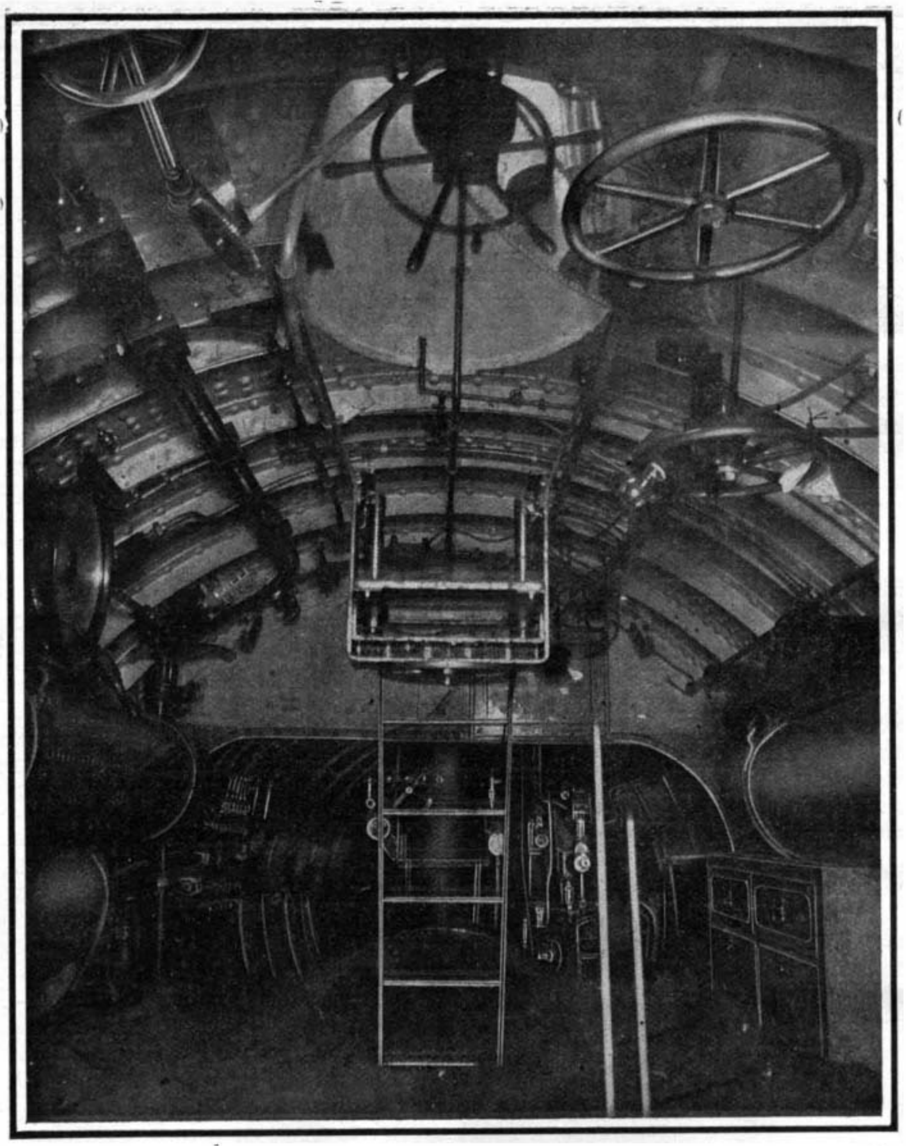
THE CONSTRUCTION AND HANDLING OF SUBMARINES.

BY WALTER BERNARD.

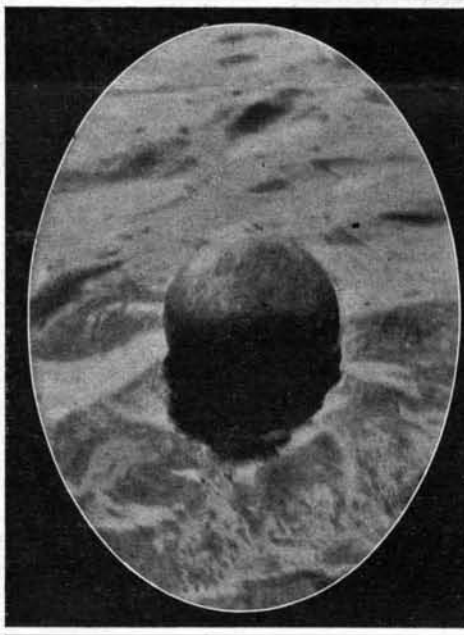
Attention is called to the subject of submarines by the competitive trials now being carried out by the government at Newport. Of the two main classes of American submarines of the diving and even-keel type, the former has been adopted by our navy. The present trials at Newport are being held between the Holland and Lake types. The eight submarine boats now in service are 63 feet long and 12 feet in their greatest diameter, and have a displacement when awash of 105 tons, and when submerged of 120. The four new and larger ones which have just been finished, viz., the "Cuttlefish," "Tarantula," "Viper," and "Octopus," the last named now being tested at Newport, are 105 feet long and 200 tons displacement. These are equipped with more powerful engines, motors, and other improved mechanisms; but in general shape, the scheme of construction, with slight modifications, follows that of the earlier boats such as the "Plunger," "Shark," "Porpoise," etc. They are of greater structural strength and said to be able to stand the pressure of being submerged 300 feet, though 200 is the official depth required at the Newport trials. The "Octopus" is supplied with a new system of submarine bell signals, whereby communication can be had with the surface. The radius of action is about 100 miles from base. She is equipped for warfare with two 18-inch torpedo tubes. Submergence is accomplished through the filling of the various ballast tanks, which include the forward and after trimming tanks, a midship tank, main ballast tank, and several auxiliary ballast tanks, which are distributed in various parts of the boat. The "Octopus" carries very little reserve buoyancy, about 800 pounds, and submerges by pointing the bow down about 8 deg., using the horizontal rudder for this purpose. To maintain submergence after reaching the desired depth, the bow remains pointed down about 3 deg., with slight variations in each boat. In making ready for diving, the boat is trimmed down by the head; and after having filled the trimming tanks to the required extent, so as to leave the amount of positive buoyancy required, about 800 pounds, the craft is in shape for the plunge. As the craft gains headway, the diving rudder is put down, and the vessel dives. The depth, registered on a scale, is regulated by the diving rudder. To maintain submergence after arriving at the proper depth, a man has to receive special training in operating the diving rudder. To return to the surface, the amidship tank is first blown. This holds 1,000 pounds of water, which is forced out under ordinary circumstances in five seconds, by means of compressed air. Another vital interior feature, both for breathing purposes and motive power, is the compressed-air system. The air is stored in a series of 2,000-pound flasks and other lesser ones. The latter are used for firing torpedoes and for blowing out the tanks. The motive power is a powerful gasoline engine for surface running and an electric motor for submerged running. The speed is from 11 to 12 knots on the surface, and about 9 knots when submerged. The stor-

