever built and will establish records, both for size and speed of construction.

Since steel must be conserved by every means possible, this underground line is protected from corrosion by a layer of a special asbestos felt, the wrapping being done speedily and with precision by a machine which first applies a waterproofing coating as the pipe revolves.

ARC WELDING

Looks to a Bright Future

That war industries have only just begun to gain the benefits of modern arc welding is shown by a recently completed industrial study of this method. This study also definitely indicated that further applications of the welding process will eventually slash millions of dollars off the United Nations war bill and will cut by 30 percent the time required to produce ships and planes.

Furthermore, it now appears that arc welding will provide the means for turning out vitally needed naval and military equipment which is more combat-proof than at present; at the same time welding should be able to save an average of three hundred pounds out of every ton of steel now going into war production.

The industrial study of welding, previously mentioned and on which the above statements are based, has been carried on by the James F. Lincoln Arc Welding Foundation. From that organization also comes the prediction that the arc welding process has virtually an unlimited field for further applications. Many industries which have adopted welding in war production will doubtless continue its use after the war, thus broadening the applications of the process in civilian production, according to the Foundation.

AIR CONDITIONING

Reverts to its Original Conception

The action of the War Production Board in asking department stores, theaters, hotels, and office buildings with air-conditioning equipment above 100 horsepower to "volunteer" such equipment for "active duty" in war production factories should serve to eliminate from the public mind the misconception of air conditioning merely as a "comfort" industry, according to Dr. Willis H. Carrier. "It is seldom recognized that air conditioning had its inception in industry as a production tool. Nor is it common knowledge that the greatly expanded production facilities of Carrier Corporation, and others in the field of air conditioning and refrigeration, are today devoted 100 percent to production for war industries," Dr. Carrier says.

"Not only is low temperature refrigeration equipment essential to the production of certain types of synthetic rubber, as pointed out by Donald Nelson in his request that stores and others 'volunteer' their equipment, but air-conditioning equipment serves a myriad of other war production requirements.

"Air conditioning, for example, makes possible a high degree of accuracy where work to close tolerances is called for. Thus, it helps insure the amazing accuracy of bombsights and firing devices. In addition, air condi-

tioning serves in the production of powder, in the loading of shells, in the production and processing of photographic film, in the manufacture of lenses and fine optical instruments and in countless other ways," Dr. Carrier points out.

AMMONIA

How This Common Chemical Aids Many Industries

AMMONIA, common to the household for cleaning woodwork, tiles, and windows; to the first-aid kit as a stimulant; and to the ice factory as a refrigerant, is an indispensable war material.

There are at least 2000 industrial uses for this chemical. Ammonia, for instance, is an ingredient basic to the manufacture of explosives for bombs, torpedoes, shells, and cartridges.

It hardens metals for vital parts of airplanes, tanks, and guns. It helps vulcanize important rubber articles. It is used in making nylon. It enters into the manufacture of fertilizers. It is employed in one process for the manufacture of "Lucite" methyl methacrylate plastic for the noses, gun turrets, navigation "blisters," and other transparent sections of fighting airplanes.

Synthesized by Du Pont and others from the elements of air and water with the aid of coal, ammonia simply is one part nitrogen—nitrogen is four-fifths of the air we breathe—chemically combined with three parts of hydrogen, a constituent of the water we drink.

Ammonia plus oxygen produces nitric acid. All military or commercial explosives require nitric acid. Furthermore, nitric acid enters into the manufacture of cellulose nitrate plastics, which have many military applications.

Gaseous ammonia flowing across heated steel under proper conditions imparts a hard, wear-resistant surface over the soft core without changing the dimensions of the metal. This process, called "nitriding," is necessary to many metal parts for airplanes, tanks, guns, and ships.

Ammonia helps in refining petroleum products. Crude petroleum contains acids harmful to stills, and these acids are neutralized by the addition of small amounts of ammonia.

The effectiveness of chlorine for destroying bacteria in drinking water is materially increased by the presence of ammonia. This combination reduces the objectionable odor and taste associated with chlorine and has a more prolonged sterilizing action than chlorine alone.

In fertilizers, ammonia is used for the ammoniation of super-phosphate and for the manufacture of urea and of sodium nitrate—synthetic Chile saltpeter.

Synthetic urea, made from ammonia and carbon dioxide, is basic to the manufacture of ammonium sulfamate, the new industrial chemical used for flame-proofing workmen's clothes, uniforms, and other textiles. Urea-formaldehyde plastics have numerous military applications.

Ammonium carbonate, a compound of ammonia, is one of the materials used to form the "bubbles" in sponge rubber. Mixed with the rubber, this chemical decomposes under heat and forms a gas which "blows the bubbles."

Ammonia is used in the manufacture of vat dyes, and in wool scouring to remove fats, waxes, and dirt. Long and varied is the list of achievements of this relatively inconspicuous chemical.

FOUNDRY WORK

Is Important Factor in Nation's War Production

THE art of making moulds and pouring molten metal into them is ages old, so the spotlight is often taken from it by new and spectacular machines when figures for increased efficiency in mass production methods are given out. But during the last decade or two, very few industries have increased their over-all efficiency to such a degree as has the foundry industry.

Mechanization has greatly speeded up almost every foundry operation. Conveyor lines do many laborious jobs of moving moulds and materials. Machines condition and deliver sand to the foundry's moulding stations.

Not the least among the contributions to the efficiency of the foundry is the improvement made in moulding machines, according to The Osborn Manufacturing Company, one of the pioneers in their development.

When Osborn built its first moulding machine in 1909, the automobile industry was in its infancy and was soon to demand mass production methods that challenged the ingenuity of engineers. Everything in the foundry was done by hand. Completion of three of four molds for engine blocks was a day's work for a moulder and his helper. The moulders shoveled their sand, tamped the sand around the patterns, rolled over the moulds, drew out the patterns—all by hand. This was a tedious process. The percentage of scrap was high and castings made under these conditions lacked uniformity.

The moulding machine was revolutionary. Today, on an automotive production line, a pair of these machines can turn out one engine block mould a minute. A tremendous load has been taken off the moulder's back. Using compressed air, and in some cases,

One of the newest moulding machines

electricity, as a source of power, the modern moulding machine rams the sand around the pattern, removes the pattern from the sand and handles the flask—all mechanically. The making of moulds by machinery conserves the human element, and the precision and accuracy of the machine is transmitted to the mould itself. The result is that castings made from such moulds are true to pattern and uniform in weight.

One of the more difficult jobs demanded of Osborn machines was the moulding of cast aluminum cylinder heads for airplanes. These cylinder heads are cast with the cooling fins as integral parts. The present demand for greater power calls for larger cooling surfaces. This means more and deeper fins. Present aeronautical design requires that the heads be moulded with the fins spaced five to the inch, and that many of them be 3½ to 4 inches deep. Those familiar with foundry practice will immediately recognize the difficulties in producing moulds so delicate, at the high working speed required.

The process of drawing the pattern from the sand without distorting the thin walls of sand between the fins called for a moulding machine built to an accuracy of a thousandth of an inch.

This demand was met, and now large numbers of a specially designed,

precision-built moulding machine are being supplied with working parts hardened and ground. These machines are capable of operating with less than one thousandth of an inch variation in the pattern draw stroke.

In addition to the cylinder heads. the modern moulding machines are playing an important role in making possible the mass production of many other precision parts, parts which meet the rigid inspection requirements necessary to qualify for a place in the finest airplanes built in the world today.

RESISTANCE WELDING

Machine Controlled by the Weld Itself

AN ENTIRELY new approach to resistance welding is made in the "Temp-A-Trol" forge welder, which makes possible combined automatic spot welding and heat-treating of alloy steels and heavy sections and permits the employment of relatively unskilled labor for spot-welding operations.

In general appearance, the new welder, shown in one of our illustrations, does not differ radically from conventional spot-welding machines. In operation, however, it employs a completely new method of control, the weld itself automatically controlling the functioning of the machine.

Up to now, resistance welding equipment has been operated mainly through the use of pre-selective controls regulating the amount of current and the duration of that current. The actual settings were determined by trial and error to give the best compromise for the "average" weld in a given material of a given section.

Actually, when operated in this manner, few welds are identical as to quality, because of variations in resistance due to varying metal thickness, varying induction losses as the material enters the throat of the welder, varying amounts of short-circuiting losses through previously completed welds in the same piece, variations in resistance due to the presence or absence of scale, and so on, and the gradual increase in electrode area due to normally unavoidable mushrooming.

It is for these reasons that many types of resistance welding operations have up to now required close supervision or handling by highly skilled personnel, especially when welding heavy sections and alloy steels.

The flexibility in operation of the "Temp-A-Trol" welder, in contrast, is demonstrated by the fact that—without changing the machine controls—welds of exactly equal quality can be produced consecutively in ¼ to ¼ inch, in 3/16 to ¼ inch, in ¼ to ⅜ inch, or in three sections of ¼ inch material at the same time.

In addition to this, the "Temp-A-Trol" welder can be used to automatically heat-treat the weld in the same operation. This post-heat refines the grain size of the weld, increasing its ductility, gives the proper grain structure, and "tempers" the weld nugget and adjacent area to any desired amount consistent with the characteristics of individual alloys. It eliminates the accepted "necessary evil" of coarse and brittle grain structures when welding alloy steels and heavy sections of other metals.

The weld controls the machine

To set the controls of the "Temp-A-Trol" welder it is necessary only to determine the temperatures which will produce the best weld and heat-treat characteristics in any given material. This is a relatively simple matter. The controls of the machine are then set to values corresponding to these temperatures. After the controls are once set, the machine will automatically compensate itself and reproduce identical quality welds under wide ranges of variation as to metal thickness, cleanliness of metal, and other welding conditions.

The basic element of the control which makes this possible is the incorporation in one of the welding electrodes of a highly sensitive thermo-couple. This thermo-couple automatically shuts off the current when the correct temperature is reached, turns it on again when the weld has been cooled to the proper degree, turns it off when the correct heat-treat temperature has been reached, and so on.

Thus, instead of having a definite weld-time and welding-current with variable weld-quality, the new welder reproduces a definite weld-quality with automatically self-adjusting current and time cycles.

CUTTING OIL

Speeds Production, Lengthens Tool Life

MACHINES making parts for airplanes, tanks, ships, and guns are showing increased production and longer tool life with the use of a new industrial cutting oil recently perfected. In one recent demonstration, the new oil, known as "Cut-Aid," was used on a machine that was throwing up a plume of smoke while operating at 100 surface feet a minute. After the new cutting oil was added to the cutting lubricant already in use, there was not a trace of smoke at 300 feet a minute. At the same time, production was increased, tool life extended, and a better finish obtained on the work.

In another operation, in a prominent metal working plant in the East. tool life was extended from three hours between regrinds to 11 hours in forming aluminum on a Brown and Sharpe automatic, reducing ¾" round stock to ¼". Finish improvement was declared to change from "fair" to "excellent."

"The new oil has proved ideal for machining aluminum—one of the most difficult metals to machine and one of the most important in the production of airplanes," says an official of the Gulf Oil Corporation, where the cutting oil was developed.

"With this oil, aluminum parts now can be machined so smoothly that in many cases they don't need to be polished, thus eliminating a full step in production. In shops where it has been used, machine tools cutting aluminum are setting new production records.

"The oil is also excellent for cutting magnesium and non-ferrous alloys and in many cases has set new standards of performance for this type of work including finer finish, and cleaner. sharper, and more accurately machined threads."

The new oil was developed by Gulf scientists following eight years of study and experiment on animal oils such as the oils of whales, hogs, and fish. These oils were chemically broken down and their best properties synthetically reproduced, then blended with mineral oil to produce a cutting oil with the industrially desirable qualities just described.

INDUSTRIAL TRENDS

ON THE THRESHOLD OF ELECTRONICS

WHEN this war is over—and almost all consideration of industrial trends in practically every field of endeavor must be placed on that horizon—the science of electronics is going to work at least a small revolution in many industrial operations. In order to gain now an appreciation of the possibilities of electronics in the future it is desirable to review some of the accomplishments of the past; on these accomplishments will largely be based the successes of the developments of day after tomorrow.

A broad definition will serve as a starting point for this combined review and peek into the future. The science of electronics may be considered to include all controlled applications of the electron—basic part of every atom—to the uses of man. Thus the field ranges from X-rays and ultra-violet light to the radio vacuum tube, to power controlling devices, to power converters, to star counters, to the electron microscope, to innumerable other uses in almost equally innumerable other fields.

The earliest familiar development in the then unnamed science of electronics was the X-ray, a laboratory curiosity that soon invaded the field of medicine and then branched out into many industrial ramifications. The medical uses of the X-ray do not immediately concern us here, but its invasion of industry certainly does. Thus, the X-ray has been put to inspection jobs in a myriad of factories, revealing hidden flaws, defective welds, foreign substances in packaged foods and other materials, and doing other similar jobs that, without the X-ray, would be left undone or would require destruction of the material. This latter phase is of particular importance now. Testing to destruction, a method often employed to determine structural defects, is wasteful of time and material. Substitution of the X-ray's penetrating eye for the inspection-by-destruction process speeds up operations, conserves materials, and results in greater knowledge of what has actually taken place within a given structure during fabrication.

In other ray fields there are ultra-violet and infra-red, both as invisible to the human eye as the X-ray, yet each as valuable to industry in its own way. On these rays are based lighting systems such as that using the fluorescent tube; drying methods that speed up painting, food manufacture, blueprinting, and so on; chemical processing procedures that cannot be carried out under visible light; sterilizing systems that kill up to 99 percent of the germs in the air; and so on almost to the limits of human imagination.

Just as the X-ray gave man new eyes with which to see through things, so has the electron microscope given him still another pair of eyes with which he can view the infinitely small. Already—the electron microscope is a practical development of only the last few years—many industries have gleaned much new knowledge of their products, knowledge that could immediately be applied to betterment of the products, of the processes employed, or both.

Then there are applications of the photo-electric cell to countless control jobs and of the ubiquitous vacuum tube to rectification and amplification processes, of electronic means for reducing the amount of smoke and dust in the atmosphere. These and many others are incubating in the laboratories of the world or are being reduced to practice, frequently under the hush-hush of military secrecy. It is largely this latter factor that prevents saying very much about the present-day status of electronics. Practically every development in this science, new or old, has military significance that must be kept under cover for the duration. It is no secret, however, that the push of military necessity is contributing hugely to the sum total of knowledge about electronics. When the veil is lifted, a whole new story will have to be written about the applications of this science. And it will be a thrilling story, a story that will have its effects on every civilized person.

PETROLEUM, A BASIC INDUSTRY

MOTOR and other fuels constitute, numerically, only a small part of the products that have been made available from petroleum by the continuing process of research applied on a grand scale. As a result, the petroleum industry is asuming an increasingly greater importance in today's industrial picture, with promise of even more wonders to come. Where only gasoline and kerosene grew from crude oil but a generation ago, there now sprouts such a widely diversified group of hydro-carbon derivatives as anti-freeze and alcohol, high-octane fuel and butadiene, toluene and glycerine, ammonia and styrene.

The foregoing short resume of petroleum products gives the key to future trends. Much of the development work that has made possible these products from the basic petroleum has been war-encouraged, and is going far toward assuring victory for the United Nations through the supplying of vital materials of war. This development, of course, is not going to stop with the end of the war; it is going to establish the petroleum industry as a supplier of raw materials to a host of other industries which will supply civilian needs in a manner never before possible.

War materials hold the center of the stage at the present moment. Of these, none is more dramatic than toluene, basic necessity for high explosives. Originally obtained from coal tar, toluene is now synthesized from petroleum at a rate undreamed of only a few years ago. Proof: During World War I, toluene sold for some three dollars a gallon. Today it is quoted at about 28 cents a gallon. In the same war field is ammonia, from which is made nitric acid, also needed for explosives manufacture. Ammonia is now being produced synthetically from petroleum. And there is glycerine, still another explosives constituent, which came formerly only from soap manufacture; now it also is being obtained from petroleum.

Alcohols in great variety, important in many industries as solvents and extractants, are now petroleum derivatives. So great has been the progress of this development that, it is said, some of these alcohols are being produced at such a low cost that alcohols from fermentation cannot compete with them.

Space permits touching only lightly on the products which the petroleum industry can extract from its raw material, products that, in turn, will become the bases of whole new industries in the future. Largely as a supplier of fuels obtained from crude, the petroleum industry has built up a vast integrated business that has proved its efficiency in the past. With such a background, coupled with the results of research and war-pressure, the industry as a whole should be able to keep up its rate of progress in the days of rebuilding after the war.

—The Editors

Star Populations

Have Our Existing Means of Observation Given Us True Samples of Spatial Objects?

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In studying objects of any sort, two things are necessary: first, to be able to find the characteristics of the accessible individuals; and, second, to find out whether these individuals form a fair sample of the whole population to be investigated.

The astronomer who applies this statement to the stars may be accused of using two words, at least, in the famous Pickwickian sense—"accessible" and "population." His justification for the first is clear. Distant as the stars are, his telescopes and spectroscopes and photometers really enable him to investigate their properties. As for the second, statisticians are accustomed to speak of a population of any sort of things, animate or inanimate, which form a definite large aggregate from which samples may be selected and studied—one may have a population of stars, or even of telephone calls.

In order that the sample which is studied in detail may be fairly representative of the population as a whole, two requirements must be met. It must be large enough to be statistically significant—and free from systematic selection. In a small sample, say of a dozen, the relative numbers of objects of different kinds will depend largely on chance, and important, though unusual, types will probably not be represented; but when the number rises into the hundreds, or thousands, it is probable that the percentages of different types found in successive samples of the same size would be nearly the same.

Even though this was found by experience to be true, the samples might not be fairly representative of the whole population. The individuals to be counted have to be picked out of the great multitude in some fashion; and it is remarkably difficult to devise a method of choice which does not favor some types at the expense of others.

In statistical studies of stars, modern astronomers are usually able to get fairly large samples to work with. Spectra — the most important single characteristic—have been observed for hundreds of thousands of stars, and we have at least approximate measures of brightness for over a million.

The apparent proper motions in the heavens are known for more than 50,000 stars, and the motions of approach or recession for many thousands. The number of stars whose distances have been measured runs also into thousands, and tens of thousands more are observable spectroscopically with existing instruments.

We can measure the colors, and get a good idea of the temperatures of as many stars.

In some ways we are more limited. We can find the masses of stars only if they are doubles in orbital motion, and their distances have been measured. Even so, about 600 systems are available. Densities can be found only for eclipsing binaries, but we already have data for some 200 of them, with many more awaiting observation.

We do not know nearly as much as we wish we did about the causes of real variability in brightness; but this is not for lack of material, for thousands of variable stars are known, and hundreds of them have already been observed in a fairly detailed manner. There are certain classes of variables —for example, the novae—for which we must wait upon time to send us more to observe; but scores of these are known, and eight or ten, at least, have been observed very fully.

The white dwarfs, a few years ago, formed an exception, an obviously important class with only three or four members; but persistent search has increased the number known to more than 20.

A search for unique objects would be most encouraging among the stars with peculiar spectra. But, even here, it is noteworthy that—so far as the writer can recall—there is hardly a single object which really stands alone. It looked as if this had happened at last, when the first spectrum of a super-nova was observed and found to be different from anything known previously; but the next super-nova had almost the same spectrum.

We can see so far into space, and there are so many stars there, that there appears to be a very good chance that anything that is seen once will be seen again within a few decades or less. There is nothing new under the sun—or in the heavens far beyond it.

There is really good reason to believe, therefore, that we have already observed examples of nearly all the kinds of stars or other luminous bodies that exist in space—though the recent discovery of super-novae reminds us that "there are as good fish in the sea as ever were caught."

We must never forget, however, that this knowledge, wide as it is, is subject to severe limitations. The greatest and most unescapable of these is the obvious one that we can observe only what we can see (treating photography fairly enough as another kind of vision). Anything which is the object of astronomical study must either give out light on its own account, because it is hot, like the Sun and the stars; or shine by reflected light, like the planets and some diffuse nebulae; or give out light of its own when stimulated by the light of a near-by star, like comets or gaseous nebulae; or, finally, obstruct or absorb light, whether in general, like the dark nebulae, or in particular wavelengths like the gases in interstellar space, or in the atmospheres of the planets. There is one exception: a dark body may reveal its presence by the effects of its gravitation, producing orbital motion in a luminous companion. The faint companion of Sirius, first discovered in this way, was later seen telescopically; but there is reason to believe that some other such stars may be substantially dark. But even this exception would be unknown to us if the companion star did not shine.

This limitation excludes from our study all cold bodies outside our own planetary system. We can predict from general physical principles what they should be like. Large masses (more than 100,000 times the Earth's) must be intensely hot inside, gaseous throughout, and self-luminous—in fact, stars—unless they have reached the degenerate state of enormous density, which the white dwarfs approach. Masses 10,000 times the Earth's should settle down into a partly degenerate condition, in which they would be cold

and dark; those less than 1000 times the Earth's should, like the planets, have cores of ordinary solid matter—the larger ones with very extensive atmospheres like Jupiter, the smaller, with little or none, like the Moon; and from this there should be a continuous gradation through bodies like asteroids and meteorites down to fine dust, and at last to individual molecules and atoms. At the bottom of the scale, the particles are so enormously numerous in many regions of space that they produce observable absorption effects; but there is a vast intermediate range of size within which they are hopelessly unobservable.

From the rotation of the galaxy it follows that the total gravitating mass in it is not many times greater than that of the luminous stars. A considerable part of the excess is doubtless accounted for by the dust and gas; but there may still be a large amount in the form of dark bodies. On a census of individuals, these may be very much more numerous than the lucid stars—or perhaps not. We have only this to go on. When we try to count the stars in a given volume of space—preferably in the region close to us—we find that the great majority are fainter, and less massive, than the Sun. The numbers increase as we go to still fainter and smaller bodies—indicating that there are a great many more beyond the limits of our study.

THERE is some evidence that the rate of increase slows up, and perhaps almost stops, for the faintest stars which we can observe. We can reasonably extrapolate and say that there must be enormous numbers of bodies of one tenth the Sun's mass; but beyond the limit at which bodies would settle down into a solid, rather than a partially degenerate state, we cannot safely estimate.

We have as yet no idea at all why or how so much of the matter in the galaxy ever came to segregate into huge lumps like the stars. It is in fact hard to see how this could happen, if we start with the conventional assumption that the matter was "originally" distributed with rough uniformity through galactic space. On this basis, the stuff that ultimately formed a star would at first have been distributed through a volume at least a light-year in diameter. Unless the relative motions within this scattered assemblage were exceedingly small, the mass, when it shrank to the dimensions of a star, would be rotating far faster than the average star—indeed, it would have too much rotational momentum even to form a wide binary pair.

Yet, if the galaxy as a whole was rotating, as it does now, about a central condensation containing a considerable part of its whole mass, the attraction of this condensation would pull apart a configuration as exceedingly tenuous as that just described, and prevent it from condensing at all.

We do not know, of course, whether, when the stars were formed, the galaxy —or the matter which grew into it— was of its present size. The theory of the expanding universe points the other way. But, in our complete ignorance of what actually happened, we have no basis at all for even guessing how many smaller masses were formed in the same process.

THIS we do know: our methods of observation give an exorbitant, and almost incredible, preference to the stars of great mass and luminosity. Our capacity for observing a star depends not on how bright it *is* but on how bright it *looks,* and hence very largely upon its *distance.* The stars visible to the naked eye, for example, run down to about the limit of spectroscopic observation in full detail with high dispersion. To be thus visible, a star of the Sun's real brightness must lie within a distance of approximately 50 light-years—and we find a considerable number of these. But a star of 1/100 of the Sun's luminosity will be visible without a telescope only if it lies within five light-years. There are dozens of stars of about this brightness within 50 light-years, but a five year radius occupies only a thousandth part of the volume of the larger sphere, and it is not surprising that we do not find one within it. Inside this small sphere, we know of only three stars — the bright double Alpha Centauri, and its very faint distant companion often known as Proxima Centauri. This tiny star is but 1/25,000 as bright as the Sun.

If, on the other hand, we seek stars a hundred times brighter, in reality, than the Sun, we can see with the naked eye all that are nearer than 500 light-years. Our vision ranges over a thousand times greater volume of space than for stars like the Sun. If they were distributed in space as thickly as stars of the Sun's brightness, our list of stars visible without a telescope should contain a thousand times more of the brighter sort than of the fainter. This is remote from the facts; something like half the stars in question belong to the brighter group—or those still brighter, and one or two percent to the fainter group. In our list of "bright stars" those of high luminosity are therefore preponderant in the proportion of (roughly) 30 to 1. But, when we apply the obvious correction necessary to pass to the numbers of stars in the same volume of space, we find that the fainter stars are in an even larger majority.