(*Continued on page* 410.)

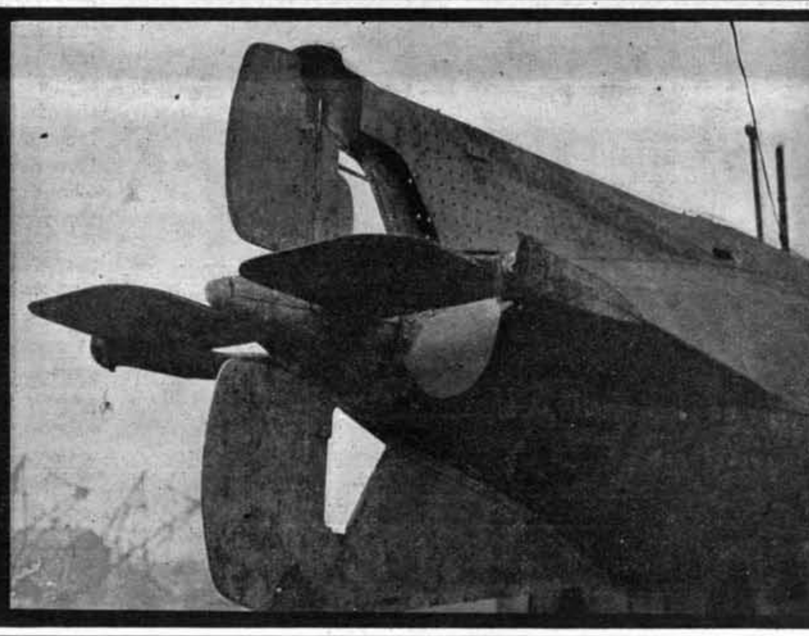


In the roof is the conning tower with the steering wheel; to the right the inside tiller wheel; below that the wheel to operate diving rudders; aft of the ladder are the engines; to the left are depth gage and air and ballast tanks.

Submarine Interior, Looking Aft.

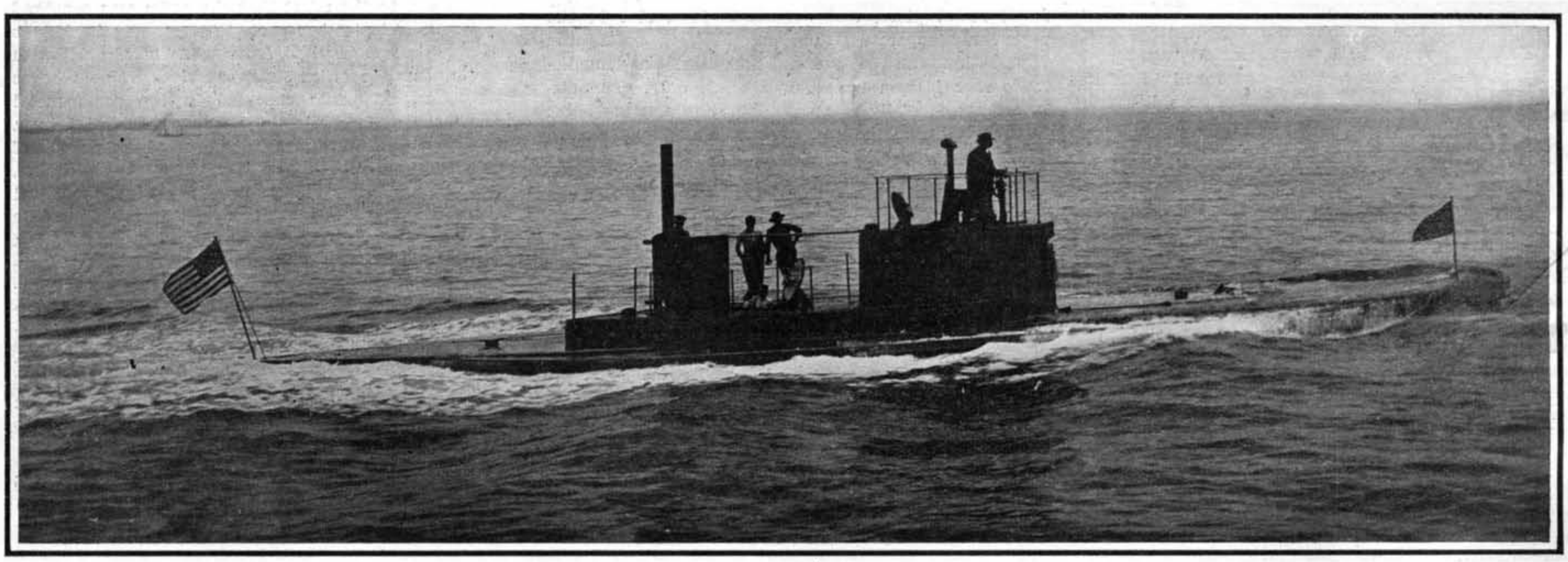


Hollow Copper Signal Buoy Containing a Telephone Receiver for Communication With the Submarine.



Stern of a Submarine, Showing the Horizontal Diving Rudders, the Steering Rudders, and the Propeller.

Signal Buoy Attached by Wire, Released from Inside Submarine, Rises to Surface to Locate Submarine.



Length, 85 feet. **Displacement,** 250 tons. **Speed,** 10 knots on surface. Submerges on an even keel. In emergency can release a 5-ton keel and rise to the surface.

THE TWIN-SCREW LAKE SUBMARINE.

down into the finished steel rail. The chemical composition of the steel is determined by the treatment in the converter; where, as above stated, the undesirable elements in the iron are removed, or, as far as possible, reduced in percentage. The impurity which causes the most trouble by producing brittleness in a rail is the phosphorus. But, unfortunately, the phosphorus cannot be removed by the Bessemer process; and, consequently, the percentage which exists in the ore will be found in the finished rail. The carbon, which is the principal hardening element in the rail, can be perfectly controlled. It can be entirely burnt out in the process of blowing, and the desired percentage reintroduced by pouring a certain amount of molten spiegeleisen into the converter after the blowing is over.

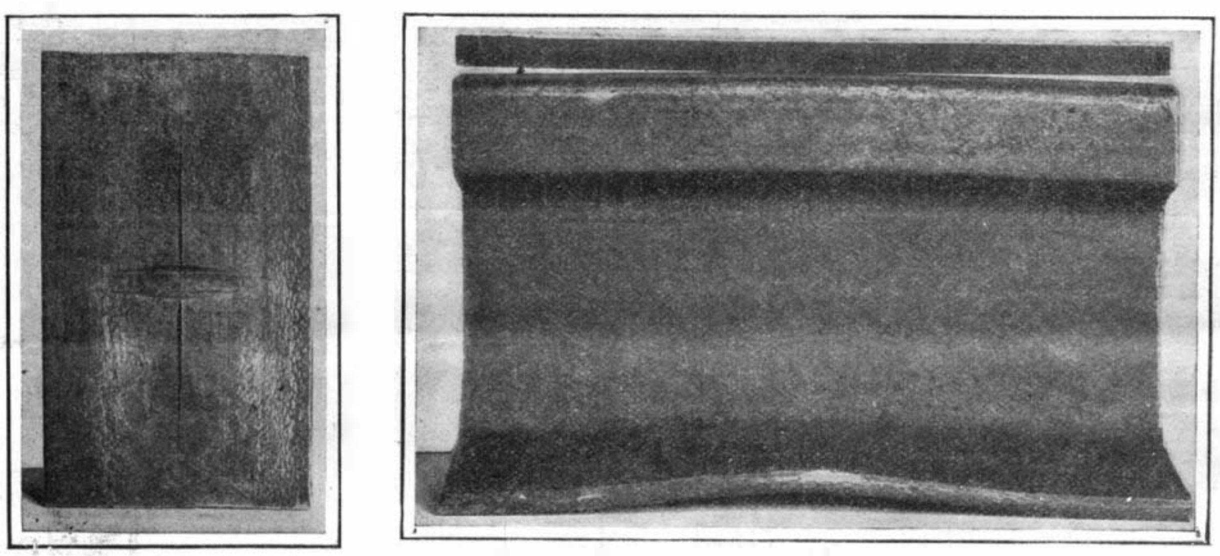
By way of illustrating the composition which would give an ideal rail, we will take the case of some rails which were rolled under the specifications of an engineer of international reputation, who has given his whole life to the study of this particular question. These rails were rolled at a leading mill in Pennsylvania, between the years 1897 and 1898:

Carbon = 0.60 to 0.65 per cent.
Phosphorus = not over 0.06 per cent.
Manganese = 1.10 to 1.30 per cent.