The brightest super-giant stars, such as Rigel and Alpha Cygni, exceed the Sun 10,000 times or more in brightness. Such a star would be visible to the naked eye at a distance of 5000 light-years. Among the 22 apparently brightest stars there are the two super-giants just named, and only two which are comparable in real brightness with the Sun—Alpha Centauri and Procyon. This is a small number to argue from; but if space were uniformly filled with stars it would indicate that the super-giants were about a million times less frequent, in a given region of space, than stars like the Sun. This is an exaggeration for two reasons: first, a distance of 500 light-years extends on both side of the galactic plane, into vast regions where the stars are thinly scattered; second, at these great distances we must reckon with the absorption of light by the thin dust-haze which fills the galaxy and makes remote stars look fainter than they otherwise would.

MAKING a liberal allowance for these, it nevertheless follows that the necessary limitation imposed upon us by the selection of stars bright enough to observe gives the super-giants an advantage of at least 10,000-fold against stars as bright as the Sun, and of many a billion times against the faintest dwarfs.

We must therefore be cautious about the interpretation of direct counts of the stars. For example, almost all the stars which present marked peculiarities in their spectra are found (when we can investigate the matter) to be of high luminosity. The assumption that peculiar spectra in some way not yet understood were naturally associated with a great real brightness is tempting. But if one in a thousand of the highly luminous stars is peculiar, we shall stand a good chance of finding not one, but a good many such stars among the million stars which appear brightest in the sky, and are visible in a small telescope.

The stars of one percent of the Sun's real brightness will constitute but a very small fraction of these stars (since we can see them only when they are near us) and an equally unusual peculiarity may stand a very good chance of being missed altogether for lack of an adequately large sample to study.—*Princeton University Observatory, October 1, 1942.*

The Folsom Mystery

Its Solution is Largely Contingent on the Solution of Another Mystery

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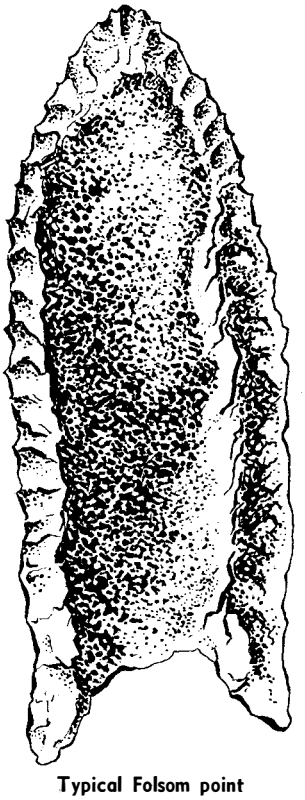
No mystery in American archeology has been more fascinating than that of the Folsom culture. In the 15 years that have elapsed since the original site was excavated at Folsom, New Mexico, archeologists have diligently pursued every clue that might shed a ray of light on the shadowy "first" Americans. Their subsequently discovered sites, scattered over a wide area in the High Plains region of the United States, reveal little about them except that they were hunters of animals long since vanished: extinct American camels, bison larger than the historic variety, strange South American sloths, and even the huge American elephants, the mammoths. Their characteristic hunting tool, a grooved, exquisitely fashioned "point," superior in workmanship to any other variety of point known from the New World, speaks eloquently of their artistry and skill. But, so far, there is little else except these peculiarly shaped, beautifully made "Folsom" points to speak for the intrepid hunters who made them. Tantalizingly, his unmistakable weapon, but not Folsom Man himself, appears in site after site associated with the now-extinct animals which he hunted.

Although geology has brought corroborative evidence to bear on the antiquity of Folsom Man, it is paleontology, the study of fossil animals, that has so far offered the most revealing clues. There is no longer any doubt that the association of the Folsom point with the bones of extinct animals is real and not accidental. The first discovery, in 1927 at Folsom, New Mexico, of peculiarly shaped implements of human manufacture associated with the bones of a species of bison supposedly extinct since the closing period of the Ice Age, has since been duplicated in other regions by scientists whose investigations were conducted under conditions imposing the strictest control. But the question of the exact age of the Folsom culture is still a controversial subject *revolving largely around the question of when these large Ice Age animals actually disappeared.*

Most of the geologists and students of fossil animal life who have attempted to aid in dating the remains take the view that the last of these animals perished in the closing period of the last glacial retreat some 15,000 to 25,000 years ago. Some, however,



Typical Folsom point

express the belief that many of these archaic beasts lingered down into a period perhaps as late as 5000 B.C.

The animal most commonly hunted by Folsom Man, and hence most commonly used for dating purposes, seems to have been a species of buffalo slightly larger than the existing species and somewhat more powerfully horned. It is commonly termed *Bison taylori* by scientists, in contrast to the term *Bison bison* applied to the living form. Beyond size distinctions the animal's skeleton is not markedly distinct from the living bison which, as a matter of fact, may be its direct descendant. At all events, *Bison bison,* the living form, seems clearly to succeed the older Ice Age bison, probably at the termination of the last glacial withdrawal. The larger form was doubtless adapted to enduring greater extremes of cold, and may have failed to hold its range as the post-glacial climate began to swing toward a warmth maximum to which the animal was ill adapted. Instead, a new and smaller bison, perhaps developed from the bigger species in more southern areas, flows in over its receding range. Whatever the cause, *Bison taylori* vanishes from the High Plains and the historic (living) buffalo succeeds him.

Whether the larger animal followed the ice back northward and lingered there beyond its survival in the United States is a problem which has received little consideration. No data have been available, and both paleontologists and archeologists have concentrated their attention upon the problems of the more immediate area. Hidden away in old books, however, discussed by naturalists interested only in existing animals, a curious broken thread of clues winds backward into the days of the first voyageurs who explored the Great Northwest. If these clues are comprehended in relation to the archeological picture which we have just discussed, they take on a strange and almost startling significance.

As the first explorers and hunters drifted into the region around Great Slave Lake and wandered through the valley of the McKenzie River, they found bison to be present in large numbers, even in this far northern area. As acquaintance with these animals was extended, hunters began to comment that these northern buffalo were larger and differed somewhat in habits and appearance from their southern relatives of the Great Plains. Though difficult of access and hence viewed by few scholars, these distinctions were eventually accepted as valid and the big northern bison came to be regarded as a more rugged variety of the southern animal.

Eventually, in 1897, a naturalist named Samuel Rhoads undertook to describe the type and establish its scientific validity by giving it a varietal name. As a consequence, the animal has since been known as *Bison bison athabascae.* Unfortunately, most of the measurements which exist are hunters' measurements upon the body and are of little value in making comparisons with the skulls of extinct

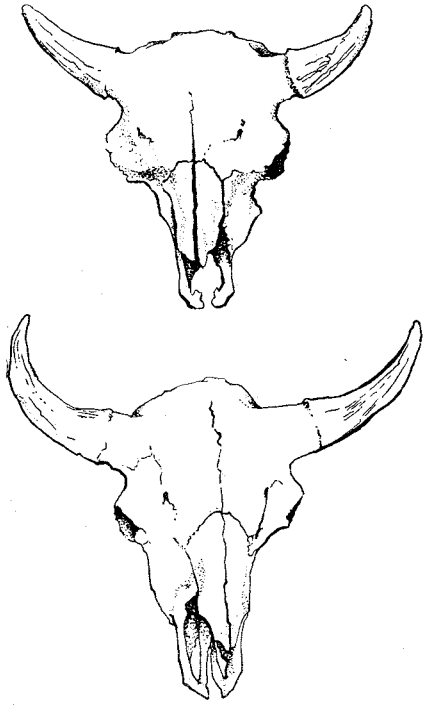
animals found in the form of fossils.

Rhoads published a few figures, however, and the writer has had access to a few others. These figures tend to bear out a very interesting point which even Rhoads saw fit to hint at in a tentative way: namely, that these big northern bison in certain measurements fell within the size range generally regarded in the United States as representing only the fossil forms of the closing Ice Age. Though, as one might expect, there are contradictions and discrepancies in the various accounts, the earlier literature, in particular, is emphatic upon the subject of large size and greater length of horn. The measurements across the forehead from the base of one horn tore to the other are much greater than in the southern bison and as large as in the fossil forms found associated with man.

At this point a question must inevitably occur to the reader. These northern bison, whether or not we attempt to relate them to the fossil bison found associated with early man in the Plains region, are a cold-loving form. Where were they when the ice sheets lay across Canada? Obviously it would seem that their range must have been pushed much farther south. How, then, can we ignore the fact that this big animal may also have been hunted by early man in the High Plains region, or even the suspicion—call it no more than that—that *Bison bison athabascae,* at least in a reduced and mixed fashion, bears some intimate relationship to the big Middlewestern bison of the closing Ice Age? Even if, like some scholars, we merely regard the present northern bison as a climatic phase of the ordinary Plains bison, the question might still arise whether the fossil bison species known as *taylori* could not then be viewed as a similar and even more vigorous reaction to glacial conditions.

Since the surviving northern bison now inhabit a Woods bison preserve in Northern Alberta, it would seem at first glance a very easy matter to settle some of these problematic relationships by a more extended study devoted to detailed comparisons of the skeleton of this bison with that of the fossil forms hunted by the Folsom people. Here again, however, the problem is much more complicated than it appears.

The number of Woods bison declined greatly during the 19th Century and at one time was estimated to be as low as 50 head. In 1893 the Canadian government passed the first laws attempting to protect them. A slight upswing in numbers took place. Then, in 1925, the Canadian government carried out a policy which the American Society of Mammalogists vigorously but fruitlessly protested. Large shipments of Plains bison were introduced into Woods Buffalo Park and a large-scale intermingling of the two types took place. Clearly it is now impossible to be sure of the strain represented by an individual bison. The number of unmixed animals must now constitute a very minute, if existing, fraction of the herd.



Skulls of *Bison bison* and *Bison taylori,* showing comparative sizes of skulls. Drawings by the author, from specimens in Nebraska State Museum

In drawing attention to the tantalizing similarities between descriptions of the fossil species and that of *athabascae,* the existing northern form, it must be remembered that no really thorough comparison is possible in the present state of our knowledge. Nevertheless, the implications of similar body size make it impossible to ignore the fact that the northern bison, at least as it existed in early historic time, may have actually represented a type somewhat more archaic than the Plains bison. If, as seems likely, the fossil bison pursued by the post-glacial hunters of the Middlewestern United States was a form adapted to colder winters, it may have lingered for a time in the Canadian areas, perhaps being slowly bred out as a pure type. If the animal survived in this form, it is unlikely, in spite of its temporary isolation during the 19th Century, and its preference for a forest habitat, that it escaped contact with its southern relative during the days of the great herds.

Evidence is not lacking that a gradual increase in horn size and ruggedness extended from the south to the north in geographic sequence. Such a sequence may suggest that the transition from the fossil to the living form was progressive in both area and time. Only the onset of post-glacial warmth would seem to suggest an adequate causative factor.

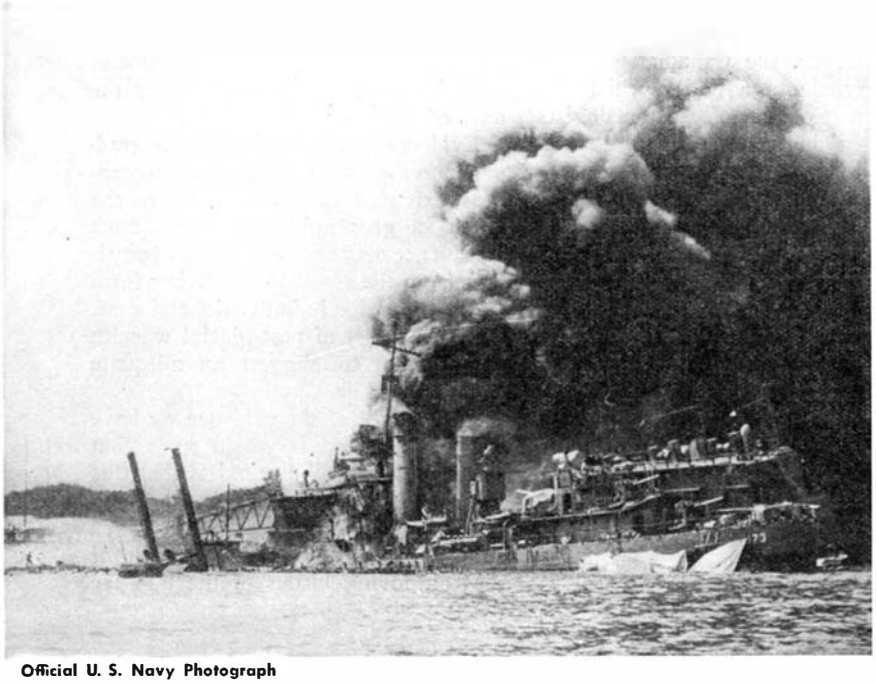
In the light of the evidence we have here summarized it would seem that a reasonable possibility exists that this inadequately known phase of the living bison represents, at least in a mixed and dying way, the blood strain of the cold-loving bisons of the late Ice Age.

Whether or not this interpretation is correct, the southward extension of the range of this species during the last ice advance cannot be ignored as a possible confusing element in the study of bison remains from archeological sites where complete skulls are missing. In the size of leg bones the living *Bison bison athabascae* could not be distinguished from the fossil form. Inadequate study of both animals, as well as a dearth of fossil evidence from the Canadian areas, has shrouded in mystery both the disappearance of the fossil species and the appearance of its successor, the existing Plains bison.

Where the big northern woodland bison belongs in this succession of forms can be revealed only by much more thorough research than has as yet been attempted. In so far as evidence exists, however, it is not adverse to the view that these bison may represent an archaic form existing only as a marginal remnant, now fast disappearing.

Nevertheless, even if we could prove that the northern bison bore a very close relationship to the fossil type, we could not, on that basis alone, argue that man's occupation of the Great Plains was extremely recent. Only the last great ice withdrawal seems adequately to explain the change in the type of bison in the western United States.

Undoubtedly the relationship between the big woodland bison and the fossil species hunted by Folsom Man demands clarification. When this is successfully accomplished, we may be much farther along the road toward dating those mysterious forerunners of the American Indian in the Great Plains.



Official U. S. Navy Photograph

The destroyer *Shaw*, in Pearl Harbor on December 7, 1941, shortly after Japanese aerial bombs made direct hits. A false bow got her back to a West Coast yard

Broken Ships Made New

Fast Work by Civilian Engineers is Getting Allied Warships Back Into Service in Record Time

DAVID O. WOODBURY

It is no secret that American warships are taking a battering by the enemy and that some of them are limping home from the battlegrounds of the seven seas, ripped and broken and urgently in need of repair. Half ships, backs of ships, fragments of ships sometimes—destroyers with their bows blown off, submarines torn asunder as if a giant can opener had done the job; corvettes with whole broadsides open to the waves, cruisers with masts down and decks tangled with steel.

In the early part of the war it was German psychological strategy to claim a ship sunk as soon as it was hit. For a while after Pearl Harbor the Jap used the same ruse. But neither enemy does so now. Too many Allied ships have been knocked to pieces only to reappear again better than new, actually stronger in armament and up to the minute in every essential detail. The Axis has learned to fear the vessels it has crippled but not destroyed. The enforced rest period for repair gives our navies a chance to catch up on the latest wrinkles of battle-tested equipment and to send their ships back to sea more formidable than ever.

The secret of this work of renovation — most of it accomplished in American navy yards—is the lightning speed our technicians have developed in making repairs, speed and ingenuity born strictly of the emergency. Feats of reconstruction are being done today which even a year ago would have been called impossible. Before Pearl Harbor a sunken hulk like the bombed destroyed *Shaw* would have been left to rust at the bottom of the bay. But after the Japanese betrayal a new spirit of "can-do" hoisted the *Shaw* out of her grave, fastened a false bow on her, and sent her 2000 miles to a West Coast navy yard for permanent repairs. Now she is back in the fighting line, a deadlier ship than when she was first built. The whole job took three months. A similar rebirth awaits the cruiser *Marblehead,* whose blasted hulk was sailed half way around the world from the Battle of Java to an American port. In ordinary times such an effort would have been absurd; today it is part of the routine of the new warfare.

The credit for performing these miracles of rejuvenation goes to a group of young engineers in our navy yards who have developed methods of their own, not out of books or conventional practice, but out of their own heads. These surgeons in steel are not of the Navy at all, but are men who have joined the show since the war began. A few months ago they were landlubbers with little knowledge of ships and a merciful ignorance of official red tape. The steadily increasing number of damaged ships limping home appealed to their imagination and they asked to be taken into the Naval Reserve so that they might exercise their special talents while the regular Navy men went to sea. Gladly their request was granted; the Navy was not dismayed by the fact that they had no formal training in marine construction. It simply told them to go ahead and do the best they could. Today they are the world's foremost experts in sending broken ships back to sea.

Officially this gang of young bloods is known by the prosaic title of Navy Yard Hull Superintendents. But in fact they are gamblers who play the last ounce of mechanical ingenuity against time. Operating on their own responsibility in what amounts to an administrational vacuum, they turn out seven-week jobs in three weeks, five-day repairs in a single night, and seemingly achieve the impossible with every problem they undertake. They are little known outside the yard gates and they receive no medals. But they are patriots none the less. Voluntarily they have sacrificed good civilian salaries, given up their private lives, thrown away their holidays and spare time, all because they have discovered a vital way to help win the war. They are young, angry America stepping up front to fight.

How they work is typified by the example of a young lieutenant who may be called McCantry, on repair duty in an Atlantic Coast yard. Not long ago a battered warship was on her way in from sea, her "availability" for overhaul only eight days. This ship had been on action station for months—some 40,000 miles of sea duty without a break. Officers and crew were weary from weeks of confinement in her battleshaken interior. To get

back to work their vessel must be renovated from stem to stern—in eight days. They were angry particularly because they knew that this could not be done.

Commander Gurney, the Boss Hull Superintendent of the yard, was the first to hear of her coming by radio. He took a quick look at the work board in his office and summoned McCantry. "Do what you can, young fellow," he ordered. "Put her in Dock Four and turn the yard loose on her. I'll inform your wife you won't be home."

Mac grinned; this was a challenge such as he loved to meet. Pulling the telephone to him he began rounding up his forces. All over the yard shop bosses and estimators threw on their coats and converged on a Navy tug at the pier. Within ten minutes McCantry and his men were on their way down the harbor to meet their ship. Their timing was perfect. Within half an hour they had scrambled aboard the tired warship and were on their way back to the yard. During the trip they had just 30 minutes to complete their inspection and lay their plans.

Skilfully Mac surveyed the damaged ship. There was certainly plenty to do. Hull plates sprung on the port side, super-structure cluttered with wreckage from a direct bomb hit, mast out of line, small boats smashed, gear of all kinds gone adrift. In the wardroom, however, he made no comment, only asked for details. The Executive Officer threw a list on the table. It was ludicrous in its length. New A-A guns, new cranes for the boats, new magazines and fire control; hull plates removed and straightened, mast reset. Acid lockers and fuel tanks cleaned and relined, radio equipment replaced, crew's quarters remodeled, windlasses, anchor gear and steering equipment overhauled. Ventilating system, boat cradles — everything — pulled down and refitted. From fighting tops to keel plates the ravages of uninterrupted battle service had to be erased. And at the bottom of the list was this: Complete overhaul and repair of potato-peeling machine.

THE Executive Officer grinned wryly. "Here you are, Lieutenant. Do whatever you can in a week."

Most of those jobs were major operations—a month's work at least, by pre-war standards. But McCantry had learned to work differently. Snatching a pad and pencil he began to break down the list and pass the sheets to his various yard bosses amid a cross-fire of discussion and orders. There was no time for formal blueprints or routine procedure. Every foreman must carry his part of the work in his head or scratched on the back of an old envelope. After this one conference there would be no further powwows. If difficulties arose they would have to be solved empirically, on the spot.

Omcial U. S. Navy Photograph

The *Shaw*, with temporary bow in place, has returned to the United States for final repairs and the installation of a new bow. She is now deadlier than ever

When the Navy Yard was reached Mac's plan of campaign was complete.

In the hour and a half required to drydock the ship the young hull superintendent rounded up his supplies and set the various shops in motion. The dock was not yet dry when a thousand men, drawn from every department, began swarming aboard with their tools. Power lines were going up, portable machines were swinging aboard from overhead cranes; stagings were being lowered over the ship's sides. While the sailors scurried ashore to be out of the way, workmen were penetrating into every compartment, each charged with a specific job.

Already familiar with the ship's layout from stem to stern, McCantry established a route of inspection and began circulating methodically, showing each riveter and welder, carpenter and linoleum layer how to work without interfering with his neighbor; keeping up the tempo with a cheery word or a bit of advice or praise. The important thing in an emergency like this was to set the pace and maintain it. It was a battle against time: The men all knew their jobs; all they needed was the example of a boss ready to sacrifice himself to the limit to accomplish the work. So, through the first day and night and the second day Mac remained aboard continuously, without sleep, carrying a sandwich in his hand and a bottle of pop in his pocket. By the second night things were proceeding so well that he kept on until the unrelieved stretch had lengthened to 66 hours. Only then was he so sure of success that he could throw himself down on his office desk to snatch a few hours of badly needed sleep.

IT was McCantry's hunger for punishment and his calm assumption that every man under him could take it as well as he could himself that put this job through. At the end of six days and nights, with all hands working 16-hour shifts, the ship was completely repaired and renovated. Every item in the list was checked off and done, even to the overhauling of the potato-peeling machine. On the seventh day the vessel was ready for sea, better than new.

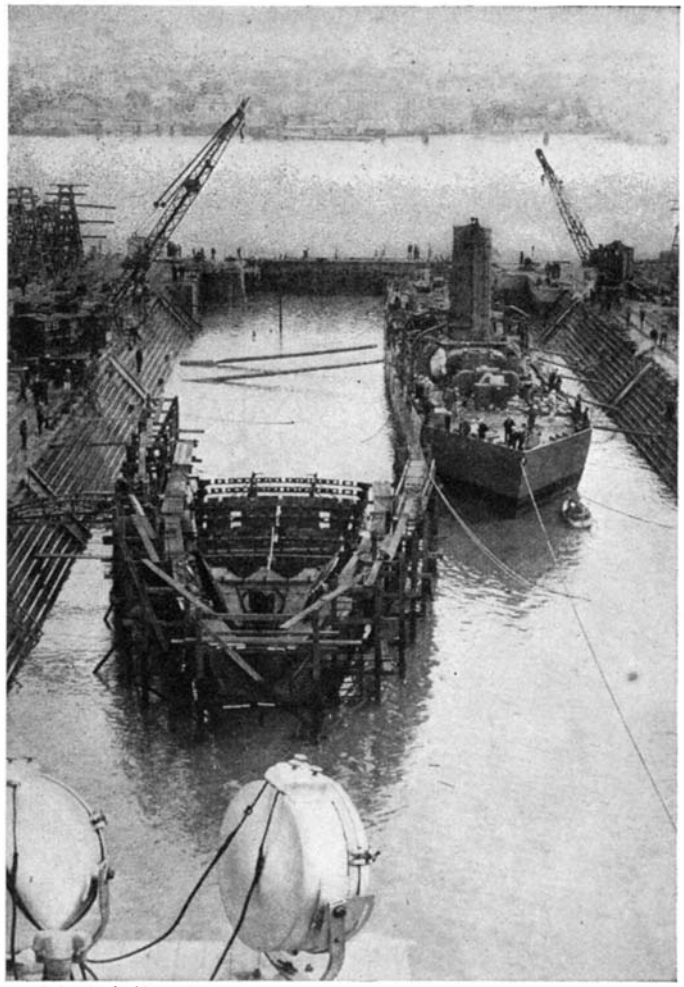
The secret of wartime repair lies in the democratic system of free enterprise and individual responsibility. Each new job is pushed through to success in record time because it is a complete campaign in itself, under the guidance of a man who is in an individual race against the enemy. When the need for high-speed repair first hit the yards no one knew how to meet it. The hull superintendents were kindergarteners then and the Navy did not expect very much of them. But it had no choice but to turn these reserve technicians loose and let them try. What these Commandos of the shipyards did with the opportunity has set a new American standard for high-pressure work which has been copied in every shipbuilding yard in the country.