In this rail the phosphorus is exceedingly low and the carbon is high; thus securing, as far as the chemical composition is concerned, a rail that combines hardness with toughness. These rails have exhibited magnificent wearing qualities. Some of them, which were laid at the entrance to one of the biggest and busiest terminal stations in this country as long as twelve years ago, have, in the interim, carried a traffic of 350,000,000 tons. Yet in all these years they have shown a wear of only 3/32 of an inch on the head of the rail; and all the joints are to-day in perfect condition. Although this particular lot of rails was of exceptionally high quality, it may be said that the average rails of that period, rolled to the specifications of the engineers of the railroads, were, in a general way, of the same hardness, toughness, and durability. Now, let us compare the composition of those rails with that of the typical rail which is being rolled to-day under the specifications of the manufacturers. The following table shows the composition adopted by agreement among the manufacturers themselves; and it represents the composition of the rails which have been breaking so badly during the past winter, photographs of several of which, taken as they lay along the side of the tracks, are shown in the accompanying illustrations.

Carbon = 0.50 per cent.
Phosphorus = not over 0.10 per cent.
Manganese = 0.80 to 1.10 per cent.

Comparing this composition with that of the earlier rails, it will be seen that the phosphorus has been raised from 0.06 to 0.10 per cent, an increase of over 60 per cent. This increase is one of the chief causes of the brittleness of the present rails. The phosphorus is present, not because of any wish of the makers to raise the percentage, but because the low-phosphorus ores have been pretty well exhausted from the mines, and a grade of ore has been reached which is high in phosphorus. The manufacturers would be only too glad to reduce this percentage; but as long as they use the Bessemer process, they are quite unable to do so.



Bottom View and Side Elevation of a Rail Tested to Destruction in Testing Machine to Show the Effect of Bending a Rail Across a Tie. This Occurs When a Heavy Wheel Load Bears on the Rail on Each Side of a Well-Tamped Tie. The Effect is Frequently a Break in the Base of the Rail, Starting, as Shown, in a Longitudinal Fracture. Manufacturers Claim That Most Breaks Occur in This Way; Engineers Claim That "Piping" is the Chief Cause.

THE PERIL OF THE "BROKEN RAIL"—ITS CAUSE AND CURE.

The only method known by which steel rails low in phosphorus can be made in large commercial quantities and at a moderate price is the open-hearth process. But the number of open-hearth rail-making plants in the country is very limited, and it has been estimated that to put in open-hearth plants would involve first and last an outlay of over $60,000,000. Naturally, manufacturers are desirous of holding on to the Bessemer process in spite of its limitations; and there seems to be little doubt that the cause of the rejection of the engineers' specification and the substitution of their own, is to be found in their realization of the fact that to make steel rails of the combined hardness and toughness demanded by the railroads is no longer possible with low-grade ores under the Bessemer process. When the quality of the ores coming from the mines began to depreciate, showing high phosphorus, the rail mills attempted to meet the difficulty by lowering the percentage of carbon, and for a while they succeeded in turning out rails which were tough enough not to break under winter traffic and heavy load. But these rails proved to be deficient in hardness. They battered down badly and wore away quickly on the curves. In answer to the demands of the railroads, for harder rails, they raised the percentage of carbon; but although they furnished a rail of sufficient hardness, the high carbon and the high phosphorus together gave too brittle a rail, and hence the enormous failure of nearly 3,000 rails in three months in this State alone during the past winter.

So much for the question of the composition of the rail, which, after all, is scarcely more important than the question of its mechanical treatment in the process of casting and rolling. There is no denying that the rail mills have lately been up against a very hard proposition; for not only have they been trying to make tough rails from high-phosphorus ores by a process that was never intended for such a purpose; but they have been confronted by the conditions, that if they were to keep pace with the ever-increasing demand for rails, they must increase the output of their mills, and hurry up the process of manufacture from one end to the other.

Now, as a matter of fact, the only earthly chance for the production of a good quality of rail by the Bessemer process, when the ores are of undesirable quality, lies in the *extension* of the time of manufacture, not in its *curtailment*, as we shall now proceed to show.

We have already explained that after the molten cast iron has been blown in the converter, the proper percentage of carbon is reintroduced by pouring some molten spiegeleisen into the blown metal. When the addition is made, it is desirable that some little time be given for the necessary reactions to take place; and in the early days of manufacture quite a definite period was allowed before the recarbonized metal was poured into the ingot mold. To-day, however, there is no delay whatever, the spiegeleisen being introduced into the converter at the very time that the latter is being tipped over to discharge its contents into the ladle; and from the ladles the metal is immediately poured into the molds.

Another, and by far the most serious, change which has been made in the endeavor to increase the output and reduce the time of manufacture relates to the cropping of the ingots. By referring to the accompanying illustration, showing a vertical section through an ingot after it has cooled, our readers will see that in the process of cooling two important actions take place. First, there occurs what is known as a segregation of the material; that is to say, certain of the constituents of the steel, such as the carbon, phosphorus, and other impurities, being of lighter specific gravity, tend to separate out from the mass and gather toward the top of the ingot. Also, since the metal cools from the outside toward the center, there is a tendency of the solidifying metal to shrink toward the outer surfaces, and this causes a cup-shaped depression at the top of the ingot, which extends down in the form of a narrow slit or crack into the body of the metal, which, together with gas bubbles, forms what are known as "pipes." Evidently, the upper portion of the ingot, because of this segregation and piping, is less pure, more brittle, and more subject after rolling to contain longitudinal flaws. Consequently, in former days, it was customary to crop off from the ingot from 25 to as high as 33 per cent, and roll the rail out of the remaining two-thirds, the rejected portions being remelted in the furnace.

But in the endeavor to increase the output of the mills and keep pace with the demand, manufacturers have reduced this cropping of the ingot to as low, in some cases, as from 8 to 10 per cent, removing merely the extreme end of the ingot. To take a typical case, an ingot measuring 19 inches by 19 inches by 48 inches long, if cropped 30 per cent would make three 80-pound rails; but with a cropping of only 7 or 8 per cent, the same ingot would produce four such rails.

Now the engineers claim that this extra rail is not reliable, both because of the segregated material which it contains, and because of the fact that as it is rolled down to shape it is liable to include the "pipe," or incipient longitudinal fracture which existed in the ingot itself. The manufacturers, on the other hand, claim that while they cannot produce quite so good a rail from the upper fourth of the ingot, they can still produce a sufficiently good rail for practical purposes. A rail which contains within itself the unclosed, unwelded opening, which was carried over in manufacture from the ingot, is known as a "piped" rail. The manufacturers claim that the breakages rarely occur from "pipes." The engineers contradict this, and say that the experience of last winter particularly shows that "pipes" were the most frequent cause of breakage. It would certainly seem from a study of the accompanying photographs, which were taken at random from hundreds of rails which lay alongside the tracks of one of our leading railroads, that "piping" is by no means an infrequent cause of rail breakages.

From the above considerations we believe our readers will agree that the situation is pretty clearly defined. Evidently, under existing conditions, with the low-phosphorus ores practically exhausted, the only thing left to be done, if we are to have absolutely reliable rails that will not break under the present heavy loads and under the conditions of frozen tracks, is to abandon the making of rails by the Bessemer process and get rid of the phosphorus and other impurities by adopting in its stead the Open-Hearth process; at once return to the slower methods of manufacture of a few years ago; be content to crop more freely from the head of the ingot; and also adopt, in the subsequent manipulation of the rails, a slower process with more frequent passes through the rolls and a more gradual bringing of the rail to its final shape.

THE CONSTRUCTION AND HANDLING OF SUBMARINES.

(*Continued from page* 408.)

age batteries are stowed in tanks inside, at the bottom of the boat, and by a system of clutches the main shaft can be connected to either the motor or gasoline engine.

The "Lake" is a specimen of the even-keel type of submarine, which was launched at Newport News in February, 1906. She has a submerged displacement of 250 tons, is 85 feet long, and has been manufactured in this country and abroad for several years by the Lake Torpedo Boat Company. The term "even-keel" refers to its method of submergence, the vessel attaining submerged depths without changing its longitudinal stability or horizontal trim, as it is unnecessary to point the bow downward in order to submerge. The "Lake" is constructed with steel cigar-shaped hull, over which is built a wooden superstructure, which forms a level deck of a few inches freeboard while the vessel is on the surface. Within this superstructure, and outside of the steel hull, are stored the gasoline fuel tanks, air flasks, etc. Water is also admitted to the superstructure when the vessel submerges. The Lake boat has the same motive power as the Holland boat. The air system also is practically the same as in the Holland boat, but the air flasks are stowed on top of the main steel hull instead of inside. Submergence is attained first by admitting water ballast to tanks contained in the steel hull and superstructure to bring the craft awash, or with tip of sighting hood alone showing above the surface; and then hydroplanes, or horizontal steel wings at the sides of the vessel, are tilted in such manner as to cause the water to impinge against them and drive the boat down to the desired depth. A large conning tower is on top of the hull, of the same structural strength as the latter, and through this projects the omniscope or periscope. All the mechanism for operating the boat is centered in the conning tower. A water-tight hatch is provided to seal the conning tower off from the hull of the craft. One of the principal features of the Lake boat, devised to insure greater safety of the crew during submergence, is that of a drop lead keel of 5 tons weight, which can be readily freed from the bottom of the boat in case of danger by pulling a lever, thus giving the craft sufficient buoyancy to return to the surface. It is claimed that the knowledge of the letting go of this keel, which will instantly give 5 tons of positive buoyancy, inspires a feeling of safety and tends to banish nervousness from the crew while the boat is submerged at great depths. Forward is also a diving compartment for leaving the vessel when submerged, working on the same principle as a diving bell. This compartment is not so much a safety compartment as it is for a diving bell for carrying on work at the bottom of harbor entrances, through which a diver may proceed to the water-bed and submarine mines can be destroyed and laid. The vessel has buffers or wheels, which keep the hull from injury when running on the bottom. The "Lake" has twin screws, which are driven by gasoline engines when traveling on the surface and by electric engines alone when submerged.

One of the up-to-date features recently installed on the "Plunger" is a copper signal buoy, 15 inches in diameter, which is arranged to be readily released from the inside in case of danger while the boat is submerged. This rises immediately to the surface, indicating the exact position of the craft, and serving as a distress signal in case of an accident. The ball buoy and a reel of 200 feet of 3/16-inch bronze wire are incased on the bridge, just in front of the conning tower in a box-like compartment. A telephone can be installed inside to afford direct communication to the submerged boat. Large ring holes also have been attached to the "Plunger" and the other submarines, so that they can be lifted and brought to the surface immediately in case of a disaster.