McCantry and his companions cut their eye teeth on the Allied warships that limped into our yards in 1940 and '41. These foreign casualties were especially tough, for they had been through the combined infernos of Crete and the Western Approaches, surviving attacks by torpedo, naval gun, and aerial bomb. Some of them were almost total wrecks—floating junkyards that even their owners despaired of saving. Moreover, they were built in a different style from our own. Thousands of small fittings—valves, bolts, pipes, and machines—were of slightly different design and could not be replaced out of American stock. Many a repair part had to be made up specially for the job, often by hand in a machine shop or foundry. From the start this kind of work taught the young technicians to improvise, taking whatever they had on hand and making it fit. When standard steel plates were not wide enough, they patched smaller ones together by welding. When American electric lamps didn't fit foreign sockets, they ripped out whole wiring systems and put them in new.

Every visiting ship carried a full set of plans by which repairs were supposed to be possible — in their home yards. But many of the specifications couldn't be met in America. So the hull superintendents sometimes had to ignore the plans altogether, inventing new layouts and construction details as they went along. Thus they made a virtue of necessity and soon had developed the habit of solving their problems out of their heads, leaving standard practice behind. They knew the results required; how these were achieved mattered little so long as the job was done quickly and with success. It was an engineer's paradise. With the huge resources of the yards at their backs they could build new ships out of old ones with no other limit than their own ingenuity and endurance. The old complaint that "it can't be done" had become for them a challenge and later a guarantee of success.

Our allies, desperate for ships, were incredulous. When a great dreadnought came in for repairs the British feared that the job would take a year. Her wounds, though not publicized, were extremely serious. At the end of 70 days she sailed again, a new battleship with many improvements suggested by the loss of the *Graf Spee*. The British were delighted. As many as possible of her naval casualties are now sailed to American yards for repair.

The heavier the steel of a warship's hull, the tougher the problem of cleaning her up after bombs and torpedoes have torn her apart. A typical case of heavy repair confronted a sandy-haired young ensign named Mullins, who had graduated from engineering school less than two years before joining the Reserve. He had to get this ship into drydock without permitting her ragged bottom plates to smash up the dock flooring on the way in. Coolly he had her crew make the ship fast to a pier in deep water. Jumping into a diving suit he went down with a couple of professional divers with underwater cutting torches. The three of them spent all day and part of the night cutting loose jagged pieces of steel, constantly in danger of having their life lines cut by the knife-sharp edges all around them. Mullins had never been down before; without practice he shouldn't have gone. But he wanted to save time by applying his knowledge of cutting methods directly to the job in hand. As a result the ship was drydocked a full half day ahead of schedule and repairs beat every previous record set by the yard. Mullins's example in that first risky operation had put every workman on his mettle.



Official U. S. Navy Photograph

The *Shaw*, in drydock on the West Coast, with her new forward section shown in the foreground ready for installation

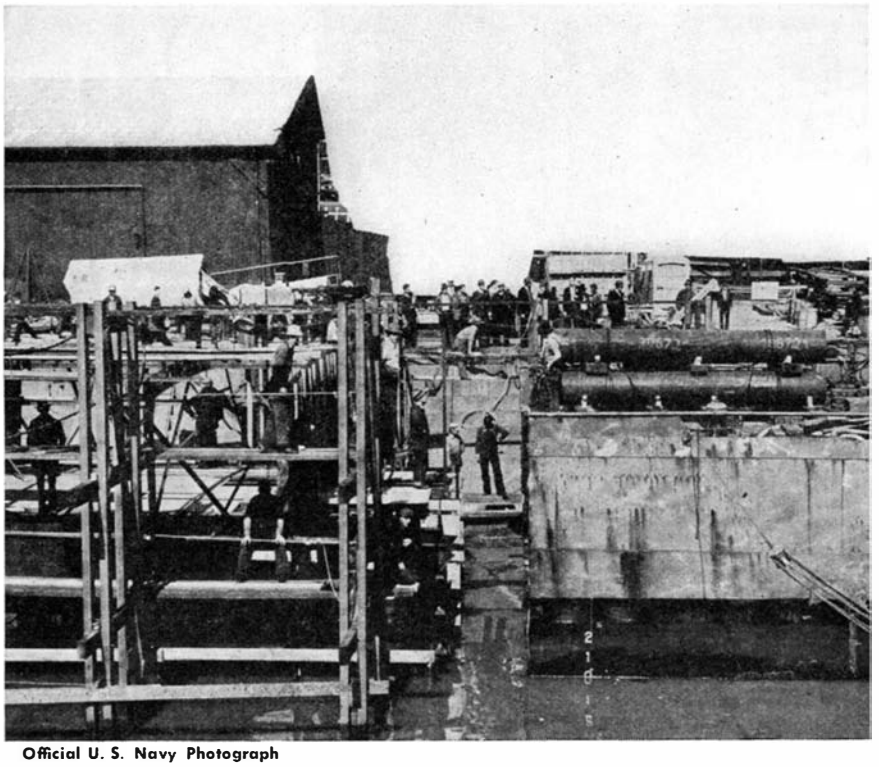
These young hull superintendents wear the uniforms of Reserve officers of minor rank—indistinguishable from thousands of others who do our naval fighting and patrol. But their authority is out of all proportion to their stations; it is unique. To be in charge of a whole warship under repair is to be the boss of every civilian on the job and to have priority to get things done immediately in all the shops. It means that the young engineer must know every compartment on the ship, understand the purpose of every beam and plate and every machine, and know how to find any kind of trouble and set it right. In addition, he must handle his men skilfully and get along with every yard boss into the bargain.

He is working on his own, with millions of dollars worth of ship at his mercy. Actually he is tied solidly into the navy yard organization in a position that is simply streamlined to fit the emergency. In each of the yards he and his colleagues report to a Chief Hull Superintendent—a naval old-timer who parcels out the work and keeps a seasoned eye on his little group of virtuosos. The Chief in his turn is responsible to the yard's Construction Officer, who is directly answerable to the Commandant. None of these three head men tolerates red tape. In this repair job there is something of the spirit of the research laboratory, where independence and initiative are 90 percent of the stock in trade. Only one requirement is held over the men: they must get their work done right, in record time. How they do it is their own affair. They must work out their own contacts with departments of

supply and manufacture and transportation. Nobody interferes with them unless by their failures they prove themselves unequal to the job.

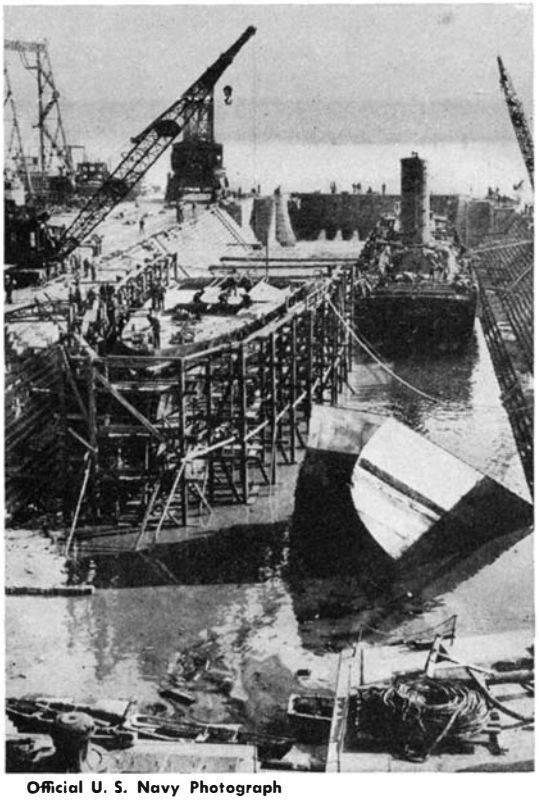
In peacetime such tremendous responsibility on young shoulders would be impossible. But results have proved repeatedly that lifelong experience is not necessary. Ingenuity and plain common sense get the hull superintendents out of every jam. When they come to the yard they do not enter any long course of training, but are given a repair job and told to go ahead. If they make mistakes they must rectify them as best they can. The Navy knows that these fellows have been used to independence. Their great contribution will be innate judgment and the energy of youth. The Navy has learned that when a man has no time to make mistakes he won't make them.

The hull superintendents are drawn from all over the land—from industry, business, laboratories, sometimes from college graduating classes. Admiral Yarnell, of China fame, is credited with the idea of digging them out and giving them a try. When the repair problem threatened to become serious he persuaded the Navy Department that industry was full of young engineers who would make top-notch fixers of damaged ships. He made a tour of the technical colleges and large corporations and interviewed hundreds of men from 25 to 30 who had shown outstanding ability along engineering lines. He told them there was a big job to do in the yards; that, although he could offer them little money and no fame, they would have an unbeatable opportunity to serve their country by doing the work they knew how to do best. If they would come he would see to it that red tape was cut and that the sky was made the limit for results. They took him at his word and joined the Reserve in droves.



Official U. S. Navy Photograph

A close-up of the operation of joining the *Shaw* to her new bow. The ship, at right, is being floated into position for attaching the bow which is seen at the left



Official U. S. Navy Photograph

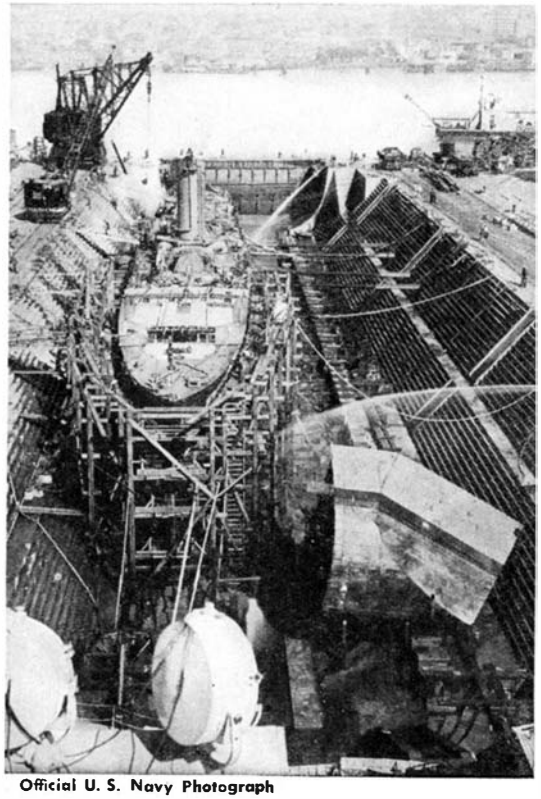
The *Shaw's* temporary bow has been removed; ship (in background) will be floated to new bow

McCantry, for example, was a welding specialist for a large manufacturing outfit. Mullins worked for a farm machinery concern. Young Johnson had been a naval architect with the Maritime Commission. Teale had a small consulting firm of his own. These men and many more like them had been uneasy in their civilian jobs for some time. They wanted to get into the game but saw no way of making their special talents useful. Then came Yarnell's offer and inside of a month they were repairing ships.

Men like Martin and Baker, cement plant engineers, had been responsible for many short-cuts and improvements in their own line. Both thought they had something to give the Navy and both joined up. Martin had once been a football man and Baker was a tennis star; both knew the value of quick independent decisions and at the same time understood team play. In their Nebraska home town they were told they were crazy to go to sea, but neither listened. They went to West Coast yards and began.

BAKER specialized in destroyer repairs and eventually sailed with a gang of mechanics to Pearl Harbor just in time for the Jap onslaught. When the *Shaw* made her place in the news by rising from her grave and making the run back to the States under her own steam, the Japanese were puzzled, for they had seen the ship's magazine explode, ripping 50 feet of bow clean out of her. The mystery was easily explained. Ensign Baker had asked permission to try an improvised salvaging operation. Getting it, he had hauled the wreck into drydock, cut away several hundred tons of mashed plates and beams and then calmly welded a mud-scow bow over the *Shaw's* wide-open end. It was not a new trick but the time record for such a job had never been approached before. And time was now more valuable than gold.

There are other men like Baker,



Official U. S. Navy Photograph

Once more a whole vessel, the *Shaw* is a monument to the spirit that will eventually emerge victorious

working at Pearl Harbor on jobs that can't be described. Regular Navy and Reserve are on duty there together, and the hull superintendents are hanging up records as good as or better than the *Shaw's*.

These Reservists are successful largely because so much is expected of them. One fellow named Smith, in an East Coast yard, makes a specialty of long hours. Twice recently he has gone for 36 hours without sleep when small patrol boats had to be repaired in a hurry to get back to the Atlantic submarine hunt. Smith gets home on an average of once a month and then only for a few hours. He has a cot set up in his tiny office and lives largely on sandwiches and coffee handed him by the crews of the vessels he repairs.

ANOTHER hull man named Telford prefers trick jobs, the less routine the better. The Boss Superintendent knows this and gives him every mechanical impossibility that comes along. Telford's high-water mark was a vessel with a smashed mast and a lot of topside damage that had to be sent to sea in three days. It was 24-hour work all the way through. He had to make and install a new mast, which he did in the rigging shop complete. It was ready to set on the last night, 12 hours before sailing time. Telford decided to set it himself. And so, about midnight—moonless, pitch dark, the wind whistling through his baba coat—he climbed aboard the spar and rode into the sky at the end of a wire rope sling suspended from a hammerhead crane far overhead. Then for three hours he jockeyed the mast up and down, easing it into place in the ship by signalling the crane operator above him with a flashlight.

It was a grim job but Telford himself was not grim; he was almost blythe. All through the night he swung in the air, singing, and his song carried through till dawn. And though Telford was pretty well frozen, pride sent him below to try a piece of thin paper between mast butt and seat when the job of lowering was done. No mast had ever fitted before on the first try but this one did. Lieutenant Telford had made the measurements for it himself and was not in error by a thousandth part of an inch.

Gleeful victories like this go on day and night in every yard. Word came to one hull superintendent named Deane that half a dozen "PT-boats" were urgently needed "somewhere south." Deane revolved the problem in his mind and quickly eliminated all the orthodox solutions. The PT's were too small to make the long trip by themselves and too big to be shipped by rail. So he decided to load them aboard a converted merchantman scheduled to leave the yard next morning.

Grabbing a ruler he went aboard to make measurements. As he expected, the 'tween-deck space was too low for stowing the boats and nothing could be done to improve it. The only way out was to dismantle the boats and send them south in pieces. Calling in the boat manufacturer to give him help, Deane quickly stripped them of everything—guns, torpedo tubes, masts, pilot houses, and all. Plywood bulkheads were ripped out by main force. He knew that others like himself could put the little craft together again on arrival.

In the middle of the night—as usual—he was ready; the PT's had been trimmed down to fit. Taking a boss rigger up on the ship's fo'c'stle he established communication by flashlight with the crane operator 160 feet above and the PT's began to swing through the air toward the cargo hatch. As the first one inched down Deane realized that the hatchway wasn't quite long enough to let her through. At any other time the whole plan would have been scrapped as impossible. Figuring rapidly, Deane decided to drop the boats slantwise, nosing them through the hatch and hitching their sterns in last. It was a delicate operation in the dark but it worked, with a trifle less than one inch to spare. The whole flotilla was snugged down in the hold by morning without scratched paint on any one.

THE spirit that sent the pioneers across the Plains and drove back the frontiers of science in the laboratories is sustaining these youngsters through their long night vigils and daily grinds. What keeps their courage up is their perpetual interest in something new. Every repair problem is a fresh challenge, prefaced by the near conviction that it can't be done. What the Navy has done is to let loose the native American love for invention. These hull superintendents are never held down by routine. Their energy is never sapped by long waits while red tape unwinds. Nor is it falsely buoyed by hope of recognition or financial reward. They will never get medals or newspaper headlines. But they will get something else that means more to them than all of these—the certain knowledge that without them many a ship would never again meet the enemy.

For the millions who must remain in civilian life this vital achievement of the Naval Reserve is a heartening thing indeed. It proves how strong are the sinews that lie dormant in a nation whose enemies once crowed that it was too soft and too slow. For the McCantrys and the Mullinses, the Deanes and Telfords, the Bakers and Smiths are no different from ourselves and each of us will be capable, when the time comes, of turning in as good a performance as theirs.

●

¶ *THE foregoing article tells the story of only one of the many groups of unsung heroes who, just as much as the soldier, the sailor, and the marine, are doing more than their share toward winning the war. The stories of others of these groups are being ferretted out, and it is hoped that, censorship permitting, more than one of them will be published in the pages of this magazine.*—The Editor.

Contact Lenses

With Recent Advances in Technique, These Aids to Vision Have Become Much More Satisfactory

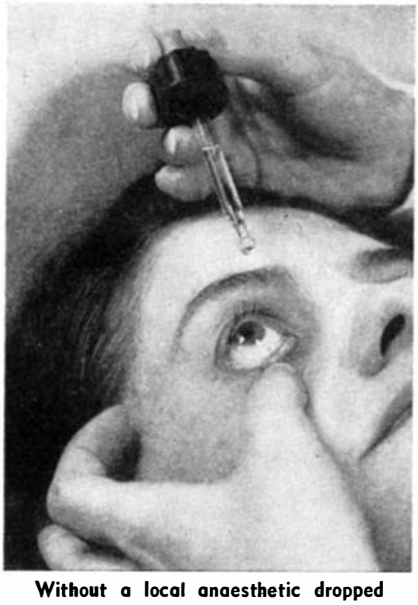
ALSTON CALLAHAN, M.D.
Atlanta, Georgia

"INVISIBLE glasses? Contact lenses? You mean the kind that you put underneath your lids right against the eyeball? Ugh! I don't think I could stand them. Are they safe? And aren't they frightfully expensive?"

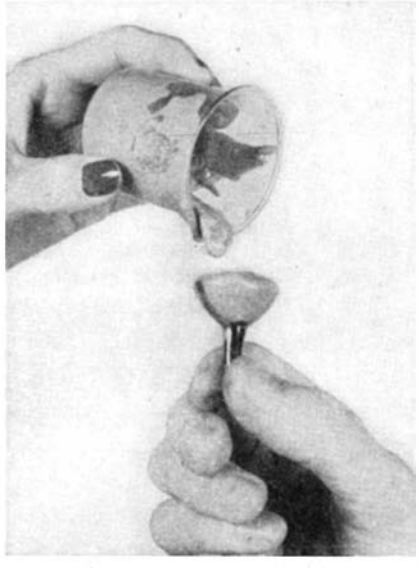
Many react in such a manner when the subject is mentioned, and it is true that the aversion to putting something into the eye is natural. But here are the facts.

It is only in the past few years, since clear plastics were devised, that the safety of contact lenses has been entirely beyond dispute. Also, it is only in the past few years that their construction has been scientifically accurate. Today, there are between 3000 and 5000 wearers of contact lenses.

Until recent years contact lenses were made only in certain sizes. This required an exhaustive sitting while the user's size was selected, necessitating insertion and removal of dozens of lenses in the attempt to find one having the correct fit. The contribution which has now made contact lenses far more usable was made by T. E. Obrig, a New York optician, who pioneered in making molds of the individual's eye, entirely of plastic material, so that the fit was as precise and individual as a fingerprint. Obrig's investigation of contact lenses showed that the size of the cornea varied so much in different persons that it would be next to impossible to fit them really accurately from stock sizes. Therefore, each lens must be tailor made. Exactly how this is done is shown in the accompanying series of illustrations.



Without a local anaesthetic dropped into the eye it would be a difficult, painful procedure to take a cast of it



The warm wax for making the mold is poured into a little glass casting shell, ready to invert quickly over the eye, as in the picture above

First, a local anaesthetic is dropped into the eye, so that no pain will be felt during the casting.

Next, Negocoll, a hydro-colloidal plastic composition somewhat midway between a wax and a jelly, and which is liquid when warm but solid when cool, is heated to 118 degrees, Fahrenheit, and allowed to cool to 107 degrees. It is then poured into a small casting shell, and the shell is quickly inverted and gently pressed against the front of the eye as the lids are pulled out of the way.

The Negocoll cools in a few minutes to normal body temperature and solidifies, whereupon the mold may be removed from the eye.

The casting shell is pressed against the eye. In the photograph the upper eyelid is over the shell. Some of the jelly-wax trickles down the cheek

The casting shell, bearing in the wax the perfect imprint of the eye, is then placed in some convenient holder, and freshly mixed dental stone, ordinarily used for making casts of teeth for plates, is poured into it.

This substance hardens to form the cast. The fifth picture shows two typical castings. The one held in the hand shows only the reverse side, on which identifying marks are scratched, but the separate one shows an exact duplicate of the front surface of an eye. So accurate are these castings that impressions of small blood vessels can be traced.

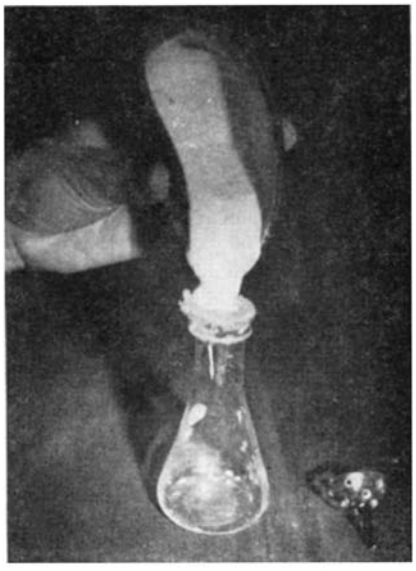
IT is from these castings that the contact lenses of clear plastic are made to fit the eye.

The final photograph shows a pair of finished contact lenses. It will be noticed that the central position of each lens bulges out slightly. This central position does not come into contact with the central, transparent part, or cornea, of the eye at all. The outer, flanged part, rests only on the white part of the eye where it causes no pain or disturbance.

The "power," or strength, is ground on the non-contacting central portion of the lens, which will be in front of the cornea.

When the lenses are worn, the space between the central position and the cornea of the eye is filled with a special buffer solution, dropped into the hollow of the lens before it is inserted into the eye. Wearers—even highly nervous persons—learn quickly how to insert and remove contact lenses, the initial hesitancy soon giving way to a routine, as with a dental plate.

After the first fitting, contact lenses are worn for an hour or so. This period of time is gradually extended as tolerance is developed, until they



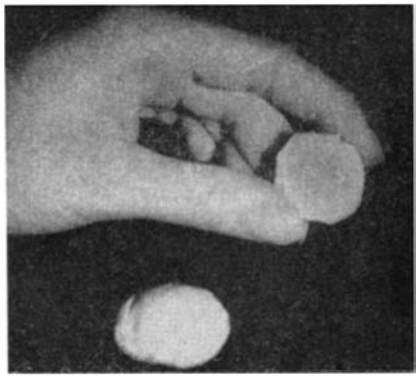
From the cast just made, which might be called a negative, a positive cast, duplicating the eye, must now in turn be made. Casting shell lies on table

are used continuously six, or eight, or even 12 hours. It is best to remove them every night and re-insert them every morning, but one young man, who did not read the instructions carefully, left his lenses in for two weeks without doing any harm to his eyes.

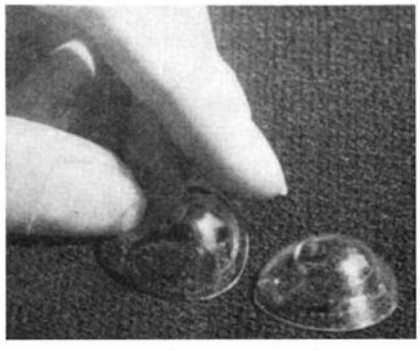
DESPITE all precautions taken in making the mold, it occasionally happens that the lens will touch a position of the cornea, which eventually would cause damage. Formerly, exhaustive studies with the microscope were necessary in order to rule this out. Here came another of Obrig's outstanding contributions—the use of fluorescein. When invisible ultra-violet rays are thrown on fluorescein, it glows brightly in the dark, and has thus been made use of in producing spectacular effects in the theater. Obrig filled the space between the lens and the eye with fluorescein and turned on the ultra-violet radiation. If the contact lenses fitted perfectly, the entire central area glowed. If the lens touched the cornea in any area, however small, that area remained black, for the fluorescein was displaced. By grinding off a minute amount of the lens, and then retesting with fluorescein, it is possible to continue the adjustment until the fit is exact.

The "physical fit," or the actual fitting of the lens, can therefore be achieved to perfection, while the "optical fit," or the grinding on the lens of the correct strength, whether it be for cone-shaped cornea, astigmatism, near-sightedness, or far-sightedness has been done accurately for some time.