Of unusual and timely interest are the photos here reproduced, giving a realistic glimpse of one of these wonderful little engines of destruction of the diving type now in service. Both sides and every foot of the round steel tube are lined from stem to stern with intricate and delicate machinery, levers, valves, etc., each having a particular function in manipulating and operating the fish-like craft in the depths of the sea. The center view, looking aft, shows the commanding officer's platform above the conning tower and steering wheel. To the right is the large inside tiller wheel, and below, the wheel to operate the diving and horizontal rudders, while in the background is the compartment for the engines. On the left is shown the large indicator, registering the submarine's depth below the surface, and its deflection from the horizontal. Below this is one of the 2,000-pound air flasks, underneath which is one of the ballast tanks. The bow view shows the main fighting feature of the craft, viz., the torpedo tube, and the pipe above connected with the air flask for expelling the torpedo from the tube. On the right and left sides are seen the air flasks and ballast tanks. The important forward trimming tanks are shown on either side of the torpedo tube. The vessel is made to dive bow down by aid of each particular tank. Above the torpedo tube are a special steering wheel for pointing the submarine at the time of firing, depth registers, speed indicators, etc. For getting the range while submerged, a periscope is employed, the end of which protrudes a foot or more above the surface, which reflects below the location of surface objects. On firing a torpedo, the boat has to be pointed, put nearly level, and at the same time kept beneath the surface at the requisite depth, so as to have the periscope lens just clear of the water—all of which requires great care and intelligence on the part of the officers and crew.

The Current Supplement.

The new Connecticut Avenue Bridge at Washington, D. C., the largest of its kind in the world, is about to be opened. This is one of the most noteworthy concrete bridges in the world, for which reason engineers will doubtless read with interest Mr. F. N. Baustett's article on the structure in the current SUPPLEMENT, No. 1637. Simon Lake writes on safe submarine vessels and the future of the art. Coming as they do from a well-known authority, his criticisms and his advice are valuable. A new method of treating sewage, invented by W. D. Scott-Moncrieff, is described and illustrated. M. Klar's splendid dissertation on the manufacture, denaturing, and the technical and chemical utilization of alcohol is concluded. In this particular installment he describes the malting process, the gelatinization of the raw material, the saccharification of the raw material, production of the yeast, fermenting the sweet mash, and the production of alcohol from the mash. Joel A. Allen continues his treatise on the influence of physical conditions in the origin of species. Our Berlin correspondent discusses electrically-operated equatorial mountings for telescopes, elucidating his remarks with many helpful photographs. "A Method of Photometry of High Candle Power Units" is a title of an iconoclastic article by F. B. Lambert. The two hundredth anniversary of the birth of Linnæus falls upon May 23, 1907, and for that reason the splendid biography prepared by Dr. H. Kramer should be read with interest. Dr. Alfred Gradenwitz describes a new direct-reading wind gage.

The Geological Survey's New Director.

With this issue, a new name appears at the head of the weekly press bulletins published by the United States Geological Survey. It is that of the new director, Dr. George Otis Smith, who was appointed by President Roosevelt to succeed Mr. Charles D. Walcott on the retirement of Mr. Walcott from the directorship to take up his new duties as secretary of the Smithsonian Institution.

Dr. Smith is one of the younger members of the Survey in point of age, as it is only thirty-six years since he was born at Hodgdon, Aroostook County, Maine. He has, however, had fourteen years of continuous service in geologic work. After graduating from Colby College in 1893, he joined a Geological Survey party working on the Marquette iron range, Michigan. During the three following years he took a post-graduate course in geology at Johns Hopkins University, receiving in June, 1896, the degree of Ph.D. As the result of a civil service examination which he took for the position of assistant geologist, he became connected with the United States Geological Survey soon after his graduation.

As assistant geologist and as geologist, Dr. Smith has worked in Michigan, Washington, Utah, North Carolina, the New England States, New Jersey, and Pennsylvania. For seven field seasons he was engaged in reconnaissance and detailed surveys in Washington. In the course of this work he made a special study of several artesian basins, and the results were published in a water-supply paper. He made a report also on the coal fields of the Pacific coast. The results of his investigations in Washington found further expression in a report on the rocks of Mount Rainier, in the Tacoma, Ellensburg, Snoqualmie, and Mount Stuart folios, in a professional paper on the geology and physiography of central Washington, and in a paper on gold mining in central Washington. In addition Dr. Smith contributed articles to the bulletins of the Geological Society of America, and to various periodicals.

In 1900 the United States Geological Survey issued the Tintic Special folio in which Dr. Smith described the geologic structure of that famous Utah camp. He had previously co-operated with Mr. G. W. Tower, Jr., in producing a report on the geology and mining industry of that district.

Following his years of activity in the far West, Dr. Smith began areal work in Maine. Eventually, supervision of all the Survey's geologic work in New England was assigned to him, and direction also of the geologic work in the areas of crystalline rocks in New Jersey, Pennsylvania, and Maryland. In the course of these investigations he made a special study of several economic subjects. The Survey's statistical reports for 1905 on mica, graphite, and asbestos were prepared by him. Last July he was appointed geologist in charge of petrology with scientific supervision of the Survey work in that department.