Chief among the few minor problems yet to be completely solved is the matter of the "chemical fit," for a few eyes have difficulty in using a standard buffer solution worn regularly between the lens and the cornea. But recent investigation in the shifting of the acid-alkali balance has pointed out a new approach to this, and it is likely that the small fraction of people who cannot be "chemically" fitted will be even further reduced. Though the use of this fluid complicates to a slight degree their insertion, doctors who prescribe contact lenses point out that it is because of this



An exact cast of each eye. The one in the hand shows the back on which identifying marks are scratched. The other, lying on the table, is a front



From the molds just made, the final contact lenses are cast in plastic and finished, each as individual as a fingerprint, are each a precise fit

that these lenses, once fitted correctly, may last easily ten years or longer. For the ordinary factors which render necessary the changing of ordinary glasses every year or so, because of altering astigmatism and so on, are entirely neutralized by the "fluid lens" which naturally fills whatever irregular space is present. And thus their cost, when the period of service is considered, is not so great.

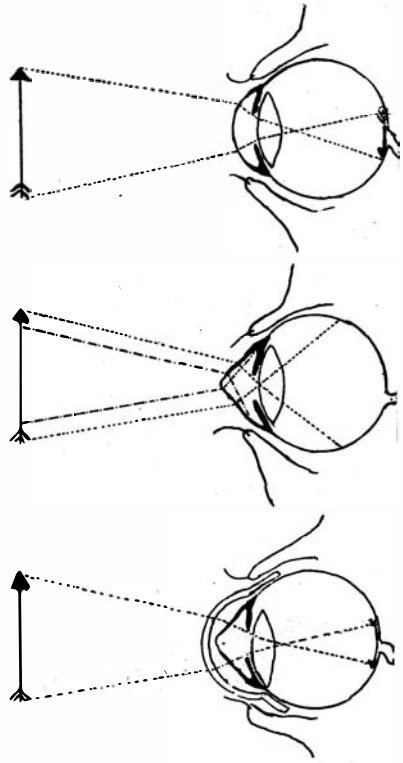
Fitted contact lenses are still quite expensive, as each pair is as individual as fingerprints. Melted down, you could buy the plastic used for only a few cents; but so highly technical is their fitting, to say nothing of the skill required of the manufacturer, that i is unlikely that they will soon b cheaper.

Contrary to a widespread belief tha contact lenses were designed primaril to satisfy a desire for a more sightl substitute for spectacles, the motiv for their development has been to giv vision or protection to certain kind of abnormal eyes which can be bene fitted by no other means. One suc example, showing how a contact len gave good vision where there wa practically none, is shown in the draw ings.

The upper drawing shows a norma eye which attains perfect vision be cause the cornea and lens focus th rays of light from the object viewe onto the retina, from whence it goe to the brain by way of the optic nerv

In the middle drawing is a case c keratoconus, or cone-shaped eye. Be cause of the cone shape, the rays c light are not focused—some do n pass through the pupil and othe spread out to the edge of the pupi All this eye can see is the differenc between light and dark, and ordinar glasses will not help.

But the contact lens in the low drawing affords normal refraction the light rays again. As is show it fits against the white part of th eye, but does not touch the clear pa (cornea) where it would cause di comfort. The intervening space



A normal eye, an abnormal eye (serious case of keratoconus), and the optical effect of contact lenses: restored vision in a "hopeless" case

filled with the special buffer solution regularly worn with the contact lenses. Now, since the refractive index of this fluid is almost the same as that of the fluid within the eye itself, the rays of light focused by the contact lens pass unchanged by the distorted cornea to the retina as happens in the normal eye.

There is a rather widespread belief that contact lenses are a new idea but this is by no means the case. They represent the culmination of years of hard work and investigation by a score of scientific men, most of whom approached the problem from different angles and each of whom made some real contribution to the solution.

The first scientist to propose and record such an idea was the astronomer, Sir John Herschel, who suggested in 1827 that a glass shell could be devised to fit over the eye to protect it from infection by a diseased lid. Sixty years later F. E. Mueller, in Germany, made one of blown glass which successfully protected for several years the eye of a patient who was unable to close it because of cancer of the lid.

In 1888, A. Fick, also of Germany, suggested that contact lenses be used for the condition called keratoconus, or cone-shaped cornea, described above. For this the Zeiss firm made contact lenses of blown glass.

In 1892 Sulzer ground some contact lenses of optical glass. They gave good vision but caused discomfort and could not be successfully worn.

In 1909 the Mueller optical firm produced contact lenses of "glass eye" glass but, among other imperfections, these contained impurities and had a very short life.

In 1920 Carl Zeiss accurately ground and polished contact lenses of chemically resistant glass, but only in one size. By continuing their research they found that varying sizes could be made. Not only could these be used for conical cornea, but also for near-sightedness, far-sightedness, and astigmatism. For the first time, contact lenses were brought within reach of the average person having a more commonly found type of defective vision. Many persons were fitted with these lenses, but to users in the United States it meant not only an exhausting sitting, requiring the insertion of dozens of lenses in the attempt to find one having the right fit, but also a long delay, since the lenses had to be shipped back to Germany one or more times to have the necessary strength ground on the lens.

And now we have the new type of all-plastic, individually *fitted* lens and other refinements. This is where the present story takes over—contact lenses made really wearable.

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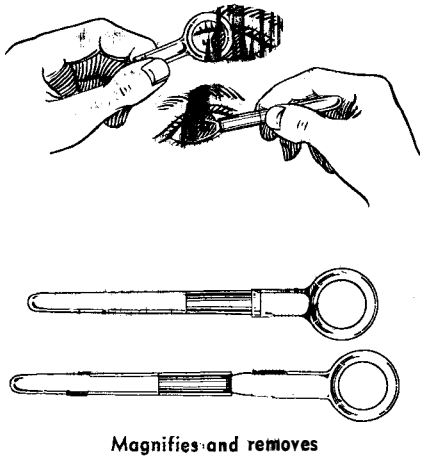
PARTICLE REMOVER

Smooth, Magnetized Wire Loop For Foreign Bodies In Eye

A MAGNIFYING glass is often of great assistance in locating foreign bodies in the eye, and such bodies can be conveniently removed by means of a loop of smooth wire. These two aids in particle removal have now been combined in the Mag-Optin unit shown in the accompanying drawings. The magnifying lens is made of a plastic material and is unbreakable. The handle is also of plastic, and the wire loop is affixed to the end of it. The loop itself is magnetized so as to assist in the removal of magnetic particles from the eye. Non-magnetic metallic particles, of course, are mechanically removed by the smooth wire loop.



Magnifies and removes

SACCHARIN

No Harm in Ordinary Use of the Super-Sweet Substance

Now that sugar is rationed, the thoughts of some have turned to saccharin and there are rumors that saccharin is dangerous. While killjoy friends are always ready to tell us that whatever we enjoy is "dangerous," *The Journal of the American Medical Association* is no killjoy about saccharin. It states editorially:

"Sugar rationing and new emphasis on weight reduction have doubtless increased the use of saccharin for sweetening purposes. Renewed interest in the possible harmful effect of this substance is an apparent corollary. Earlier investigations of saccharin, however, have failed to reveal dangerous side-actions except from extremely large doses. Likewise the evidence does not reveal any reason why saccharin cannot be used continuously in average sweetening doses for an indefinite period. Many patients have taken saccharin for years without harmful effect."

IVORY DOME

Baldness May Be Caused by Calcification of the Skull

A NEW theory of the cause of baldness has been proposed in *The Journal of the American Medical Association,* by Dr. Frederick Hoelzel of Chicago. The cranial sutures, or little wavy joint cracks of the skull, also other skull openings, may become calcified and shut off some of the circulation to the scalp. He describes "observations which I made while serving as technician in gross anatomy.

"I then had occasion," he continues, "to remove the brains of about 80 cadavers for separate use in the neurology classes and incidentally noted a seemingly obvious relation between the blood (vessel) supply to the scalp and the quantity of hair. Baldness occurred in persons in whom calcification of the skull bones apparently had not only firmly knitted the cranial sutures but also closed or narrowed various small foramens through which blood vessels pass, most prominently in persons with a luxuriant crop of hair.

"These blood vessels are mainly veins which normally communicate with the diploic veins in the spongy tissue of the skull bones but which are evidently pinched off by calcification of the foramens. Various stages of this process of impairing the blood circulation of the scalp could be observed.

"This, then, not only explains why baldness occurs but also why men are more likely to become bald than women, since bone growth or calcification is generally greater in males than in females.

"Obviously 'hair tonics' or vitamins are not likely to restore a blood circulation through what has practically become 'solid ivory.' Moreover, one wonders whether the promotion of a higher calcium intake among adults may not eventually increase the incidence of baldness and the sales of its vaunted remedies."

Science in the Forest

Modern Forestry Management Takes into Consideration All Phases of Wood Growing and Utilization

G. H. COLLINGWOOD
Chief Forester, American Forest Products Industries, Inc.

MODERN forestry, plus more scientific utilization of wood, are insuring adequate supplies of this vital natural resource for all of America's war needs while maintaining reserves for the future. The fact that wood is as important to military effort as oil, coal, or iron ore makes this especially significant. More than that, the importance of wood is further increased because its principal components, lignin and cellulose, are the basis for increasing numbers of "ersatz" products.

Sugar, textiles, proteins, alcohol, cattle fodder, industrial chemicals, and plastics —as well as an endless number of other derivatives — can be obtained from wood. Nazi war production is backboned by wood. In this country wood contributes to the war effort by providing in whole or in part approximately 1100 items of Army and Navy use. These include ships, cantonments, pontoons, gunstocks, tools, barracks and equipment, explosives, flamethrowers, gas masks, airplanes, packing boxes and crates, paper products, and fabrics.

To supply these needs our forest products industries are being called upon to produce 38 billion board feet of finished lumber this year. In addition, wood is needed for chemical distillation, fuel, and paper pulp. This is tremendous but not disastrous when one bears in mind that timber is a growing crop—a replenishable natural resource.

Fortunately, trees are living organisms whose growth and natural capacity for reproduction may be accelerated by careful management. Trees will die, but a forest may live forever. Many timber owners of the United States, well aware of this, are engaged in a program of conservation and reforestation whose objective is to guarantee abundant supplies of this basic raw material for all time.

This objective can be attained. Much has already been accomplished. Shortly after the turn of the century the then chief forester of the United States uttered a prediction concerning the future of our timber supply which, had it come true, would have proved dire indeed. "We have all but reached the end of these forests," he said. "We have reached the point where the growth of our forests is but one-third of the annual cut, while we have in store timber enough for only 20 or 30 years at our present rate of use." On the basis of such premises, he prophesied an inevitable "timber famine" which would affect every individual.

After more than 30 years, our annual new growth of timber amounts to over eleven billion cubic feet. This is not board feet, but in addition to fuel-wood, pulpwood, and other products which are adapted to measurement in cubic feet, it includes 32 billion board feet of saw timber. When we entered the war, this new growth, or annual crop, was approaching the point where it would balance the annual amount commercially consumed. Had the war not intervened, the new growth might have equaled or even exceeded the annual forest drain from all causes by 1945.

Commercial harvesting of trees does not account for the entire amount taken from the forests each year. Fire, insects, tree diseases, and decay take constant toll. Ceaseless war must be waged against these fruitless losses as part of the forest industries' program for forest conservation and silviculture.

What may not be generally realized is the fact that timber is a crop just as surely as wheat or corn. Consequently, trees must be protected from fire and such "natural enemies" as insects and fungi. They should be harvested before ripeness turns into rot. There is no better way to provide for new timber crops.

Because this stand of trees has been thinned, those remaining will increase in growth rate. Note low, economical stumps

FORTUNATELY, areas naturally suited to forest growth are abundant, and timber stocks are available for our needs. One third of the United States is covered with trees. When the colonists arrived in America, there were some 822 million acres of forests. During the succeeding three centuries those forests have yielded over seven trillion feet of forest products for the building of the country. Despite that use, and excluding the acreage cleared to make room for cities, towns, and farms, we still have 630 million acres of forest. This includes over 460 million acres classed as commercial forest, of which nearly a quarter is virgin timber. The term "virgin" applies to timber so old that it antedates the memory of man so that much of it has long since reached maturity and needs to be harvested to be saved.

America is now, and has been for 20 years, in a period of forest transition. No longer is it necessary to clear land for additional agricultural production. The present forest area of the United States is generally recognized as serving its maximum use if it

continues to grow trees. This realization heralds a new era in which timber is being harvested as a crop, rather than "mined" after the destructive fashion of pioneer days.

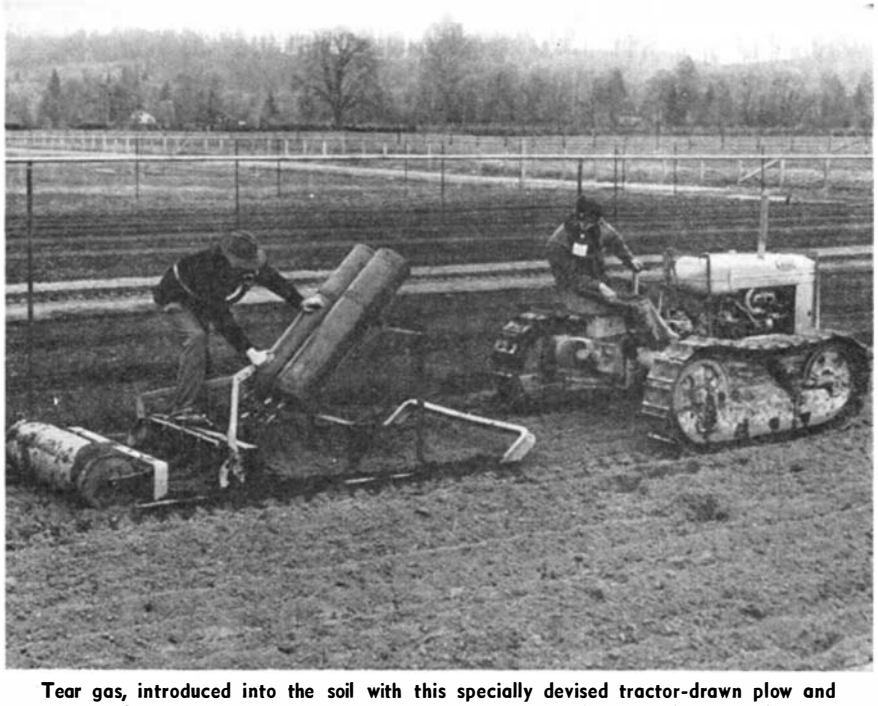
Forestry is based on the established fact that trees are living plants whose reproduction, growth, and development may be encouraged by the application of relatively simple rules. Where possible, forests are harvested in ways to assure recurring crops of new trees. Where clear-cutting is necessary, this can be done by leaving seed-trees. Individual windfirm trees with full crowns may be left at frequent intervals across the cut-over area, or groups of trees, capable of protecting one another while producing seed, may be left along water courses, on ridges, or in strips. Where practicable, selective cutting keeps the forest continually productive, at the same time avoiding abrupt changes. Forestry also calls for effective protection of the growing trees from forest fires, continuous warfare against insect pests and tree diseases, and effective use of as much of the wood as possible.

Baling tree seedlings at a nursery. The forest industries of the Pacific Northwest alone are reported to have planted some 60 million seedlings during the past 10 years

Most of the badly deforested areas are the result of repeated fires which destroyed the natural sources of tree seed. Only by extensive seeding or, preferably, by planting small trees can these lands be brought back to productive forests. This calls for the maintenance of tree nurseries where seedlings or transplants can be grown preparatory to planting them on the fire-scarred stretches.

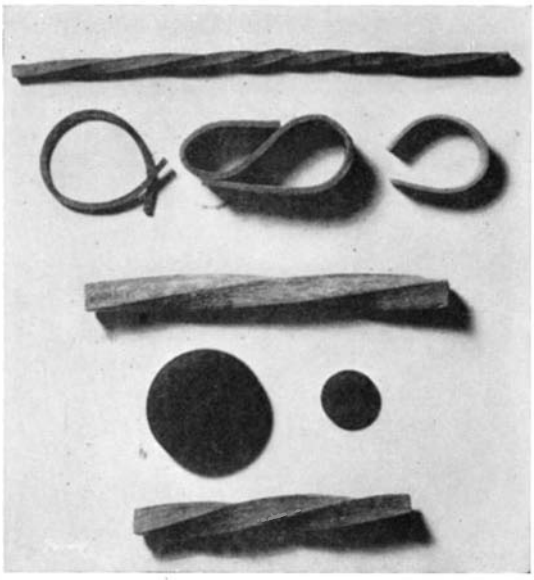
One representative example of an industry-operated nursery is the "tree factory" at Nisqually, Washington, where 25 million seedlings are being produced to reforest burned-over areas. Here are employed the latest scientific developments, including treatment of the soil with tear gas to kill weeds, selection of the seeds according to the location of their parents in order to select seedlings best suited for various soil sites and elevations, and a toughening treatment for the tender seedlings to build up their resistance and ability to survive after they are transplanted and "on their own." More than $500,000 is being spent on this nursery to supply seedlings with which to restore the forest on thousands of acres in Washington and Oregon. The Nisqually Nursery project represents real progress toward the goal of the forest industries—to keep the forestlands continuously producing crops of trees. In the Pacific Northwest alone the forest industries have planted 60 million seedlings in the last ten years.

Admittedly, planting is only feasible as a means of correcting mistakes or repairing disasters. It is neither practical nor economical to rely on artificial propagation alone to maintain forest growth and insure continuous yields of timber. This can best be accomplished by working with nature to assure seed sources, to keep to a minimum the ravages of fire and disease, and to apply the principles of tree growth. Scientific forestry, therefore, comes into the picture at the very source, out in the woods where the fallers and buckers are operating.



Tear gas, introduced into the soil with this specially devised tractor-drawn plow and roller, is being used in continuing experiments to kill weeds at the Nisqually Nursery

Rules for conservative cutting vary according to the kinds and sizes of trees being harvested, the locality, and a variety of other conditions. Where trees of differing ages grow together, and especially where the forest consists of several kinds of trees, with young and old together, the generally accepted practice is to cut selectively. This term is applied to an operation where only trees over a certain minimum diameter, together with those which are defective, are harvested.



By a special treatment process it is possible to bend and twist certain woods to such shapes as these, shapes that will be permanently maintained

The smaller trees are left to make further growth and to provide seed for restocking the openings. Stands of trees that are growing too thickly may be thinned to hasten the growth of those that are left. Selective cutting is also adapted to stands which are used for more than one purpose, as in the South, where one operation may yield sawlogs, turpentine, plywood, and fuel.

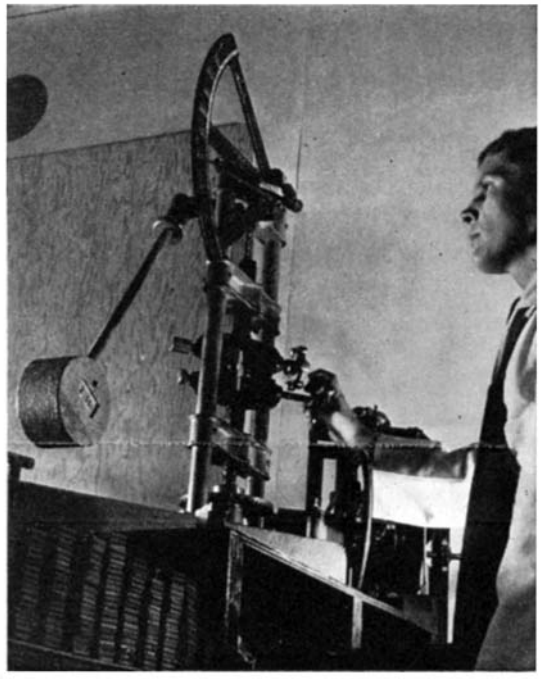
Some kinds of trees demand direct sunlight in early youth, and languish in the shade. Accordingly, they often develop large areas of one-age forests. This is particularly true of Douglas fir in the Northwest where often most of the trees in a given stand are about the same age and, generally speaking, the same size. It may be advisable to clear-cut these stands and leave clumps or strips of firm-rooted, large-crowned mature trees to reseed the cut-over area. Under such conditions the seed trees may be the sources of fertile seed to cover the surrounding land for several hundred yards. After the area is fully stocked with young trees, the old seed trees may be, and often are, harvested.

Regardless of the difference in operations, forestry aims to perpetuate the forest. At the same time, it must be accompanied by continuous efforts to protect the young, growing forest from fire.

Definitely planned cutting to assure continuous forest growth is relatively new in this country. So also are the efforts of the states, the federal government, and the timberland owners to protect all forest growth from fire. Many timbermen in the East and South, however, are harvesting third- and fourth-growth timber, whose each successive crop is the progeny of seed trees left from earlier cuts.

The expanding program of forest management for continuous growth has been popularly called "tree farming." Its practice includes larger industrial operators as well as many thousand forward-looking owners of farm woodlots. Of the nation's commercial forest area, 39 percent is held in industrially productive private ownership, 21 percent is in National Forest reserves or other forms of public ownership, and 40 percent is in farm woodlots. The Pacific Northwest holds nearly half the virgin saw-timber stand, all of which is under protection, and an increasing proportion is classed as managed "tree farms."

Since young and middle-aged trees grow most rapidly, managed cutting increases the efficiency of forest-land. In general, trees should be harvested when they reach an age when their annual growth begins to taper off. Since every tree in the forests of this country keeps its growth record in so-called "annual rings" within its trunk, it is possible to sample a few trees in any stand to determine when to harvest for maximum timber yield. In some cases the greatest annual yield is realized when relatively young, immature trees are cut. This is true of Southern pine grown for pulpwood. These trees make excellent pulp, but most of the product of Southern mills is Kraft, or heavy wrapping paper, which need not be white. This is an advantage, since the high resin content of Southern pine makes bleaching expensive. Under careful forest management Southern pines grow to a diameter of eight inches in seven years, which, although admittedly exceptional, can provide 14 or 15 full crops of pulpwood in a century. Under management and protection from fire 300 square miles of Southern pine forest can keep a 500-ton-a-day paper mill in operation forever. As against this, 2000 square miles of Northern spruce forest, not under intensive forest management, may be needed to do the same.



In this plywood testing machine, specimens are pulled apart to show relative strengths of the wood and glue. The wood must rupture before the glue

WHERE forest stands have been selectively thinned so that individual trees may receive plenty of light, second-growth pine on Southern "tree farms" are not uncommonly big enough for turpentining in 15 years. In fast-growing sections small sawlogs may be ready for harvest in 20 to 30 years, and whole forest areas under management frequently grow 300 to 400 board feet per acre per year.

The blanket on the floor, the handful of "wool," the hat, are wood products

The great stands of old, untouched timber still in the Pacific Northwest are alone sufficient to supply all the country's lumber needs for many years, were no new trees to grow. As the old trees are harvested, the new growth can meet all of the newsprint demands of the entire country year after year. This is especially true where hemlock, once looked on as a "forest weed," is now used for pulpwood, and where the larger logs are in demand for airplane stock. New forest crops in this region are ready to harvest in 70 years or less.

Fire is the greatest single obstacle to forest growth. Young trees are most vulnerable to fire damage; older trees are protected to some degree by thicker, more resistant bark, and because the more inflammable foliage is higher from the ground. Destruction of young growth and seed sources renders denuded forestland incapable of unaided recovery. More than that, fire destroys much of the fertile soil humus, making difficult the establishment of "tree plantations." Most forest fires are caused by man, either from incendiary motives or because of carelessness by smokers, campers, hunters, fishermen, and picnickers. To offset this, workers in the woods are almost extravagantly careful of fire. Some might think the adjective ill-chosen, but woodsmen and foresters know that no extravagance is more unforgivable than a blaze that sweeps through the woods.

Together with insects and tree diseases, fire accounts for 15 percent of the annual use and loss of forest products, the other 85 percent being consumed by man. If the first three of these factors could be controlled, new tree growth would soon balance the needs of industry and home uses, despite the tremendous demands of the war.

Constructive cutting practices, therefore, protect seed sources and provide thorough-going fire protection, while unproductive and burned-over areas are restocked with nursery-grown seedlings. These, together with effective utilization of all harvested trees, are the basis of the "tree-farming" program which is the forest industries' assurance that American industry will not lack wood.

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How's The Weather?

Odd Weather Predictors, Some of Which Can be Shown to Have Little-Known Scientific Backgrounds

MANY "signs" have been used by humans to foretell atmospheric conditions. Although a number of these have little or no value, others may be the basis of reasonably accurate predictions. The following are random selections of nature's odd weather gages.

Previous injuries are often used as storm indicators. How often have we heard statements like the following: "Well, I believe it will rain. That lame foot of mine is aching."

Such previous injuries may give more trouble before or during the beginning of the storm. While prophecies based upon such pathological conditions are not always reliable, their accuracy is far greater than that of the average curbstone predictor.

There is scientific background for such forecasting. The healing of injuries is not as perfect as we may suppose. The tissues, the capillaries, and possibly the nerves heal unevenly. Since the circulation system is sensitive to air density, the capillaries may become sufficiently distended during low pressures to cause pain in varying degrees. In other words, the former wound acts as an indicator for low pressure much as a barometer does, although less perfectly. As a low barometer indicates an oncoming storm, so does the former injury.

Other ailments: People with rheumatism, arthritis, or other ailments can also predict storms for similar reasons. Neurotic people and those with poor hearts are often sensitive enough to prophesy atmospheric conditions. More often, people's dispositions are enough impaired during lows so that others may use them for living barometers. Sleep of otherwise normal humans is interfered with during periods of lowered pressure.

Courtesy "Taylor-Rochester."

This condition must not be confused with that of people who go to higher altitudes. The atmospheric density becomes less as one goes upward, but the aches and pains one feels during steep climbs by train or auto have nothing whatsoever to do with the weather conditions.

People who are sensitive to changes in atmospheric pressure often go to a doctor unnecessarily. The conditions which cause their discomfort are harmless and temporary. If such persons possessed a barometer and watched it carefully, they would be able to tell the serious symptoms from those due to lessened air densities. A microbarograph would be ideal, but an ordinary aneroid barometer would also be quite satisfactory.

WIND caves have the peculiar quality of acting as natural barometers. Caves with enormous capacity may have limited exits to the atmosphere. During high pressure the atmosphere will be forced into such caves. During lowered or lessened "outdoor" densities the accumulated air will blow out of the vents. Wind Cave of the Black Hills is such a cave, but there are others, like the Medicine Hole of the North Dakota Killdeer Mountains, which acts in much the same manner. Although less accurate than a barometer, due to suction of winds and perhaps other causes, the movements of air currents in caves are quite useful as weather indicators.

Wells and Springs: In late medieval times in Italy there were some wells which acted queerly. On most days they would produce water by pumping, but it was observed that on days preceding a storm they would not. The failure to yield water was used as a storm predictor by some. Others attributed magical properties to such a knowing fluid and either shunned or sought (depending on the temperament of the individual) the liquid because of its supposed supernatural properties.

However, the scientific explanation is the simple one. The valves of the pumps used at that time were often considerably above water. It would be hardly possible for pumps to operate 30 feet above the level of the liquid under the best conditions, and almost impossible under usual conditions, yet excessive pumping frequently lowered the well to this critical stage. During the low barometer such pumps tended to protect the well against excessive depletion. The well, therefore, predicted weather about as efficiently as a crude barometer.

Springs and wells sometimes become

"milky" or cloudy before storms. In many instances these are used as local weather forecasters. This seemingly peculiar phenomenon also can be explained scientifically. All flows from underground sources dissolve some gas. Under heavy pressure more gas is dissolved than under low pressure. If the air density is high, gas does not flow or form easily on coming to the surface. If the pressure is low, however, enough tiny bubbles will form to give the water a temporary milky appearance. Often the particles of released gas will bring into the spring or well the sediments deposited during other periods. These may remain suspended and give the liquid a murky or milky appearance. Also the flow may be increased a little during such periods. The spring is therefore like a very crude barometer and, as such, can be used for forecasting purposes.

Moisture phenomena are often used for amateur forecasting. Hazy air gives evidence of the abundance of water vapor. As such, it may be a crude indicator of rain, and because aqueous gas is lighter than air, it is a crude gage of barometric pressure. The "ring" or "rings" around the moon, the halos, coronas, and similar phenomena likewise predict rain.

Human hair is sensitive to atmospheric moisture. Naturally curly hair becomes more curly when the air is damp. Artificially fashioned hair, even the press of one's woolen trousers, tends to go back to the natural state under such hygroscopic conditions. Scientists have recognized the significance of this truth in constructing one of the water-vapor testing instruments, the hair hygrometer.

Landscape features are popular as weather guides. If a mountain or butte to the west becomes unusually hazy or is obscured by a certain type of cloud, a storm will soon be upon us. But this is because weather in our latitude usually travels from the west and we are merely observing it in advance. Pikes Peak of Colorado and Crow Peak of the Northern Black Hills are examples of this type of indicators.

Rainbows in the west also fortell an oncoming rain. But they always occur in the early morning, on rain which is already falling a short distance to the west and which in all probability soon will reach us.

The foregoing indicators are of considerable scientific interest. In no case, however, are they as reliable as the devices used by the weather forecasters. If one lives in an area where such phenomena cannot be conveniently observed, it is some satisfaction to know that good instruments, intelligently used, are much better than nature's weather gages.

• • •

FLOATING GLASS

Made By New Process, Has Many Potential Uses

A NEW type of opaque glass that floats like cork and can be used as the buoyant element in the construction of life boats, life rafts, life preservers, and pontoon bridge supports has been developed by the Pittsburgh Corning Corporation. The new product, called Foamglas, also has valuable insulating qualities. It has a weight of only ten pounds per cubic foot—one fifteenth that of ordinary glass—and is odorless, fireproof, and vermin proof.

It is now under active investigation by certain Federal government agencies as an alternate material for such critical products as cork, balsa wood, cellular rubber, and kapok, which are largely imported. Foamglas does not resemble any form of glass heretofore manufactured. It is extremely light in weight, opaque, rigid, and has a cellular structure containing a myriad of tiny air-tight cells which give it buoyancy and insulating properties.

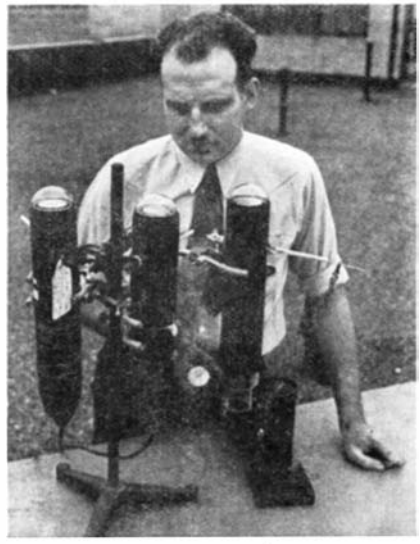
It can be sawed or drilled with ordinary tools. Because of its closed-cell structure it will not absorb water and it will float indefinitely. It is available in slabs 12 inches by 18 inches and in thicknesses of 2 inches, 3 inches, 4½ inches, and 6 inches.

Foamglas is produced by firing ordinary glass which has been mixed with a small quantity of pure carbon. At the proper temperature the glass softens and the carbon turns into a gas which then acts upon the molten glass very much as baking powder or yeast behaves when bread is baked. By proper selection of the glass batch, the type of carbon, and by exact control over the time and temperature used, it is possible to obtain rigid vitreous slabs of Foamglas in which the cells are uniformly small in size and entirely sealed one from another.

SUNFALL

Measured by Use of New Electron Tubes

SENSITIVE new electronic "eyes" developed by Westinghouse engineers to see and record invisible ultra-violet rays in sunshine will be used to make daily measurements of "sunfall" in the United States to study its effect on the wartime health of the nation. The new sun-measuring instruments eventually will operate in 20 of the world's first solar observation posts to be set up for a nationwide ultra-violet study by the United States Weather Bureau. By recording the amount of ultra-violet which penetrates through the haze of big metropolitan centers, Weather



Measures sun tan rays

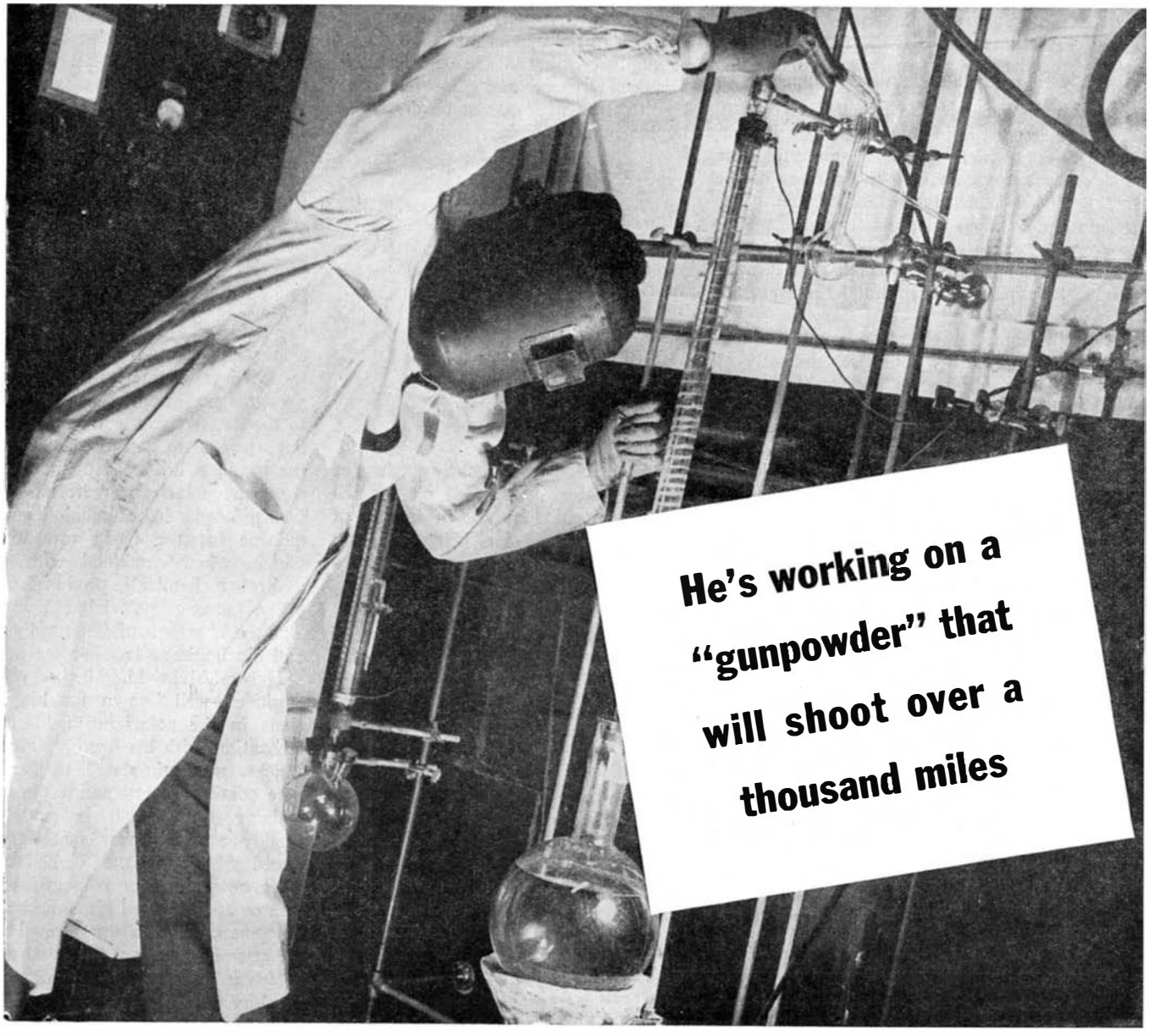
Bureau officials believe that it may eventually be possible to forecast for several days in advance the intensity of sunfall over a city.

Development of new electronic light cells in the meters will make sunfall measurements as accurate and uniform as the familiar rainfall statistics now issued by the Weather Bureau, according to Dr. H. C. Rentschler, Director of the Westinghouse lamp research laboratories.

"Many of the effects of the sun's invisible ultra-violet rays on human health are still a scientific riddle to research men, mainly because of a need for uniform and dependable instruments to measure solar radiations," Dr. Rentschler explained. "Electronics research has now produced a tool that will make it possible to meter and standardize a unit of sunlight just as accurately as a watt of electricity or gallon of fluid.

"Sun statistics taken from various climate zones and compared with the health statistics of those zones will be one way in which research men can study the effect of ultra-violet on humans. Such studies could be aimed at determining what preventive or curative effect, if any, sunlight has on such diseases as tuberculosis and rickets and the relationship between liberal exposure to ultra-violet and general health," Dr. Rentschler said.

In appearance, the ultra-violet sun meter resembles a long, oversized



The black powder of the American Revolution could lob a cannon ball about a mile. At the time of the First World War the normal heavy artillery range, with smokeless powder, was about twenty miles.

For this war, chemical research developed a propellant that has a range of hundreds—even thousands—of miles. Already it has carried four-thousand-pound projectiles from somewhere in England straight to the heart of German industry. It has dropped destruction on a Japanese fleet that was nearly a thousand miles from our outposts. From "Shangri La" it sent all Tokio scurrying for cover.

The new "gunpowder," which has changed the whole strategy of war, is *high-octane gasoline.*

In modern aerial war the bomb is the shell, the airplane is the cannon and high-octane aviation fuel is the propelling charge. The side which has the best aviation fuel—the one which gives the most power, the greatest range per gallon—enjoys an advantage of tremendous value.

Fortunately for the United Nations, the development of high-octane gasoline was a triumph of the American petroleum industry. Long before Pearl Harbor, U. S. petroleum chemists were seeking and finding new and better components for aviation fuels—iso-octane, Ethyl fluid and many others—developing processes and facilities for producing these aids to high-octane quality in volume. They advanced the art of refining petroleum from a simple distilling and cracking process to a science of synthesizing special chemicals—then blended these chemicals into fuels of predetermined characteristics and quality. Since Ethyl fluid plays an important part in the manufacture of high-octane fuels, Ethyl research engineers have cooperated with petroleum technologists in their search for better fuels. And because fuels and engines are inseparably related in their development, we work with engine designers in their efforts to get the most from these superior fuels. Today it is our privilege to furnish our product and devote our technical experience to the cause of American victory.

ETHYL
BRAND OF ANTIKNOCK COMPOUND
ETHYL CORPORATION
TRADE MARK REG. U.S. PAT. OFF.

ETHYL CORPORATION
Chrysler Building, New York City

Manufacturers of Ethyl fluid, used by oil refiners to improve antiknock quality of aviation and motor gasolines.

radio tube. At the upper end of the instrument is a flat metal button about the size of a half dollar and surrounded by a circular wire electrode. The metal in its refined state is sensitive only to that portion of the ultra-violet in sunlight which produces sunburn. The sun's rays, striking the surface of the disk is a nearly perfect vacuum, cause the metal to release a stream of photoelectrons which travel to the electrode. This current is so small that it must be expressed in millionths of watts, or microwatts.

From the electrode, photoelectrons pass to a tiny condenser, actually an "electronic bucket" which stores up the energy over a period of seconds and then releases it in a single charge across an electrical circuit in the tube. Each time the condenser discharges its quota of photoelectrons, a sensitive relay "trigger" registers a sharp click which reveals that a known quantity of ultra-violet is reaching the earth. The number and frequency of clicks provide research men with the total quantity for any given period of time.

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ENGLISH RATIONING—In England during the first three months of the war 1,000,000 cars were laid up due to rationing of gasoline, the increased price of gasoline and tires, and the greatly increased taxation. The sales in July 1940 were only one-quarter of those in 1938, and purchase of new cars was thereafter forbidden.

• • •

GLASS CAMOUFLAGE

Fibers Employed As Covering for Nets

GLASS, ordinarily thought of as a substance used to reveal rather than conceal, today is helping to conceal America's vital war plants against the day when they may become the target of enemy bombers.

Because they are light in weight, don't decay, are unaffected by fresh or salt water, and will not burn, fine, flexible glass fibers thinner than a human hair are being used as the covering, or garnish, for the metal-mesh camouflage nets which are employed to hide strategic war production plants and other possible bombing objectives from enemy raiders.

The glass fibers, manufactured by Owens-Corning Fiberglas Corporation, are spread over chicken wire and painted with designs that blend with the surrounding terrain, whether it be cultivated fields and orchards, or the houses and gardens of a village or suburb.

The fibers can be painted as often as necessary to keep the camouflage design in harmony with seasonal changes in the appearance of the surrounding countryside. Since the combination of metal and glass is incombustible, the nets cannot be destroyed by incendiary bombs.

• • •

JELLY—Even though the pectin makes jelly jell, it is impossible to produce jelly without sugar. Pectin and fruit juices alone won't do it. Sugar unites the two and is the vehicle which carries flavor.

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WOODEN TIRES

Being Used on Ship-Yard Trailers

TWELVE blocks of hard maple per wheel, soaked in linseed oil for 24 hours and fitted as shown in two of our illustrations, are being used on tractor-drawn trailers in a shipyard

Two views of the method of applying a new wooden tire for trailer use

of the Federal Shipbuilding and Dry Dock Company. These trailers spend most of their time moving 20-ton ship propellers, although it is reported that the wooden-tired wheels will stand up satisfactorily under a load of 50 tons.

The rubber tires that were replaced by these wooden blocks weighed 100 pounds each. It is stated by the shipbuilding company that the wooden replacements are good for from one to two years and probably even longer if the blocks are thoroughly boiled in paraffine before assembly.

NEW POLARIZER

Made From Materials Available in this Country

POLARIZATION is one of the present-day fields where research and production stimulation, together with shortages of raw materials, have put the pressure on scientists and engineers to develop substitute materials which have proved to be more suitable than the products hitherto supplied. Before the war, polarizing materials manufactured depended on alkaloids such as quinine for the basic raw material which, when combined with iodine and other chemicals, produced a crystal of strong polarizing properties. But the shortage of imported quinine and cinchonidine has become acute.

Hence Alvin M. Marks, research engineer, well known for his inventions in the polarizing field, in collaboration with his brother, Mortimer Marks, was stimulated to perfect a new continuous crystalline plastic polarizing film which is made from readily available raw materials produced wholly in the United States. This new polarizer is available as a film or as laminated glass, and the development assures the United States a source of supply of this vital product which is an essential part of our war machine.

Today polarizing material is used in gunsights, range finders, binoculars, telescopes, and sighting devices in general, either as a variable light control or to remove glare. Other uses are for blackout protection, navigational instruments, scientific instruments, non-glare goggles and eyeglasses, polarized illumination to produce non-glare lighting, photography and television, polariscopes, three dimensional movies or still pictures, and so on.

X-RAY

Machine Gives Radiations More Penetrating than Radium

DEVELOPMENT of a direct current X-ray generator operating at a potential of more than 4,000,000 volts makes possible for the first time production of radiation which is more penetrating than the gamma rays of radium and which has an intensity greater than

Wanted: MORE EXECUTIVES!

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

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

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

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

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

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

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

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

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

Send for "FORGING AHEAD IN BUSINESS"

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

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

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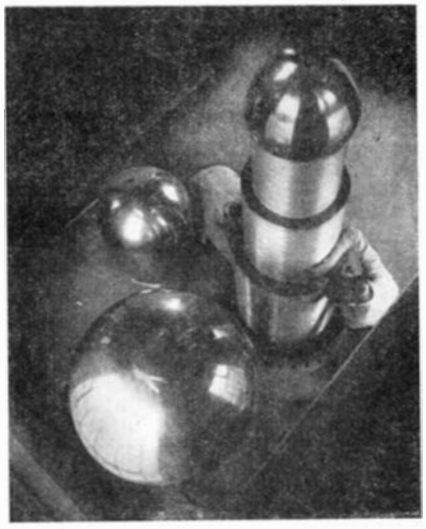
that of the entire available world supply of radium. The new generator was announced in a paper presented by Dr. John G. Trump, its designer, and R. W. Cloud who described construction of the apparatus, while a paper by Dr. Richard Dresser of Boston reported the preliminary clinical observations on the use of these high voltage X-rays. The papers were presented at a meeting of the American Roentgen Ray Society.

The new generator, developed at the Massachusetts Institute of Technology, the design of which is based on the Van de Graaff type of electrostatic high-voltage machine, consists of a dome-shaped high-voltage terminal about two feet in diameter supported on a column of alternate insulating and metallic spacers. A single insulating belt 12 inches wide travels at high speed within the column and transfers an electrical charge continuously between the ground and the terminal. This assembly is mounted within a sealed metal pressure tank in order that by compression of a mixture of air and Freon gas the electrically charged belt, terminal, and column may be insulated. This tank is four and one half feet in diameter and 13 feet high.

In operation, a negative electric charge is sprayed on the insulating belt at its lower end and carried up into the high-voltage terminal, which thus acquires a negative electrical pressure in direct proportion to the stored electrical charge. The voltage may be adjusted from a few hundred thousand volts to the maximum of more than four million volts by controlling the current sprayed on the charge-conveyor belt. The X-ray tube is fixed vertically within the generator column. A metal extension of the tube passes out through the bottom of the tank and terminates in a water-cooled gold target surrounded by lead shielding and provided with beam-defining portals and shutter. The tube consists of 100 glass rings between each of which is placed a metallic accelerating and focusing electrode connected to the generator column. The electrons for producing X-rays by bombardment of the gold target originate at the tungsten filament in the high-voltage terminal end of the tube and are progressively accelerated and focused as they are propelled down the tube at the gold target.

In describing the clinical uses of the highly penetrating radiation of the new generator, Dr. Dresser reported that the rays have essentially the same physical properties as the gamma rays of radium, but that their high intensity permits long treatment distances with the result that the depth dose is much greater than it has been possible to obtain in radium therapy.

Treatment with the high-voltage deeply penetrating X-rays produces no visible skin reaction. The first X-ray generator of the type just described was developed in 1937 to operate at a potential of 1,000,000 volts. A second and more compact unit operating at 1,250,000 volts was built



D.C. generator and its pressure tank

in 1940 for the Massachusetts General Hospital where it is in operation. The latest unit, still more compact than any of its predecessors, is operating in a special laboratory at the Massachusetts Institute of Technology, where therapeutic investigations with 3,000,000 volt rays are made under the direction of Dr. Dresser. In view of the fact that clinical experimentation at high-voltages is still in a preliminary stage, Dr. Dresser made no report on the therapeutic effects of the radiation.

NEW RUBBER

Ready to be Put to Work When Needed

A NEW and purer form of natural rubber was described in a paper delivered by Dr. John McGavack of United States Rubber Company at a recent meeting of American Chemical Society. The new rubber is called USF-rubber and is a new crude of improved properties, according to Dr. McGavack. It was designed to satisfy the demands expressed by the consumers of the crude rubber. Its points of superiority include a greater uniformity for easier processing; softness, requiring less power in milling; greater resistance to flex-cracking; good color; and cleanliness and purity of a high order.

The process for preparing the new USF-rubber has three main steps: First, dirt is removed from the preserved latex by a sedimentation method. The latex is then blended in large storage tanks to obtain and maintain a uniform quality of latex with a definite proportion of total solids. Finally, the rubber content of the latex is flocculated in small particles by a new technique instead of being coagulated by acid in a larger mass. In the flocculated form the rubber particles are themselves purer and may more easily be washed free of soluble impurities.

"It is unfortunate that this development which required so many years of research cannot immediately be put at the disposal of American industry," Dr. McGavack stated. "However, we now have the process and are ready to put it to work wherever needed, in plantations of the west now and later in the plantations of the far east when they have been recovered."

MILITARY MOVIES

Now Being Made With Finest Equipment

THE Air Corps movie-makers "are there with their cameras" at every important maneuver, and they co-operate with the newsreel cameramen in making Army aerial subjects. They also co-operate with major production companies in Hollywood, in technical advice on military subjects.

The big fireproof film library at Wright Field contains motion-picture records of Air Corps maneuvers and special events dating back to remarkably clear, if somewhat jerky, motion pictures of the tests at Fort Myer, Virginia, of the first Army airplane purchased from the Wright brothers in 1909.

Improved sound recordings are being obtained through use of recently installed sound equipment said to be unequaled between New York and Hollywood. The equipment mixes sounds from four separate sound tracks. The commentator talks into a microphone in a soundproof recording room, while separate sound tracks are made for background effects, and the tracks are blended with proper modulations to get the finished film sound track.

Wright Field Aerial and Movie Laboratories are equipped with newest-type processing equipment, and the movie laboratory processes all motion pictures shot at Wright Field.