Recently Dr. Smith has had special opportunities of studying the methods and organization of the Survey and of other government bureaus. He served as chairman of the committee on accounting and bookkeeping, which has been working for the past year under the direction of the committee on departmental methods appointed by the President and known as the Keep Commission.

Dr. Smith is a fellow of the Geological Society of America, a member of the American Association for the Advancement of Science, of the American Institute of Mining Engineers, of the American Forestry Association, and other scientific societies.

A gasoline tank rarely explodes. It cannot unless it contains gasoline vapor and air in explosive proportions, which latter condition is almost never present. It does not explode because it contains too little air or too much gasoline. Even if a tank of gasoline were to burst from heat applied to its exterior, the confined heavy gas would not explode if in contact with flame or fire, but would burn instead. True, a tank of gasoline with no vent could do considerable damage were it to burst and throw burning oil and flaming gas about, but one thousand gallons of gasoline in a vessel's bilges would not be so dangerous from explosion as a hundredth of that amount. The larger quantity would burn rapidly, while the smaller would be sufficient, if mixed with the proper amount of air, to utterly demolish almost any boat.

Correspondence.

Cyclone Observations.

To the Editor of the SCIENTIFIC AMERICAN:

I notice in issue of March 16 article by W. T. Hall in regard to center of funnel of cyclone being white. Some years ago I saw a phenomenon similar to that on a small scale when I visited the great Karg gas well at Findlay, Ohio. The flow of gas from a pipe 5 inches in diameter, and at a pressure of (I think) 175 pounds to the inch, was ignited and allowed to issue from the pipe horizontally about three feet above the water of the river. The force of the gas projected the flame from 50 to 100 feet horizontally, and the heat and currents caused the steam rising from the water to take form of miniature cyclones, and one after another they formed and slowly moved over the water in a course parallel to the flame, and each one, shaped like a slender vase, semi-transparent, showed a whitish core or center its entire length. It was in the dusk of evening, and in the strong light these twisters showed with remarkable distinctness, and one after another they rose upward and disappeared. I thought at the time that conditions must be similar to cause the great destructive cyclones.

In the same paper, relating to the experiment in acoustics where the boy ringing a bell ran to meet others, and the effect of the sound on those meeting him: I have frequently noticed the same effect when riding on the cars and meeting another locomotive on which the bell was ringing. As our car approached the strokes of the bell would be abnormally loud, and soon as we passed the sound of the bell was scarcely heard at all. I have wondered what the reason was and never heard it explained. F. M. PRIEST.

Klamath Falls, Ore.

The Prevention of Sea-Sickness.

To the Editor of the SCIENTIFIC AMERICAN:

Through the kindness of the American consul-general here, my attention is called to No. 293 of the Export Edition of the SCIENTIFIC AMERICAN, January, 1907. On page 15 of this number you publish "A New Remedy for Sea-Sickness."

Allow me, in the interest of ocean travelers in general, to state the following:

For the last fifteen years I have studied the question of a costless prevention of sea-sickness.

A remedy for curing sea-sickness there is none, and will never be. The point therefore lies in its prevention, for "prevention is better than cure." My simple head-bandage made by folding a towel, a large handkerchief or anything similar, dipped into hot salt or sweet water, and applied round the head a few times, restores the proper circulation of the blood, relieves the abdomen from pressure, and checks the cerebral anæmia.

The question I wanted to solve was to find a costless way of preventing sea-sickness. While traveling over thirty years in all kinds of weather, at all seasons, on the seas of this globe, I always felt a great pity for the steerage passengers, especially women and children, who had to suffer so severely when the sea got rough. For this reason I had to abstract from the application of any apparatus, be it electrical appliance, thermophore, or any other construction for which a man has to pay.

The system of hot-water bandages round the head (as one can hardly call it an invention) is mine; all inventions and constructions that have come out ever since I published my simple prescription are based on my system and have passed through my hands; up to now every one of them I have had to condemn for being too heavy, cumbrous, dangerous, or too costly, etc.

If any of them were useful the large steamer companies would have accepted them at once. You can well imagine how very important it is for steamer companies to prevent people becoming sea-sick in the cabins. How pure and sweet the air would be at sea in the cabins if it were not for the repeated vomiting of bile, whose effluvia are extremely volatile and settle down at once in the curtains, floor, ceiling, paint, sofa, beds, etc., of the cabins. This in time forms one of the principal items denominated by travelers, when they enter a cabin, as "ship's smell."

Perhaps you will in the interest of humanity publish this letter (you will plainly see that I have no monetary interest in the matter), and also publish my prescription for the prevention of sea-sickness, which ought to be copied by your newspapers. In winding up allow me to say that hundreds of people whom I have never seen in my life have written to me to express their thanks for my prescription.

EUGENE WOLF, Explorer.

Munich, Bavaria.

[The prescription referred to in the above letter instructs the patient to lie down flat on the back, and fold a towel soaked in water, as hot as can be endured and as tightly as possible around the head, reheating the towel at intervals.]