Technical motion pictures produced by the Air Corps Motion-Picture Laboratory for Air Corps instruction are produced by Hollywood-trained personnel. An animation studio keeps a

staff of artists busy making pictures for animated cartoon sequences in the technical films. Animation has been used for years by the Air Corps in showing technical procedures, because through its use it is possible to point out precisely the essential details in a new piece of equipment without the nonessentials.—*Kodak Magazine.*

SUB LINER

Used in Battery Rooms to Prevent Corrosion

A LINING for the battery rooms of submarines is being produced on equipment which heretofore has been used in production of Goodyear's Plioweld, an interior surface for storage tanks and similar items.

On submarines, the walls and floors of the battery room are lined with rubber or composition sheeting to protect the steel walls from corrosion by escaping battery fluid and fumes. Sometimes, Goodyear officials explain, fluid escapes from the batteries as a submarine lurches, lists, or dives at sharp angles. With the new wall protection, the fluid merely flows down the sides of the battery room to be collected in special disposal equipment.

The lining is usually installed to a quarter-inch thickness over each battery room wall and floor. It is applied in two layers, each about an eighth of an inch thick, and is cemented to the submarine battery-room walls.

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MINT—There has recently been more than a 20 percent increase in peppermint acreage in Indiana and Michigan, to provide for at least part of the 400,000 pounds of menthol which formerly were imported from China and Japan.

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FERTILIZER

War Should Assure Ample Nitrogen Supply

THE more recent increases in domestic capacity for synthetic manufacture of nitrogen should guarantee plenty of that product for fertilizers and every other conceivable agricultural and industrial use when the war ends, says a recent issue of the Du Pont "Agricultural News Letter."

American farmers annually require commercial fertilizers carrying enough nitrogen to supply the explosives requirements of around eight million 24-foot torpedoes or ten million 600-pound bombs.

Every time a 16-inch gun is fired, 120 pounds of nitrogen goes back into the air from whence it came. This means that the nitrogen needed annually by our farmers, along with such other plant-food elements as phosphorus and potash, to grow the food, feed, and fiber demanded of them, would, if converted to explosives, be sufficient for well over seven million 16-inch shells.

In 1910 American farmers used less than one-third as much fertilizer nitrogen as they require today. The increase from 260 million pounds in 1910 has been rapid and steady: 404 million pounds in 1920; 694 million in 1930; and 866 million in 1937, the last year a complete survey was made.

If all the nitrogen now needed annually on American farms had to be supplied by imported nitrate of soda, as was largely the case during World War I, it is conservatively estimated that American farmers would require more than 2,700,000 tons of nitrate of soda during the current year.

At the outbreak of World War I, the United States did not have a single manufacturing plant to extract nitrogen from the air. However, since then the chemical industry has developed nitrogen fixation plants. No longer are we almost wholly dependent on foreign sources or on the high-

priced domestic organics of vegetable and animal origin for nitrogen. However, these sources, plus domestic sulfate of ammonia, continue to constitute the current wartime nitrogen-carrying materials allocated to fertilizer use. All synthetic nitrogen is being used for purposes other than fertilizer.

If it were not for the greatly expanded domestic synthetic nitrogen capacity, imports of nitrates would be utterly inadequate for our current needs. In fact, after combining both domestic and imported sources of nitrogen allocated to fertilizers, the manufacturers in that industry face some shortage for the coming season.

Old-fashioned organics, one of the important sources of fertilizer nitrogen at this time, include the vegetable and animal proteins such as oil-seed meals, dried blood, animal tankage, and fish products. However, the trend before the present war was definitely away from these organics and toward increased use of the newer synthetic organics and inorganics. There is every indication that this trend will continue after the war.

Imported nitrate of soda was the only important source of inorganic nitrogen up to and including 1900. Beginning with 1910, ammonium salts, chiefly from by-product coke ovens, also became an important source of fertilizer nitrogen, nearly always exceeding the tonnage of nitrate nitrogen.

As recently as 1925, not a pound of liquid ammonia was used in fertilizers manufactured in the United States but, as the result of practical application of the findings of research, more than one fourth of the nitrogen used in mixed fertilizers in this country at the outbreak of the present war was supplied by various kinds of ammoniating liquors. These give promise of playing an even greater role in fertilizer production after the war.

• • •

WOOD LIFE—For every 1000 board feet of lumber treated with effective wood preservatives, an equal amount of wood products is saved for war use when the treatment given doubles the service life of the treated product.

• • •

BLACKOUT TAPE

With Adhesive Back and Phosphorescent Front

A PHOSPHORESCENT tape available in one yard rolls, one inch in width, has an adhesive back for application to surfaces surrounding openings, obstructions, and so forth. This new tape, made available by the General Luminescent Corporation, will glow in the dark for a period of eight to twelve hours after it has been activated.

ICE INDICATOR

Removes One Worry from Pilot's Mind

A NEW electronic device which signals and measures ice forming on airplanes in flight, and automatically operates the plane's de-icers, should go a long ways toward improving the efficiency of Allied bombing planes. Developed at the instigation of commercial airlines and the United States Army Air Corps, the instrument is the result of protracted research in laboratories of the Minneapolis-Honeywell Regulator Company and in flight tests over the worst icing territory in the United States.

Ice indicator in the laboratory

According to the M-H president, the need for accurate measurement of the accumulation of ice on plane wing surfaces has been acute since winter flying became mechanically possible. De-icing equipment is now standard on commercial airlines and most long-range military planes, but to operate at maximum efficiency, the de-icer must be turned on when the ice can best be cracked off.

"The 'Ice Indicator' provides the pilot with information on the thickness and rate of accumulation of ice on exposed plane surfaces," he stated. "For the first time in flying history de-icing equipment can now be turned on at the exact moment it becomes most efficient."

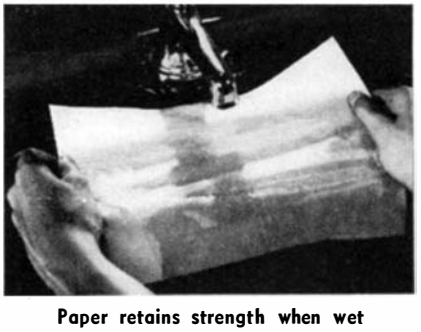
The indicator itself is composed of three separate units and utilizes principles of electricity for its operation. A "pick-up plate" or sensing element is mounted on wing or plane surface where ice accretion is to be measured. This plate, which is very small, is set flush with the plane so as not to disturb the air flow. It contains parts which actuate the mechanism by noting the accumulation of ice. The plate is connected to an amplifier inside the wing, which in turn is connected to a power supply unit. The latter does the actual work of turning on the de-icers and registering accumulation on an instrument board meter. The entire indicator weighs under five pounds.

MELAMINE AGAIN

For Buttons and High Wet-Strength Paper

TWO new applications of melamine resins for widely different purposes were recently announced by American Cyanamid Company. Buttons molded of melamine resin plastic have withstood the gruelling tests prescribed by the Quartermaster Corps for use on cotton garments, heretofore met only by buttons machined from pearl and from imported vegetable ivory; papers treated with melamine resins have high strength when wet and at the same time have substantially increased resistance to folding.

Melamine resin plastic is the only synthetic material unaffected by the stringent tests of laundering, ironing, fading, decontamination, and impregnation imposed by the Army on buttons for cotton underwear and similar items of issued apparel subjected to the most severe conditions in service. Buttons of other synthetic plastics have been accepted for other garments issued to our armed forces, but now melamine resin plastic joins more expensive fresh water pearl and imported vegetable ivory for making buttons to meet the most severe army service. Because buttons can be molded of synthetic resins without machining, their cost is materially reduced.



Paper retains strength when wet

Melamine resin also is the basis of a new treatment for paper pulp that imparts extraordinary wet strength to the sheet made from it and at the same time increases the resistance of the

sheet to folding. Previous methods of raising the wet strength of paper have required special equipment to treat the sheet after it is formed, and the treated sheet has been characterized by lowered resistance to folding. The effect of older treatments has diminished on prolonged storage under conditions of high humidity. The new treatment is applied to the paper pulp before the sheet is formed, requiring no additional special equipment beyond that usual in every paper mill. The fold resistance of the sheet made of pulp treated by the new method is approximately doubled and no diminution in wet strength or fold resistance occurs on prolonged storage even under unfavorable conditions.

High wet-strength paper, valuable for paper towels, vegetable bags and wrappings, corrugated boxes, and similar services where moist materials are handled, is especially important now in view of the widening use of paper to replace other wrapping materials now scarce.

Another type of high wet-strength paper is a recently announced product of Brown Company. Known as Aqualized paper, this new material is being tested as a substitute for cloth and burlap.

By means of an exclusive process, it is reported the individual cellulose fibres in Aqualized paper are effectively interlocked and fastened, thus giving an inherent wet strength all the way through the sheet, independent of any coating or any sizing. This paper can be made in various types, some of them highly absorbent and some of them so fabricated as to repel water.

This new paper lends itself to such unusual uses as for clothing, Army tents, sand bags, and so on. It is also being experimented with in the food field where it is being used for potato bags, crate liners, locker bags for frozen foods, and so forth.

MERCURY "BOMBS"

Save Precious Metal in Fluorescent Lamps

How Yankee ingenuity is stretching the nation's stocks of critical materials was illustrated recently by the announcement that Hygrade Sylvania Corporation engineers have cut the amount of mercury used in the manufacture of fluorescent lamps by approximately 50 percent in a process which has the double-barreled effect of saving mercury and of producing improved lamp performance as well.

Basis of this process is a mercury "bomb" which is exploded in the interior of the lamp during manufacture, ejecting the exact amount of mercury needed, and eliminating the wastage resulting from previous methods.

Mercury, high on the list of critical materials, is essential to the operation of a fluorescent lamp, because fluorescent light is caused by the action on fluorescent materials of ultra-violet rays emitted by electrically excited mercury atoms. Seventy percent of the world's mercury is produced in Spain and Italy, supply sources now closed to the United Nations. The United States produces about half of the remainder, but even in normal times has been forced to import substantial quantities of the metal. The loss of foreign sources skyrocketed the price from $84 a flask in August, 1939, to $202.50 in January of this year. Marginal mines were brought back into production under this favorable price situation, resulting in a 16 percent increase of production, but this has been insufficient to meet the swelling demands of wartime industry, even with the addition of almost all of the Mexican output, which heretofore had been exported to Japan. Stocks dwindled to 12,000 flasks in late 1941.

Under the old method of manufacturing fluorescent tubes, a mercury dispensing device dropped free mercury into the lamp during the exhaust process. It was done automatically, but the process had many drawbacks. First, there was an unavoidable waste of mercury; second, the mercury and the dispensing parts had a tendency to become contaminated, causing further waste; third, and most important, it was impossible to maintain the exactitude necessary for best lamp performance. Some lamps received too much mercury, which resulted in heavy streaks, shadows, and dark end-discoloration in the lamps under operating

conditions. Some received too little, which makes the lamp a "slumper," or one that fades out after a few hours of burning. Thus the percentage of rejects was unnecessarily high, and it was almost impossible to reclaim the mercury in the rejects.

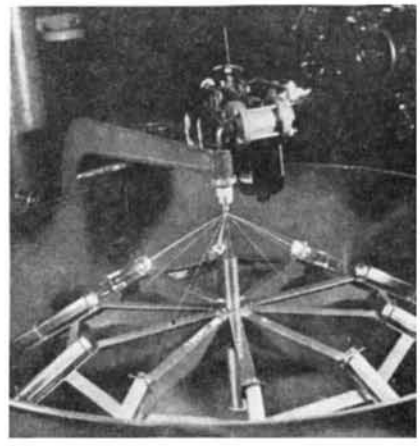
The new "bomb" process "wraps up" the exact amount of mercury needed for the lamp, down to the last milligram, in a tiny metal tube affixed to a support lead of one cathode. When the current is first turned on in the lamp, during the exhaust process, the heat expands the mercury and the tubing "explodes," releasing the free mercury.

Since the tubing length can contain no more than the exact amount, an oversupply of mercury is impossible, and a simple selector device removes from the production line any "bomb" with an insufficient load.

DIESEL NOZZLES

Now Tested for Accurate Delivery of Oil

A TINY injection spray nozzle, smaller than the tip of the little finger is literally the heart of a Diesel engine; the minute holes in the nozzle



Test tubes receive the oil

must be drilled at precisely the same angle to assure uniform injection of fuel. If such uniformity of injection is not obtained, the Diesel cannot operate at its peak efficiency.

These injection spray nozzles employ a ring of holes ranging in number from six to ten, each hole being drilled individually to a diameter as small as 0.008 of an inch. The operation of these holes is similar to that of an atomizer; the smaller the holes, the finer the spray and the more efficiently the oil burns.

The early Diesel engines used compressed air to blow the fuel oil into the cylinders. Then came mechanical or airless injection. Still later came the development, by the Cooper-Bessemer

Corporation, of the pressure relief type of fuel injection which, in contrast with the constant pressure or mechanical injection system, might be more accurately referred to as a "controlled pressure" system.

For testing the fuel nozzles used in the Cooper-Bessemer engines, a device has been developed to check the accuracy of the tiny holes. During the test, as shown in one of our illustrations, individual nozzles are fitted into an arm overhanging a tank. Around the walls of the tank are placed a number of test tubes, the number corresponding to the number of holes in the nozzles to be tested. When oil is forced under pressure through the test nozzle, each tiny stream of oil must strike the mouth of its particular test-tube receiver accurately, and deliver the correct amount of oil in a specified time. Failure to do this results in rejection.

• • •

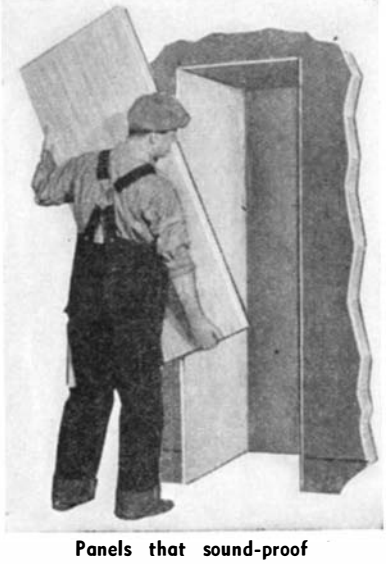
SUGAR—The first successful American sugar beet factory was established in Alvarado, California, in 1879. Nine years later, the second successfully operated beet sugar factory was built, which in that year, manufactured 1000 tons of sugar. Today California leads in the production of beet sugar. In 1941 the state produced 6,182,431 hundred-pound bags of beet sugar.

• • •

SOUND-PROOF

Panels Can be Added to Old Telephone Booths

By placing in old telephone booths a set of newly developed acoustic panels, the old booth becomes sound proof. With the panels in place the old door can be removed, as it is no longer a necessary part of the enclosure. The acoustic panels, manufactured by the



Panels that sound-proof

Burgess Battery Company, are made of reinforced birch plywood filled with a blanket of sound absorbing material, the resulting cellular design giving an adequate sound absorbing effect. The outer surface of the panels can be finished by any conventional method.

PINEAPPLE ENZYME

Can be Used to Make Tough Meats Tender

BROMELIN, an enzyme which, like certain other members of this group, has the property of breaking down meat protein and thus making tough cuts more tender, has been successfully isolated from the peels and cores of pineapples. The technique is said to consist of pressing the juice from the peels and cores at a stage of manufacture at which the juice is of little commercial value to the canner. The bromelin is precipitated from the juice by the addition of ethanol, which can be recovered for use with fresh batches of juice.

DEHYDRATED VEGETABLES

High in Vitamins, Call For Proper Packaging

WHETHER they are being produced for soldiers and sailors overseas, for our Lease-Lend allies, or for our own dinner tables, scientifically dehydrated fruits and vegetables are "delivering the vitamins." According to laboratory technicians, the nutritive value of these space-saving products may be higher for this year's crop than ever before in the industry's history.

As in the case of canned, frozen, or fresh food, vitamin content of dehydrated vegetables depends to a great extent upon the original content and freshness of the raw foodstuffs. Modern dehydrators partly solve this problem by locating their plants in the heart of the growing areas, one of the largest, in California, being within two hundred feet of its own fields.

Optimum vitamin contents of eight typical vegetables have been released by the United States Department of Agriculture, subject to unavoidable variations in the raw stock and other conditions. Arranged in the accompanying table, the figures show vitamin contents found in each 100 grams of dehydrated foods.

The packaging of dehydrated vegetables is an important factor in preserving their maximum nutritive value and palatability and is one of the important wartime projects under way in the laboratories at the New York State Experiment Station at Geneva.

Paper containers of all kinds, cardboard, parchment, foils, waxed linings, cellophane, flexible plastics, and a score of other materials are now under test by the Station scientists. Packages that may meet the necessary requirements for domestic markets may be entirely unsuited for Lease-Lend shipments and for use by combat troops, it is pointed out, because these last two categories require that the package be war-gas proof in addition to the usual requirements.

Different vegetables also present different problems when it comes to packaging. Dehydrated carrots, for example, an important source of vitamin A, deteriorate rapidly and lose color, thus greatly lowering their nutritive value unless the product is packaged under certain conditions. One of the requirements for dehydrated carrots is that the air in the container be replaced with some inert gas, such as carbon dioxide or nitrogen. The Station scientists are carrying on tests with inner liners for packaging carrots. The liners are partially sealed and then the air replaced with carbon dioxide before the final seal is made.

As a final check both of the packaging materials and the packaging processes, the various types of packages under test are being stored in a room maintained as near tropical conditions as to temperature and humidity as possible. After several months' storage under these conditions, the packages will be opened and the contents subjected to various tests, including a taste test, to determine the effect of the packaging and storing on the nutritive value and palatability of the dehydrated products.

	Pro-vitamin A (carotene) milligrams	Vitamin B_1 (thiamin) micrograms	Vitamin B_2 (riboflavin) micrograms	Vitamin C (ascorbic acid) milligrams
Beets	—	40	350	25
Carrots	90	300	300	20
Spinach	40	750	1150	150
Kale	16	500	900	300
Mustard Greens	50	—	—	400
Swiss Chard	3	550	1120	125
Sweet Potatoes	5	200	320	35
White Potatoes	—	425	250	25

ndustrial Growth

lew Products and Processes That Reflect Applications

f Research to Industrial Production

LECTRONIC CONTROL

ar Induction Motors, Operates

Micro-Watts

HE direction of rotation of ordinary ngle-phase induction motors can be uickly and accurately controlled by leans of electric circuits of negligible ower and without the use of mechani- al or moving contacts of any type rough the use of a newly developed ectronic control shown in one of our lustrations.

In the photograph an arrow points o the two control terminals, which re to be connected to any suitable ontrol circuit. The control power in his circuit is of the low order of 100 nicro-watts.

In the setup shown, the 1/50 horse- ower motor weighs about 5½ pounds; he electronic control weighs about ¾ pounds, or a weight ratio of two

Motor and electronic control

o one. The control, developed by W. . Robinette, uses two receiving type acuum tubes of less than one watt ating each.

This electronic control of motor ro- ation is applicable to a number of in- lustrial operations where a relatively mall movement of some mechanism or other moving part is to be applied o governing the direction and speed of a motor.

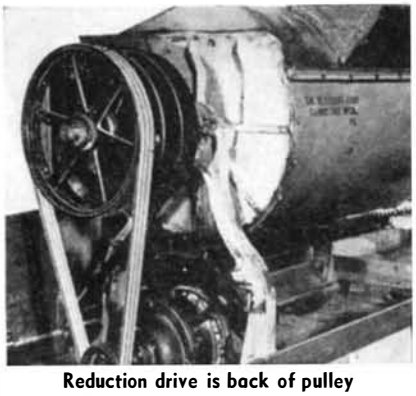
REDUCTION DRIVE

Adapts Motors to Slow-

Speed Machines

A COMPACT speed reduction unit hat mounts on the shaft extension of a machine to be driven is now avail- able in five standard sizes from ½ to 25 horsepower. The unit, made by The American Pulley Company, is attached to the shaft by means of a keyed bush- ing and is prevented from rotating by a torque arm which is bolted to the case and to a rigid support.

Within the case of the unit, shown in one of our illustrations, is a com- pact yet efficient gear train which pro-



Reduction drive is back of pulley

vides a standard fixed speed ratio of 13 to 1. Any differences between this ratio and the desired total ratio can be accomplished by the proper choice of standard pulleys for the primary belt drive. Also, there are available adjustable diameter pulleys which can be employed where operations require frequent or rapid speed changes.

HORSESHOE MAGNET

Speeds Up Welding by

Eliminating Arc Blow

A WARTIME version of the old fash- ioned horseshoe magnet has pointed the way to possible major gains in welding steel plates for war machines.

Savings in man-hours, as well as improvement in quality of welds, are expected to result when the specially designed "magnetic shunt," as the device is called, goes into heavy duty on Army and Navy ordnance mate- rials. The magnetic shunt was used in a series of tests to tame magnetic arc blow, traditional pest of the electric welder.

Magnetic arc blow, according to Charles H. Jennings and Alfred B. White, Westinghouse research engi- neers, is a tendency often developed by electric welding arcs to be deflected from their course, and thus produce slow, irregular, and frequently inferior

welding. Laboratory experiments indicate that an improvement of as much as 20 percent may be made in welding.

Deflection of the arc is caused by magnetic forces produced by the electric current as it passes through the electrode (or welding rod), the steel plate being welded, and through the arc itself, the engineers said, or it may be caused by permanently magnetized plates.

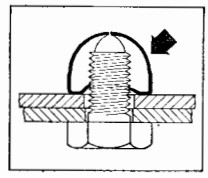
"The electric arc is a flexible gaseous conductor and the presence of external forces causes the arc to be distorted and even be extinguished," Mr. Jenning explained. "When the arc is deflected, the joining metal doesn't transfer properly to the desired location. We have found that re-routing the magnetic forces acting on the arc is an effective way to combat arc blow."

The horseshoe-shaped magnetic shunt is used in the case of heavy steel plates which are permanently magnetized. Made of two bars which are bolted together to provide a good magnetic path between the sides, this shunt is placed along the joint and changes the direction of magnetic forces in the work piece. When welding close to the end of a joint, a flat steel bar will serve as magnetic shunt.

SPRING NUT

Made in Acorn Shape, Is Self-Locking

EXTENDING inward from the base of a newly designed spring nut, now available in acorn as well as other shapes, is a series of fingers that sur-



Fingers formed in shell grip threads tightly

round the screw thread and grip on one thread in a self-locking assembly. A cross-section of one of these nuts, made by the Palnut Company, is shown in an accompanying drawing This new unit, part of the company's line of formed steel nut and lock-nut fastenings, is available in three sizes.

PIER FORMS

For Casting Concrete, Made of Laminated Fiber

LAMINATED, spiral-wound, specially constructed and wax-treated fiber tubes are now available in five standard diameters for use as concrete pier forms. These tubes, furnished in

lengths up to 24 feet and in inside diameters from 9 to 13½ inches, are cut to length on the job, by hand or power saw, in a matter of seconds.

Such pier forms, known by the trade-name of Sonotube, are easy to handle, are easily set up in place, and need not be stripped off after the piers are set up.

GERMICIDE

Added to Cutting Oils, Protects Workers

DEVELOPED to be used by adding to cutting oils, a new liquid germicide is now on the market under the name of Cutacid. Application of four ounces of the liquid in 55 gallons of cutting oil makes a solution that destroys germs, thus protecting workers who may receive skin abrasions and cuts while performing machining operations.

BRIGHT STEEL

Assured by Use of Conditioner in Pickling Bath

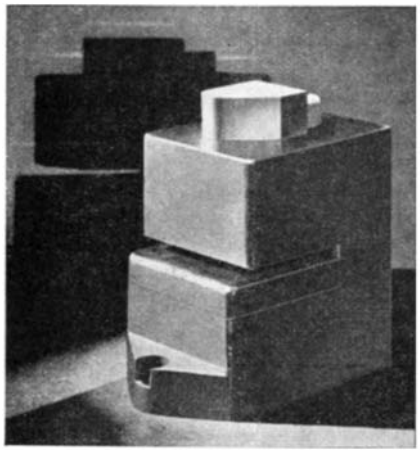
A STEEL surface conditioner for use in either hydrochloric or sulfuric acid pickling baths results in a bright metal surface which is ready for immediate electroplating. It is claimed that the use of this surface conditioner, known as Surbrite, will reduce acid consumption and metal loss in comparison with pickling practices where plain acid is used.