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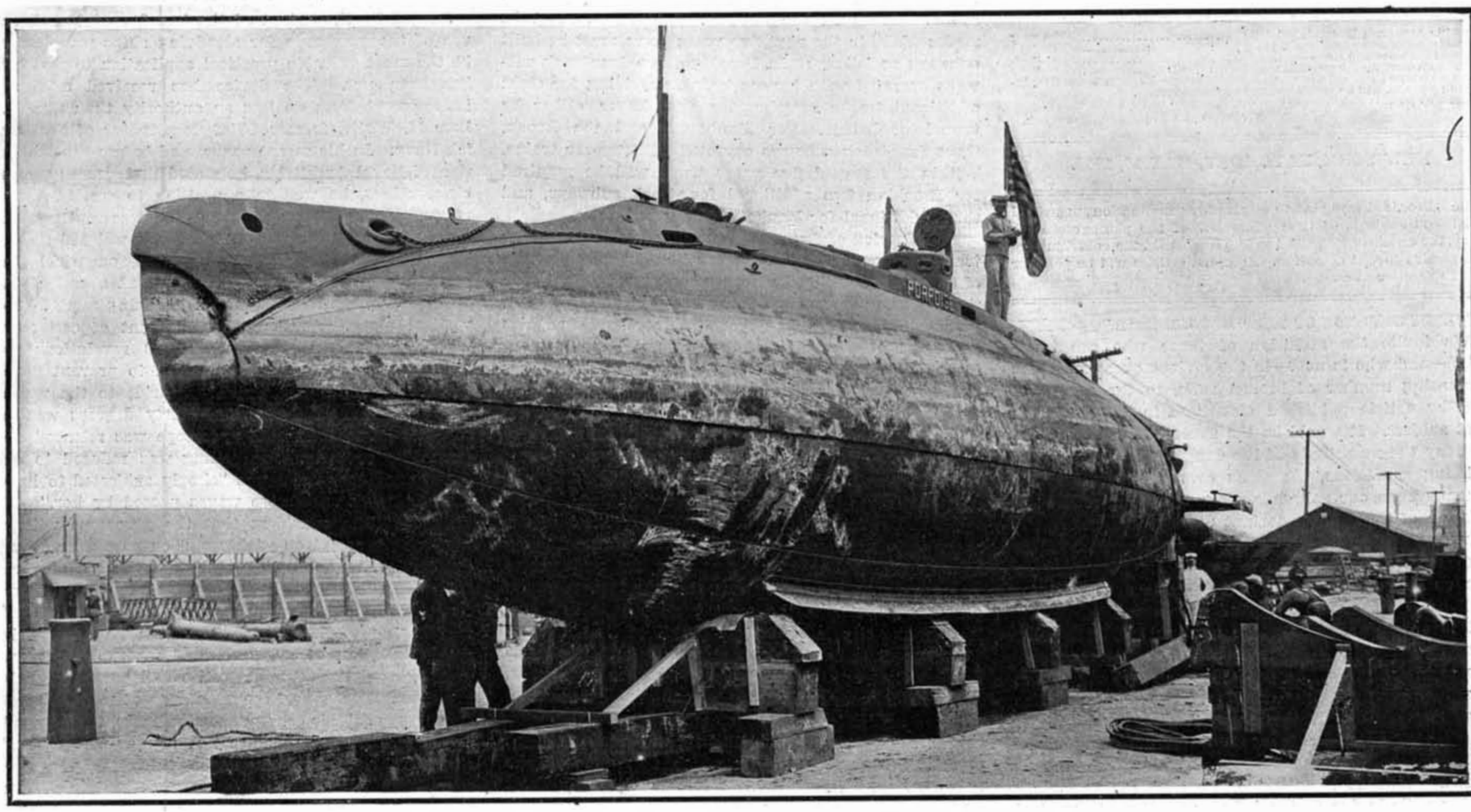
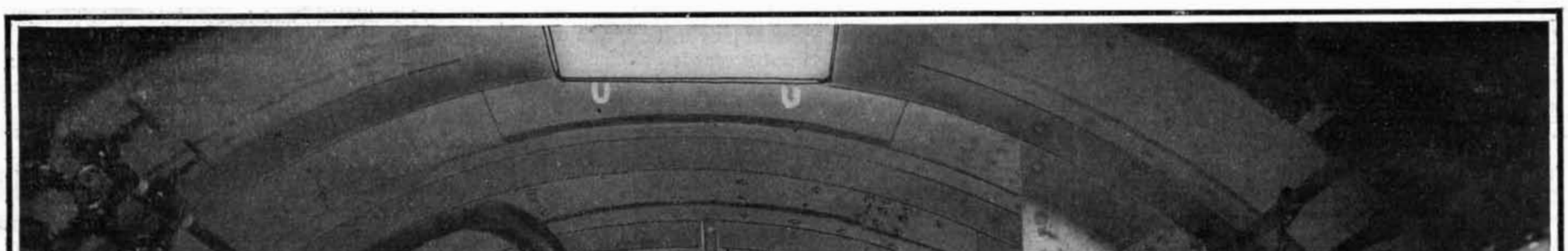


Length, 63 feet. **Diameter.** 12 feet. **Displacement,** Submerged, 120 tons. **Speed,** 5 and 8 knots.

Submarine "Porpoise" on the Ways.



Immediately in the center is the open torpedo tube. Above to the left the pipe from air tank for expelling torpedo. To right and left are air flasks and ballast tanks. Each side of torpedo tube are the forward trimming tanks. Above torpedo tube are pressure, speed, and other gages.

Realistic View in the Interior of a Submarine, Looking Forward.

THE CONSTRUCTION AND HANDLING OF SUBMARINES.—[See page 408.]