NOTCHING UNIT

Maintains Punch and Die in Alignment

WHERE metal parts require a notching operation for bending or forming purposes, a new unit has been made available which can be used with any press of suitable capacity. Nothing is attached to the press ram, the self-contained holder of the unit maintaining constant alignment of the punch and die.

These notching units, made by the Strippit Corporation, can be set up in series and standard or irregular notching patterns can be achieved in one stroke of the press ram.



Self-contained, cuts notches

UNIVERSAL VISE

Designed to Hold Work in Any Position

THE time required for involved and complicated machine-tool setups can frequently be greatly reduced by the use of a universal type of vise which

Compound angles can be "dialed"

can be applied to drill presses, grinding machines, and other shop equipment. The most complex left and right compound angles can be produced literally by the twist of a dial.

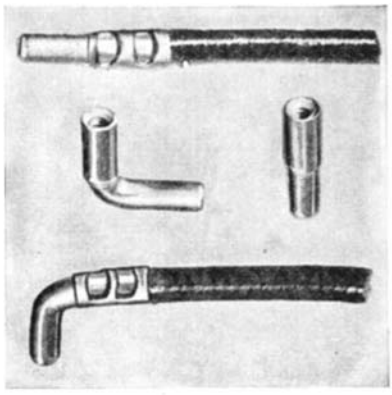
Among the accessories available for this vise, made by the F. & H. Manufacturing Company, is a pair of friction plates joined together by a ball and spring socket. These plates are designed for instantaneous clamping of work pieces whose opposite sides do not lie in parallel planes.

TERMINAL

Solderless Type Assures Durable Connections

A "PLUG TYPE" terminal designed specifically for use on panel boards and rotary switches, on shipboard—or wherever plug-in wire connections are demanded — assures a durable, solderless connection. Manufactured by Aircraft-Marine Products, Inc., these terminals are available in straight and right-angle shapes for wire sizes 16 and 14.

Easily installed—no special skill is required to crimp the terminal onto the wire end with simple hand, bench, or floor type crimping tools—the AMP "plug type" solderless wire terminal is



Straight and angle terminals

made of soft copper, annealed after fabrication to resist bending and breaking and hot electro-tinned for corrosion resistance.

FLAW DETECTION

Accomplished With Sodium Light and Microscope

SODIUM light, which has proved effective for highway lighting, is being used in several important war plants for surface inspection by microscope, because of its efficiency in the detection of pits, cracks, and flaws in materials. The sodium lamp is essentially an arc lamp, and differs from the incandescent in that it requires a special socket and individual control for each lamp.

The unusual perception of detail under sodium illumination is due to the monochromatic nature of the light, according to H. A. Breeding, of the General Electric Illuminating Laboratory. The eye, in common with other lenses, actually focuses only one narrow wave or color band at a time. Other colors in the beam tend to fog the picture. Thus, minute details may be lost in examining an object under a light which contains all wave bands, in contrast to an examination of the same object under monochromatic light which contains only one wavelength. Also, a given amount of energy from sodium light produces several times as much illumination as the same amount of energy in white light.

As in the case of sodium lighting for night safety driving, monochromatic light for microscopic inspection is most effective when spread uniformly over a large area rather than concentrated in small bright patches. In this way an undistorted view of both size and shape of flaws present is obtained. For most effective results, the level of the illumination should be comparatively high, especially when the contrast between flaw and surrounding material is low.

It is helpful in searching for cracks and blow holes to treat the part with either a light-absorbing or light-reflecting dye, the dye depending on the nature of the surface to be inspected. The dyed surface should be cleaned thoroughly before inspection. This procedure increases the contrast between flaw and object to the point where extremely small flaws can be detected. In all cases it has been found necessary to block out as much sunlight as possible, in order not to destroy the monochromatic nature of the sodium illumination.

NO SLIP

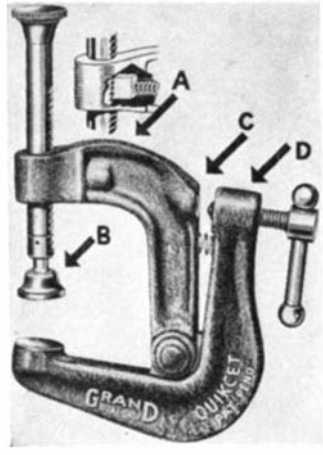
Safe Floor Surface Produced With Emery

A MIXTURE of large and small sharp mineral emery particles has been made available by the Walter Maguire Company for addition to Portland cement and water. This mixture, applied on a concrete surface to a depth of an inch, or more results in complete slip-proofing and a surface that will take heavy trucking wear.

CLAMP

Quick-Acting Design Holds On Straight, Tapered Surfaces

THE long screw of the standard type of clamp is replaced in the clamp shown in the illustration by a ratchet rod. In use, this clamp is placed in position, the ratchet rod is pushed down, and final tightening pressure is



Letters are referred to in the text; inset shows spring-loaded ratchet

applied by the short screw shown to the right in the illustration.

The clamp includes two parts hinged together in an arrangement that prevents slipping on tapered or irregular surfaces. In the illustration, A indicates the spring-backed pawl, B the replaceable swivel in the end of the ratchet rod, and C the point of application of pressure by the screw D.

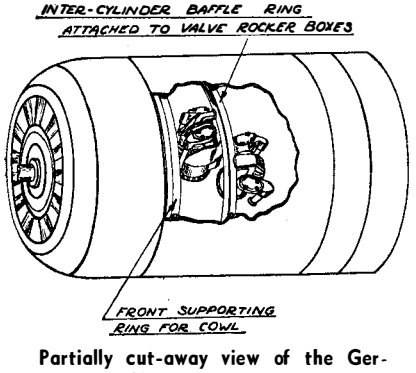
How Germany Does It

Powerful, Compact Airplane Engine Has a Pre-Designed Cooling System and Other "Built-In" Accessories

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

THE most powerful and probably the best air-cooled aircraft engines in the world are built in the United States, but there is a good deal to be learned from the German twin-row engine, the B.M.W. 801A, which has been described in *Flight* and other English technical journals. In the United States and in England we take an air-cooled engine and then fit to it cowling, cowling flaps, scoops, and other accessories. But the Germans have conceived the B.M.W. not just as an engine, but as a real power-plant unit, with pre-designed cooling and other accessories. As a result, the B.M.W. is surprisingly compact and clean, from an aerodynamic point of view.

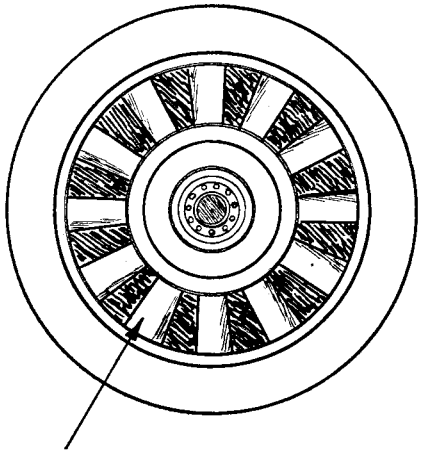
Within a diameter of only 52 inches and an overall length of only 58 inches, there is packed 1580 horsepower at take-off; 1460 horsepower at 16,300 feet of altitude, and 1280 horsepower at 18,500 feet. Of course, the B.M.W. has neither the power nor the altitude characteristics of the P & W engine that is scheduled to equip the Republic Thunderbolt, but the packing of so much power in so small a volume is



Partially cut-away view of the German B.M.W. engine, showing the cooling fan and two of the cowl rings

none the less remarkable. To achieve this small overall diameter the cowling encircles the 50-inch diameter engine closely. It is supported by front and rear rings and an inter-cylinder baffle ring, all attached to the valve rocker boxes by means of rubber-bushed bolts.

To make sure of cooling, particularly during the take-off period, the Nazi designers have introduced another innovation. At the front end of the engine the cowling is faired down to shroud a 12-bladed magnesium-alloy fan of 32 inches diameter. The fan is driven from the engine at nearly twice



Gearing doubles the fan speed

crankshaft speed, thus assuring an adequate air flow when the engine is running on the ground or in flight at slow speed. When the aircraft has a forward speed of 170 miles an hour, the fan is declutched and motored around by the air stream. At take-off there is a loss of 100 horsepower in running the fan, but this serious loss is more than offset by the positive air flow and the small-diameter, low-drag cowling. Exit of the air is by way of two circumferential slots controlled by a sliding ring and special mechanism gives uniform flow all through the engine and at exit. The air intake for the supercharger is completely inside the cowling and fed from the air delivered by the fan, which also helps in reducing head resistance. By this combination of means, a smooth exterior of low aerodynamic drag is attained.

Cylinders are arranged in staggered rows of seven each, with the lowest front and the uppermost rear arranged vertically. Details of construction are

interesting and the whole design appears thoroughly workmanlike. It is also interesting to learn that the exhaust pipes terminate in a flame damping fitting, but without shroud or screen to obscure glow.

There is, of course, a drawback to this compactness, coupled with inherent complexity, and inside the cowling there is a mass of pipes and accessories, which gives an impression of complexity and of difficulties in maintenance. But perhaps the Germans do not intend maintenance work to be carried out on the engine until the power plant is dismounted. At any rate, our designers would do well to study every bit of information that may be available.

FEAR AND HATE

Diminish and Increase With Continuing Air Raids

DR. V. L. GRUBERG, writing in the English magazine, *Flight,* attempts to reduce the psychological value of the air raid to a formula and plots the intensity of various psychological factors against time. His conclusion is that with repetition of the raids, the curve of fear gradually descends while that for hatred rises. Apparently Dr. Gruberg's belief is substantiated by studies of the Spanish civil war and other conflicts, that the air raid makes the civilian population hate so much that they are more determined than ever to continue the fight. That is precisely where the Germans made their great mistake. They thought they could reduce England by inducing fear in the civilian population and failed. The British are on far sounder ground because their raids are primarily for the destruction of war production establishments, and not for the killing of the civilian population, which is incidental.—A. K.

THE THUNDERBOLT

Saves for Weight, Compares Favorably with German Fw. 190

GERMANY'S latest single-seater fighter, the Focke-Wulf Fw. 190, of which we read quite frequently in the press, is equipped with the B.M.W. 801A, previously described in these columns.

The Fw. 190 is remarkably clean. Owing to the compactness of the engine, the fuselage does not show the somewhat "tubby" appearance which we note on fighters having engines of greater diameter. There is a total absence of excrescences to mar the beautiful lines of the ship. The Fw. 190 is powerfully armed with four cannons and two machine guns. But, what is more remarkable, is the compactness of dimensions. The span is only 34 feet, 5 inches; the wing area is only 194 square feet; the gross weight only 8580 pounds. With its powerful engine and relatively small size and its two-speed supercharger, the machine has a remarkable climb of 3000 feet a minute at a 4000 foot altitude, and at 18,000 feet, with the supercharger in high gear, the speed is 375 miles per hour.

With greater speed, greater ceiling, more powerful armament, and more power in its engine, our Thunderbolt is certain to be more than a match for the Fw. 190. But the Thunderbolt is also bigger, weighs 13,000 pounds, according to the New York *Times,* and is likely to be more heavily loaded per square foot of wing area. Our Thunderbolt will be immeasurably superior to the Focke-Wulf at great altitudes. At medium altitudes it will be faster and more powerful, but greater weight also means less maneuverability. We wish our Thunderbolt could retail all its fire power, all its armored protection, all its high ceiling characteristics, but be just a trifle lighter and more meneuverable for moderate altitude fighting. But, in all probability, other of our ships already fill the gap perfectly.—A. K.

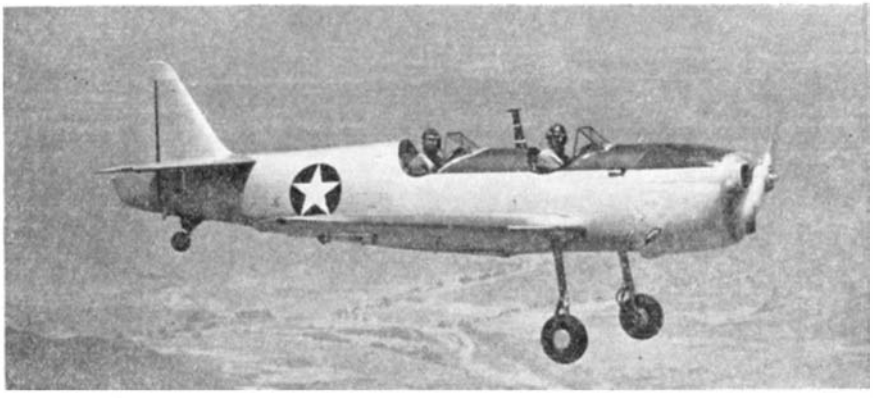
A GERMAN VIEW

Shows Striking Similarity in Research Work

SOMEHOW or other, belligerent nations secure each other's technical or scientific papers and study them with the closest attention. Thus, *Flight,* London, reprints with pride a paper on "Topical Aircraft Problems" read by Professor Dr. Ing. Gunther Bock before the Libenthal Society of Berlin, and in America the paper is hailed with the same eagerness as in London. Yet nothing very novel is discoverable. Apparently the Germans are thinking on similar lines to ourselves.

Thus, we have frequently mentioned in these columns that if the flow could remain laminar over the greater portion of the wing, the drag could be very much reduced, and that the path of progress lay in so shaping the wing as to make the suction more uniform over the upper surface of the wing, so as to delay change from laminar to turbulent flow. Professor Bock advocates exactly the same line of research. Another problem, according to the same German authority, is to eliminate the windshield and blend very large windows into a streamline form. Such practice also coincides with ours.

All the nations at war are seeking



No critical high-alloy steel in fittings or standard parts

greater power output than their enemies: Let us quote from the German authority: "This effort has led, in Germany, to going over from the carburetor engine to the injection engine. On its passage through the carburetor, the air is, as is well known, throttled and therefore energy is removed. In the injection engine the carburetor is omitted, and the fuel is injected direct into the cylinder on the induction stroke by special pumps. The throttling losses of the carburetor therefore disappear, and we obtain, by going over to injection, an increase in power output of 4 to 10 percent."

The no-thrust radiator is agitating the Germans just as it is us: "The air which passes through the radiator is heated and expands. On account of this, it leaves the radiator cowling with greater velocity than it would have in the case of a cold radiator. This increase in speed produces a thrust, as in the case of a rocket."

Considerable attention is given by the Germans, as by ourselves, to utilizing the exhaust gas energy for supercharging, and in general to utilizing exhaust gas efflux for producing thrust.

All of this reads remarkably as if one of our own engineers had read a paper before the Institute of Aeronautical Sciences. It indicates that technologists everywhere are apt to tackle the same problems at about the same stage of evolution.—*A. K.*

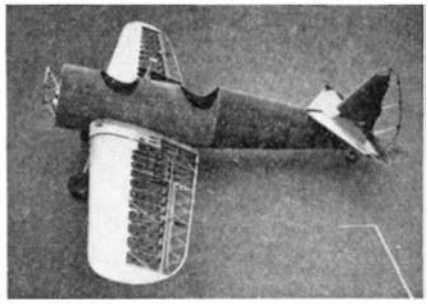
TRIM TRAINER

Ryan-built Plane Made of "Ersatz" Materials

THE Ryan PT-25 Military Primary Trainer is an excellent training plane, well adapted for its purpose in every way, and the result of many years experience in the construction of such aircraft. Powered with a six-cylinder opposed Lycoming air-cooled engine, it has speed and maneuverability. Both student pilot in the front cockpit and instructor in the rear cockpit enjoy excellent vision.

But what is perhaps more important at this time is the fact that the PT-25 dispenses with aluminum alloys and all other strategic materials, except those which appear in the cowling and, of course, in the engine, which could hardly be built of wood.

Moreover, the design is a splendid embodiment of the plastic-bonded plywood construction which is assuming such great importance today. The smoothness of line has been obtained with a minimum of compound curved surfaces, so that a manufacturing



Plywood and other "ersatz" materials play a big part in wings and fuselage

method is employed which does not require the use of ovens or baking, and cold-setting urea formaldehyde glues are used throughout. The fuselage is of the monocoque stressed skin type with ten bulkheads formed of laminated spruce, and is plywood covered. Although well streamlined, the fuselage has such lines that manufacture is easy. A unique jig allows the workman to go inside the jig and unbolt the holding forms after fabrication, so that all that is then necessary is to slide the completed section off the jig. One of our photographs shows a view of the wing construction. Each wing panel is built up from a single wood spar with wood ribs and a plywood-covered nose torque box. Fabric covers the rest of the wing. This type of construction reduces labor to a minimum and, because the weight of the wing is far forward along the chord, flutter is not likely. The simple construction is apparent from the photograph.—*A. K.*

CAMERA ANGLES

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

Your Town in Wartime

KEEP a picture diary of the changes going on in your town during the course of the war. It will be a valuable historical record not only for your own family and friends but, if well done, for the town itself. For example, this shot was made in Provincetown on Cape Cod, where the war has had a marked effect on the pattern of the town's life and ways. A Coast Guard training station

"Them Coast Guard Fellers"

there has made Coast Guardsmen part of the regular population and restrictions due to wartime necessity have limited the fisherman's choice of fishing areas. Something of the natives' reaction to the change has been caught in this picture.

Greeting Card Time

CHRISTMAS is on its way again and greeting card making is in order. This year greeting cards are more important than ever, particularly for the boys in the camps, and pictures will be appreciated by the fighting men more keenly. For the boys farthest from home and unable to get away for long enough periods to make the round trip to home and back to camp, pictures of family and friends will have a real meaning, like a visit from the folks. Whereas formerly a decorative scene of some sort did the trick fairly adequately, this year send faces.

Expose Color for Shadows or Highlights?

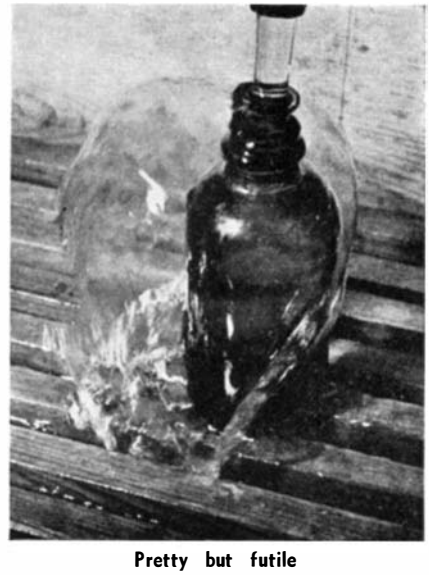
THERE was a rule once, that seemed as fixed as fate, that one should expose for the shadows and let the highlights take care of themselves. Today, some doubt the accuracy of this and in certain quarters it is even suggested that we should expose for the highlights instead. However this may be for black and white, in color, where the range of illumination should never exceed four to one for reasonably good color rendition, it is advisable to read the highlights. If we were to expose for the shadows in Kodachrome, our highlights would be washed out; if we expose for the highlights, the shadows are rendered satisfactorily enough. The one exception to this rule might be the occasion when the shadows predominate and the highlights occupy only a small part of the scene. Then, obviously, our shadows should get the major attention and the exposure meter should be directed toward them to obtain the proper exposure.

Lantern-Slide Lectures

NOTHING can teach a fellow how to make better pictures so well as the constant observation of prints that have won salon recognition time and time again. Realizing this, the Metropolitan Camera Club Council, of New York, has instituted a project under the direction of C. T. Boyles, A.R.P.S., designed to provide camera clubs with lantern-slide lectures showing reproductions of prints that have been hung in outstanding American photographic salons. Constructive criticism will accompany the prints. The photographing of the originals was done by J. Ray Hoagland, first vice-president of the Council, and Ernest F. Draper, technical advisor.

Efficient Washing

LOOKS pretty, but is it efficient? Of course not. The illustration is an exaggeration, naturally, but have you ever noticed how careless some folks are about washing roll film in tanks? They let the water run in from the faucet and hope that somehow, willy-nilly, the films will get washed. The water has to get straight



Pretty but futile

to the bottom of the tank and with enough force to drive the hypo out. The only way to do this effectively is to use a hose let down to near the bottom of the tank. The water will then force the hypo up over the top of the tank and out.

Copying Rough Prints

PRINTS on rough or matt surfaces are difficult to copy because the results usually show the texture of the paper, making the copy a rather unsatisfactory job. One suggestion to avoid this is to rub the print down with a good coating of petroleum jelly (white Vaseline). Apply the coating evenly. Illuminate the print so that reflection is prevented and that even illumination is produced. The grain is greatly minimized if not eliminated entirely. The glazing action over the paper texture does the trick.

Comparing Lens Apertures

HERE'S a handy table (Bell & Howell) which both movie and still fans should find useful. Comparing aperture *f*/2.5 with *f*/3.5, for example, we find that the coefficient of *f*/2.5 is .06; that of *f*/3.5 is .12. The latter being double the former, the *f*/2.5 aperture is twice as fast as *f*/3.5. Figures starred represent the true, full stops, each of which admits 100 percent more light than the next smaller true stop. For all practical purposes *f*/1.5 is equal to *f*/1.4, and so on:

Coefficient of Illumination	F Stops	Coefficient of Illumination	F Stops
.01	*1.	.30	5.5
.02	*1.4	.31	*5.6
.03	1.7	.40	6.3
.04	*2.	.64	*8.
.06	2.5	1.21	11.
.07	2.7	1.28	*11.3
.08	*2.8	2.56	*16.
.12	3.5	4.84	22.
.16	*4.	5.29	*23.
.20	4.5	10.24	*32.

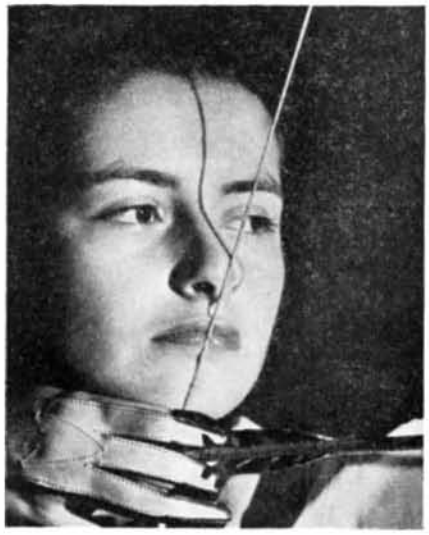
Sunset Silhouette

ONE of the reasons for the failure of many sunset pictures is the lack of interesting foreground material. Choose a viewpoint where you can include part of a boat, the wharf, or some other object, place it appropriately in the picture area, and you have something far superior to the mere sunset shot, which includes only sky and water.

"Haiti Sunset"

Record Into Pictorial

THERE's no law that says a record shot made for the sole purpose of illustrating a fact cannot also serve the uses of pictorialism. Take, for example, the picture of the girl drawing the bow string. This was one of a series of pictures made



For record and salon

to illustrate the technical details of archery. Most of the pictures in the project were useful only as part of the complete set, but here and there opportunities presented themselves for special pictorial treatment. A print such as this, for example, can be finished off in salon style, with toning and all the fixings.

Prints on China

HERE's an idea for those who have been wanting to print a picture on china or glassware. Chromatone Stripping Paper, ordinarily employed in color printing, will serve for black-and-white printing as well. Make your print as usual, strip the emulsion from the base, then fix and wash as you would when making ordinary prints. Apply a coating of gelatine to the china, glass, or whatever, then mount the print. When perfectly dry, cover with a coat of clear waterproof varnish.

Pictures for Reproduction

A FAVORITE method with engravers in judging how a print will reproduce in a publication, is to look at the print with eyes half closed. This compresses the tone scale and reduces the values to somewhere near the tone range that can be expected in the reproduction. Delicate differences between highlights, for example, tend to merge into a single tone, indicating that a new print should be made to show more contrast.

Our Book Corner

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By A. W. Carmichael

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THERE are several good textbooks of meteorology, ranging from dull to readable—as textbooks. There also are numerous popular weather books, but most of these are superficial. Major Wenstrom, formerly with the United States Army Weather Service (where he took his weather science from a 'plane), has successfully combined the good aspects of both. Result is a book which digs well into weather technicalities, but does so very readably. He exhibits a marked flair for lucid explaining. This book is solid and quite large, yet conversational—never dull. Aimed at solid readers—foresters, aviators, farmers, mariners, and other people who want to understand weather science and become their own amateur prognosticators. (484 pages, 6 by 9 inches, illustrated.)—$4.60 postpaid.—*A.G.I.*

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——OUR BOOK CORNER——

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By W. L. White

THIS, the story of Lieutenant Commander Bulkeley, of Bataan fame, his buddies, the thousands of brave Americans and Filipinos, is something all of us should read not once, but many times. Men like Bulkeley and his comrades sacrifice themselves as "expendables" for the reason, as one lad says in the book, "that those few minutes gained are worth the life of a man to the army. So you don't mind it until you come back here where people waste hours and days and sometimes weeks, when you've seen your friends give their lives to save minutes." Imperative! (209 pages, 5¼ by 8 inches.) —$2.10 postpaid.—*A.D.R., IV.*

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"

IN THIS department, in our September number, we showed a photograph of the huge worm wheel for the R. A. drive of the 200″ telescope. Through the courtesy of *Modern Machine Shop,* Cincinnati, we make available to our readers an account, written by Robert Clark, of the exceedingly refined and prolonged job of cutting the teeth on the gear within a tolerance of one second of arc (1/1,296,000 of a circle).

Only once in the history of gear cutting has there been any record of the cutting of a worm gear weighing ten tons, having 720 — ¾-pitch teeth within an overall tolerance of 0.0001″. To three men go the credit for this feat; Mr. G. Sherburne, Superintendent of the Astrophysics Machine Shop at the California Institute of Technology, and his assistants, Mr. Tom Weir and Mr. Lawrence Sills, machinists.

The gear, one of three identical gears cut, is used to drive the mechanism which positions the 200″ telescope.

The architect's drawing (Figure 1) shows a cross-section of two of the gears which are employed to position the telescope in right ascension. One of the gears makes it possible to move the telescope quickly in making a setup; the other is the final gear in a set which swings the telescope at the exceedingly slow speed required to follow a star.

The drive gear, which is 14′3″ diameter, is of cast iron with 0.25 percent of molybdenum added to give it the necessary 200 Brinnell hardness.

One of the initial problems was the design of a support for the blank which would make it possible to keep the side play down to the error allowance of 0.0001″ while the teeth were being cut. The first job, then, was to construct a bearing and spindle that would meet these requirements. This was done by machining the spindle so that it had two tapered surfaces—one near the top, the other near the bottom—that were lapped into two tapered bearings which were made to take them.

A small pilot shaft at the end of the spindle rested on a special thrust bearing which could be adjusted. By slightly raising the spindle and gear, the coefficient of friction could be lessened to prevent the spindle from freezing in its tapered bearings, although, even with this setup, the matter of lubrication to the spindle caused considerable trouble. Even the lightest oil film would permit side play of more than 0.0001″. Indeed, the capillary action of the light oil was sufficient to raise the spindle, gear, and structure—weighing more than 10 tons— as much as 0.0001″. The vertical movement was not of much importance, but the side play was. However, by the expedient of machining facets in the tapered sections of the spindle, the error caused by the oil film was eliminated to within the tolerance allowed.

Adequate temperature control could be obtained only by the construction of a room about the whole job. Air conditioning equipment was then installed, with which the temperature of the room could be controlled within plus or minus 1° F. When ready to run, the room temperature was maintained at 74° to 76°.

Calculations that had been made showed than any equipment for indexing, if placed upon the gear blank itself, would develop a warping action due to the stresses set up by the cutting, and thus would ruin the accuracy of the job. To eliminate this difficulty, an auxiliary plate of approximately the same diameter as the gear was made and securely bolted to the blank so that measurements could be taken from it for the milling operation.

In order to space the teeth properly, buttons of hardened tool steel, ground to within 0.0001″ of a given size, were mounted on the plate. Dial gages were then used to ensure perfect location.

[Note by Ed., Scientific American.—These "buttons," from here on frequently referred to, are the "toolmakers' buttons" which are familiar to mechanics. Whenever high-precision accuracy in the positioning of a cutting or grinding operation is called for, methods such as making marks by ordinary measuring are not sufficiently close. There must be some additional method of "correcting the aim" by a series of closer and closer approximations. This is done by the use of "toolmakers' buttons." First, the point is determined as closely as possible by ordinary methods. A center-punch mark is made and a hole is drilled and threaded. The button, a small steel cylinder (several of which show in Figures 2 and 4) having a vertical, central hole, is then attached by means of a machine-screw.

Figure 1: Left: **The drive in right ascension**

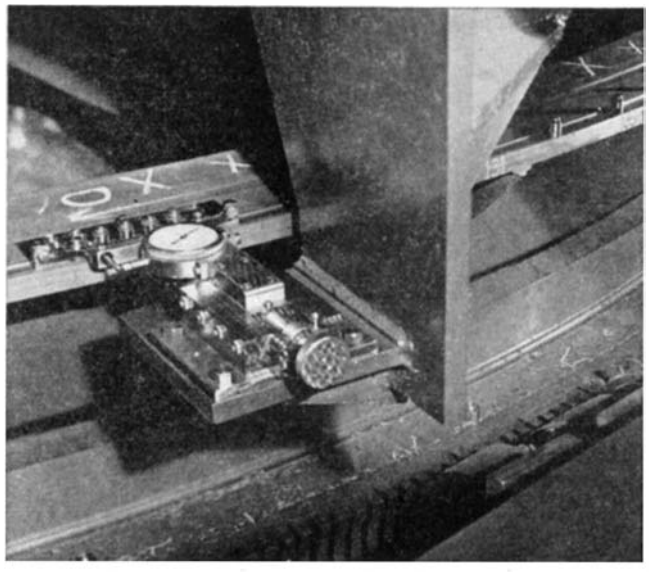

Figure 2: Right: **Positioning the teeth with buttons**

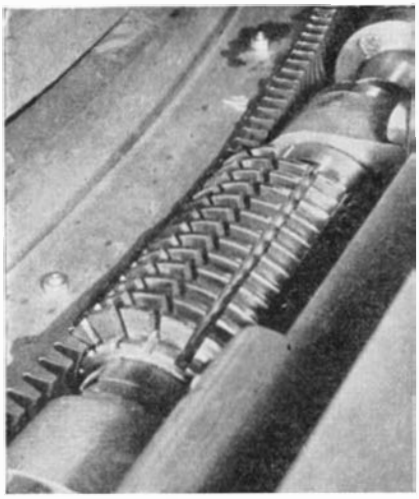

Figure 3: Cutting the teeth

The hole in the button is purposely made larger than the machine-screw, so that the button will have side play. If, now, the screw is adjusted just snugly, but not too tight, the button may still be shifted in position within small but sufficient limits. This is done by delicately tapping on its side with a light tool. When the final measurement, made in the present instance by means of a long tram rod, or trammel, indicates that the button is positioned as closely as possible, the screw is set up, and the machine is adjusted to cut in relation to this button, the button itself being then removed to permit completion of the operation. Since the dimension of the button enters into the measurements and calculations, this must of course be accurately known.]

The process of locating the buttons on the button plate presented some interesting problems. The placing of the first one was, of course, easy, but locating the second one, which was to be 180° away, was another matter. All the buttons were mounted on an eccentric, which allowed them to be adjusted slightly. The second button was roughly located with the aid of a straight-edge lined up across the center of the plate to within perhaps 0.004″ to 0.005″. Then the slow, tedious task of adjusting the buttons at points exactly 180° apart, within 0.0001″, began.

Two dial indicators graduated to 0.0001″ had already been set up 180° apart, positioned on ground ways. The first indicator was adjusted to the leading edge of the first button, and set to read zero. The second indicator was then set on the second button and set to read zero. Then the gear was revolved 180° and new readings were taken. Of course, the readings were off.

The buttons were then adjusted to compensate for the error, as closely as it could be judged, and the gear was revolved again. The error was less the second time, but still over the allowable limit. Again the buttons were adjusted and again the gear was revolved the 180°. After many more trials and adjustments, the buttons were spaced within the allowable limits.

Now came the problem of locating the second set of buttons at the 90° positions.

The exact spots for these buttons had been determined by calculations and a tram rod had been made to measure the distance from the first two buttons. From the calculations the buttons for the 90° positions were set to within 0.004″ or 0.005″. Then the tram rod was used.

At one end of the tram rod was a hardened "V," made to fit the buttons. At the other end was a dial gage, reading to 0.0001″. The tram was well insulated by wrapping it with paper, and a wooden handle had been incorporated into the construction so that the heat from the machinist's hands would not introduce errors in the readings. Just one degree of temperature shift was found to change the reading as much as 0.0002″.

The next move was to adjust the two buttons in the 90° positions so that, by using the tram in any one of the four quadrants of the gear, the error was brought within the allowable limits. This process was repeated with another tram for the 45° positions of the third set of buttons, and other trams of the correct lengths were used until all of the 144 buttons had properly been spaced on the plate. This allowed a button for every fifth tooth on the gear. When the time came for milling the intermediate teeth, an insert of four buttons, shown in Figure 2, was used.

With all the buttons properly located, it was time to cut the first gash. Then the gear was revolved 180° to eliminate accumulated error, and the second gash was made. Then to the 90° position, and so on. The rough milling was done in two stages, taking two straight cuts and leaving 0.007″ in the second cut to be removed by the hobber in the finishing cut. The hobbing operation is illustrated in Figure 3.

It was found that, during the milling, the heat generated by the cutter materially affected the accuracy of the operation. To relieve this situation, a hollow cutter arbor was used through which water at a controlled temperature could be circulated.

After the first roughing cut had been made for all 720 teeth, the method of checking for accuracy was changed. A microscope was anchored in position over the handwheel of the worm, which was graduated in 0.0001″, and a dial indicator was positioned so that it would touch a tooth some distance away on the periphery of the gear as shown in Figure 4. As the gear was always revolved in one direction only, no correction was necessary for backlash. Upon checking and rechecking it was found that the error between any one tooth and any other was only 0.0001″.

When the gear blank was made, it had been split horizontally, with the idea that the two sections could be unbolted after the rough milling had been completed, so that the top section could be revolved 180° before the finishing cut was taken. This would, of course, have increased the accuracy. However, by using the method and care described above, this action was rendered unnecessary.

The milling operations took ten months, and the finish hobbing operation took three weeks. Two and one half years in all were required to cut the teeth on the three gears. As the work progressed from one gear to the next, the accuracy improved. For instance, in the cutting of the first gear there was an error in one of the quadrants of 0.0004″. This error made that particular quadrant unusable. However, the three remaining quadrants were within the allowable tolerance and this gear is now used for the North and South declination with the bad quadrant at the top of the gear where it is never used.

This completes the abstract from Robert Clark's account of the job for the 200″. In referring to Figure 1 he terms it "the architect's drawing," which is quite correct, but the architect happens to be Russell W. Porter. At that, Porter is an architect—or was so educated.

Those who have *created* a setting circle—that is, not simply taken off the marks from another divided circle or transferred them from gear-tooth spacings (which is about the same thing), but who have themselves divided a circle out of the void and nothingness, will recognize the almost exact similarity of the method employed with the method described above. The following is a short additional note written for the most recent printing of "A.T.M.A." and inserted on page 302. It briefly explains this method of creating a setting circle, and incidentally may be clipped out and pasted in earlier printings of "A.T.M.A." by those who own that book. It runs—

"Editor's Note: For theoretical data on setting circles, see chapter on 'The Divided Circle,' in Martin's 'Optical Measuring Instruments.' Also see article on

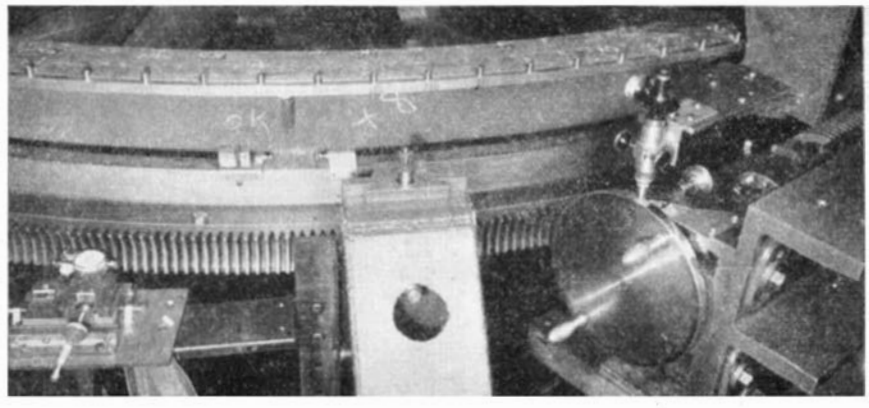

Figure 4: Measurements refined to microscopic precision

Divided Circles,' in Glazebrook's 'Dictionary of Applied Physics,' Vol. IV. The latter explains the methods used in one example chosen, for inscribing 4320 divisions, one for each 5 minutes of arc, on a 48″ circle, within an accuracy of ½ second. The method is one of trial and error in a series of closer and closer approximations.

"A crude suggestion of the principle used can be had by tacking a circle of cardboard at its center to a board. Place a reference mark (representing the cutter) on the board adjacent to the edge of the circle and mark the periphery of the circle in continuation of it. Call this zero. Select the 180° point on the circle by approximate estimate. Make a tentative 180° mark, and continue it on the board. Now rotate the circle till the 180° mark lies next to the cutter. The true 180° point should now be halfway between the rotated zero mark on the circle and the nearby mark on the board.

"Estimate new marks for a closer trial and repeat the cycle; and so on.

"Using this as a starter, in the example mentioned above, the 90° and smaller divisions on the 48″ circle were filled in by similar principles, and it all required six months of tedious slavery for the 4320 divisions. The approximations soon fell within the field of compound microscopes powerful enough to detect errors of one tenth second, or 1/86,000 inch.

"Gluttons for this general type of masochism will find in the same volume of Glazebrook a 10-page article on 'Diffraction Gratings, the Manufacture and Testing of,' by Dr. J. A. Anderson. Asked how the two jobs, the 48″ circle and the construction of a ruling engine, would compare in difficulty, Dr. Anderson stated that the ruling engine job would be far more difficult, since so many more factors enter into it—not alone equality of spacing, but length and parallelism of grating lines."

End of "A.T.M.A." supplementary note.

This is not to say that the circle job is easy, and similarly for the big worm wheel job, but only that the ruling engine job is super, hyper, ultra. The other jobs are merely super, hyper.

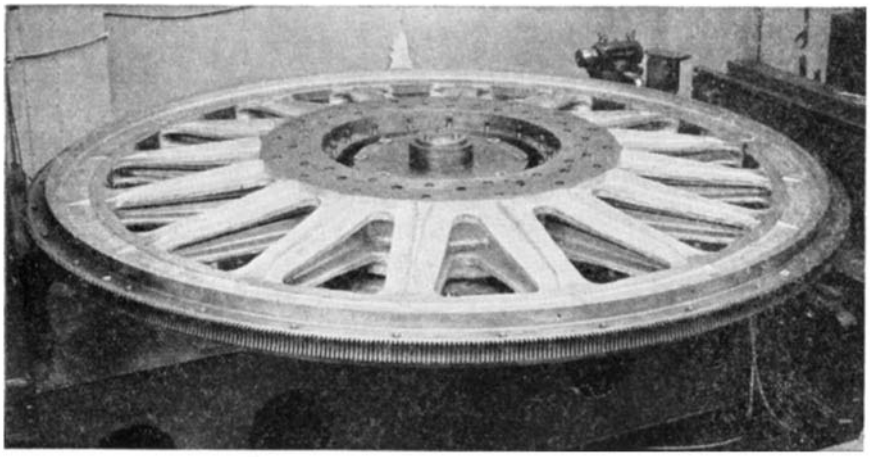

Figure 5: **The finished gear with 720 teeth of ¾ pitch**

EXCHANGE: From Peter Dawson, Care Dr. A. C. Ainsley, Greylands, Victoria Road, West Hartlepool, County Durham, England, comes the following: "Could you find two or three young fellows, at about the same stage as me in telescoptics, to correspond and keep the interest aglow, now that the difficulty of obtaining materials over here is increasing. I am only a very green amateur, aged 18, and my interest began three years ago. During this time I have been studying physics (with particular accent on optics) and hope to go to University to continue, in October. I have completed a 2½″ refractor, the O.G. of which I did not work—I just did the engineering and woodwork. I have started a 6½″ mirror and am at present grinding. I have studied that excellent book 'A.T.M.,' also 'A.T.M.A.' I am also a keen trout fisher. Do you think you could wangle it so that my correspondents are cursed with this plague too?"

LYE will protect a mirror, silvered or aluminized, from sweating due to condensation. Charles and Harold Lower, of San Diego, report thus: "A warm day followed a night of high humidity, and our mirror sweated. Lye, impure form of caustic soda (Na OH), has an affinity for water, and it is cheap, so we tried putting a can of it inside the telescope when closing up after a spell of observing. It worked. No more condensation on the mirror in the morning. Best of all, we found that it greatly reduced the tendency of the silver to tarnish. We have kept a silvered mirror in good condition for five years by this method, and the telescope was in regular use, in town. About half an inch of lye in the bottom of a peanut-butter jar will protect a 12″ telescope for a week or more, in rainy weather; much longer in dry weather. If neglected, it will continue to absorb moisture until the solution is about an inch deep. When the jar accumulates too much water we throw the lye away."

Lye costs about 15 cents a pound, at a grocery store, caustic soda (chemically pure) costs about 15 times that much; and the one is about as good as the other for this. Keep it off the mirror—silver or aluminum—and off the hands.

CURRENT BULLETIN BRIEFS

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

PERMUTIT ZEOLITE WATER SOFTENERS AND ION-EXCHANGERS is a 16-page illustrated bulletin which deals with the troubles caused by hard water in many industries and describes in considerable detail a complete line of equipment for softening such water in any needed quantities. Request bulletin No. 2386. *The Permutit Company, 330 West 42nd Street, New York, New York.—Gratis.*

THE FUTURE OF AIR TRANSPORTATION is an eight-page mimeographed folder which provides a broad survey of current developments in the field of air cargo transportation and outlines the potentialities of this part of the aviation industry in peace-time years. *Estabrook & Company, 40 Wall Street, New York, New York.—Gratis.*

INDUSTRIAL DIAMOND TOOLS is a four-page illustrated folder which gives general information on industrial diamonds and their characteristics, on where they are produced, and on a series of wheel-dressing tools. *Christensen Diamond Tool Company, 3683 East Willis, Detroit, Michigan.—Gratis.*

MACHINING ALCOA ALUMINUM is a 48-page booklet for those who are interested in this particular subject for immediate use as well as for planning for the future. Request this booklet on your company letterhead. *Aluminum Company of America, Pittsburgh, Pennsylvania.—Gratis.*

PLASTICS is an eight-page booklet illustrating and describing the manufacturing process, compression molding, and uses of phenolic plastics and resins. Given also is a brief review of recent books and suggestions as to sources for further comprehensive study of the subject. *Durez Plastics & Chemicals, Inc., North Tonawanda, New York.—Gratis.*

PATENTS, CONGRESS AND THE NATION, a statement by the Boston Patent Law Association, is a 12-page pamphlet prepared to place before interested people the facts of the attack on our patent system which has been fomented by a group of men who apparently have a very slight appreciation or understanding of the value and benefits of the system. *The Boston Patent Law Association, Boston, Massachusetts.—Gratis.*

THE OBSERVER'S HANDBOOK for 1943 contains data on the planets and other astronomical phenomena, month by month; also lists of double and multiple stars, four star maps, an ephemeris of the Sun, times of moonrise and moonset for every day of the year for four selected latitudes, and miscellaneous astronomical data to the extent of 80 very useful, practical pages. Most amateur astronomers obtain this booklet each year. *Royal Astronomical Society of Canada, 198 College St., Toronto, Ontario, Canada.—25 cents.*

75,000 RPM AT YOUR FINGERTIPS is a four-page folder describing a new air-driven grinding wheel which turns at that speed. The wheel is designed for use by die makers, industrial model builders, machinists, and so on. *Onsrud Machine Works, Inc., 3900 Palmer Street, Chicago, Illinois.—Gratis.*

COMBUSTION EFFICIENCIES AS RELATED TO PERFORMANCE OF DOMESTIC HEATING PLANTS is a 30-page booklet concerned with all phases of the subject of its title, and with definite types of fuel. The text is supplemented by a number of pertinent charts and tables. University of Illinois Bulletin No. 42, Circular Series No. 44. *University of Illinois, Urbana, Illinois.—40 cents.*

HAND-FIRING OF BITUMINOUS COAL IN THE HOME, by Kratz, Fellows, and Miles, of the Engineering Experiment Station at the University of Illinois, offers practical suggestions to householders who have been forced to change from smokeless fuels to bituminous coal in the same equipment. *University of Illinois, Urbana, Illinois.—25 cents.*

A GUIDE TO BETTER BEARING LUBRICATION is a 28-page booklet, illustrated with a number of drawings and charts, which treats the functions of lubrication, oil lubrication, recommended viscosities, circulating systems, grease lubrication, grease supply systems, and so on, for ball and roller bearings of various types. Particularly stressed are those features which, coupled with lubrication, insure longer life for machinery. *SKF Industries, Inc., Front Street and Erie Avenue, Philadelphia, Pennsylvania.—Gratis.*

KEEP 'EM WORKING is a 46-page illustrated booklet essentially designed to aid owners of Caterpillar products in getting the most out of their machines. It goes into considerable detail on the care and maintainence of such equipment. Request Form No. 7609. *Caterpillar Tractor Company, Peoria, Illinois.—Gratis.*

SIL-FOS AND EASY-FLO is a 16-page bulletin, illustrated with a large number of photographs giving details of a low-temperature brazing method using silver alloys. This method can be applied to ferrous, non-ferrous, and dissimilar metals, with speed and economy as important factors. *Handy & Harman, 82 Fulton Street, New York, New York.—30 cents.*

REPLY TO BEWILDERMENT, by A. W. Robertson, is a 16-page discussion of democracy and the nature of wartime leadership. The text is the answer to a letter received by the author, in which a request was made as to the definition of the duties of patriotic Americans. *Westinghouse Electric & Manufacturing Company, 306 Fourth Avenue, Pittsburgh, Pennsylvania.—Gratis.*

INDEX TO VOLUME 167, JULY—DECEMBER, 1942

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and

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FROM time to time the judges of the Book-of-the-Month Club choose a double selection—two books offered to members at approximately the price of one. *They Were Expendable* has been hailed as the first great story to come out of the war—the tragic epic of the Philippines as told by four survivors of the heroic MTB Squadron 3. *The Seventh Cross* is a breathtaking novel of escape, "unlike anything that has come to us from a Europe under the shadow of darkness and fear." Our judges have introduced to American readers many of the most important European writers—Sigrid Undset with *Kristin Lavransdatter,* Arnold Zweig with *The Case of Sergeant Grischa,* Felix Salten with *Bambi*—and many others. Anna Seghers surely belongs in this category. The two books together are being sold to Club members for $3.00.

SQUADRON 3 consisted of six little boats—about a dozen men to a boat. Each boat was armed with four torpedo tubes, four 50 caliber machine guns. There isn't an ounce of armor steel on these boats—they're little eggshells made of plywood, powered by three Packard motors, designed to roar in, let fly a Sunday punch and zigzag out to dodge enemy fire. Yet between December 7th and the end of February they sank a hundred times their own combined tonnage in enemy warships. For every man in the combined crews, they had already probably killed ten Japanese. Their casualties to date were only one man, wounded. They were to lose more later, but the Japs were to pay at almost the same ratio.

Suddenly five Jap bombers dive at the three torpedo boats commanded by Lt. John Bulkeley. Bulkeley's men begin circling and twisting. They pick out a plane, pour 50 caliber slugs into it until it crashes. The 31 boat gets two more. After this the planes don't bother strafing MTB boats.

Kelly, the squadron's second in command, gets bad strep infection in his arm, and is ordered to army hospital on Corregidor, where his irrepressible high spirits make him a pet of the nurses. They call him their one-man morale officer. And when Peggy, with a choice of 10,999 men on the Rock, turns down a party and spends New Year's Eve with Kelly, sharing two apples and a box of marshmallows, it's the best New Year's Eve Kelly has ever had.

Bulkeley in PT41, Kelly in PT34 surprise a big Jap cruiser. Although caught in her searchlight and a continuous stream of fire, Kelly gets two direct hits. The cruiser's magazines explode, she soon sinks. Four destroyers now chase the PT boats but both finally get away, not without casualties.

Looking like a Spanish pirate, black-bearded Bulkeley commands the PT41 taking General MacArthur and his family from Corregidor. Without navigation instruments or chart they roar along at full speed through pitch blackness. Always there is the menace of lurking Jap destroyers and dive-bombers. Yet the mission is safely completed.

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