A SIMPLE MIRROR GALVANOMETER.

Mr. James F. Hobart has described in The American Electrician a simple manner of constructing a home-made galvanometer.

The instrument described herewith is intended to obviate almost entirely the necessity for skilled manipulation, upon the principle which pays so well in the machine shop, viz., that the whole be so designed in its several parts that the machine work shall be reduced to a minimum, or even dispensed with altogether, save a little drilling, etc.

The above scheme has been adopted in making the galvanometer, which, after having been turned out "with jack knife and pliers," will give results closely approaching those received from a more elaborate and costly instrument. Fig. 1 gives a view of the instrument complete. It consists of four parts—the lamp, the screen, the lens and the coils and needles.

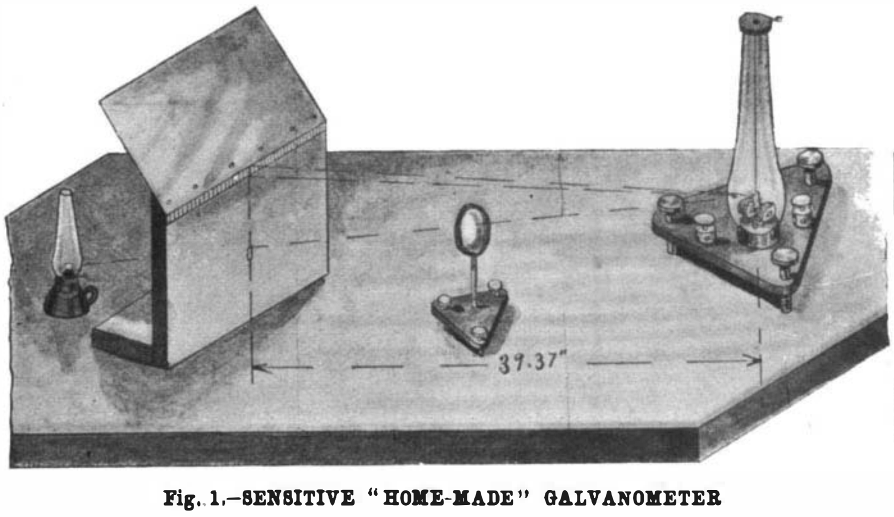


Fig. 1.—SENSITIVE "HOME-MADE" GALVANOMETER

Fig. 3.—CAP FOR TOP OF GLASS CHIMNEY.

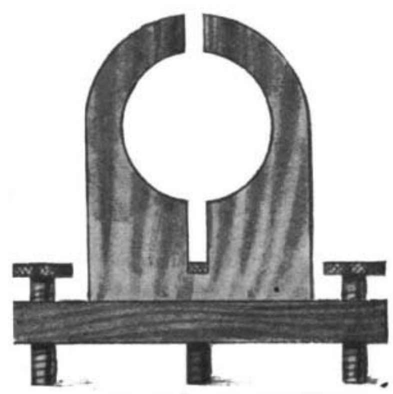


Fig. 2.—METHOD OF MOUNTING PLAIN LENS.

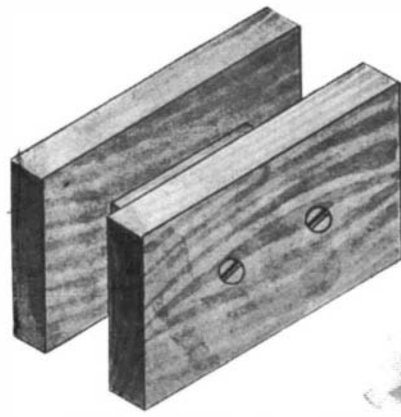


Fig. 4.—FORM FOR WINDING COILS.

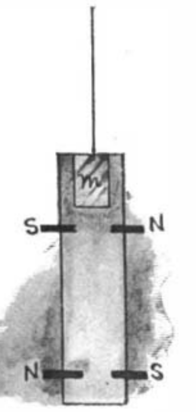


Fig. 5.—NEEDLE SUSPENSION.

For the lamp, a bicycle lamp leaves nothing to be desired, though a common kerosene hand lamp, as shown in the engraving, answers every purpose. The vertical board is as high as the lamp, and the scale is attached to the top edge of the board. The scale may be an ordinary yard stick or ruler fastened to the board, or it may be a strip of paper ruled to millimeters and shellacked to the board.

The tin shade is simply to cut off some of the light which otherwise would be reflected over the top of the scale and dim the bar of light. A clean, sharp slit may be made by cutting a somewhat large hole in the board, and covering it with a bit of cardboard or brass, in which a slit of the size found by experience to be best has been cut.

The lens may be an ordinary reading glass or it may be one of the cheap lenses to be obtained in almost any shop for a few cents. Almost any form of lens can be made to answer, but preferably it should be a double convex, of very long focus—16 inches to 18 inches. If a reading glass is used, it may be mounted by placing the handle through a hole in the base board as shown. If a plain lens is to be used, a cheap mount is shown by Fig. 2. A bit of board is cut out as shown, and the hole through it is just a trifle smaller than the lens. A narrow V-shaped groove is then cut around the center of the inside of the hole and a saw kerf run into the board as shown. This allows the lens to be pressed into the groove, and the spring of the wood holds it there.

The six leveling screws are common brass wood screws, 4 inches long, about ¼ inch in diameter, with the top of the head filed off flat. The edges of the disk thus formed may be milled in pretty good shape by rolling the edge of the head under a single-cut file of the required degree of fineness. Place the screw on a hard wood board or, better yet, on a sheet of lead, and by rolling under a file, the milling can be quickly done. By all means use a lathe, if you have one, in preference to the file method.

The third member of the family is built on a bit of board cut about 8 inches on a side, of triangular shape, as shown. Three leveling screws are let in and two binding posts are placed in connection with the coil. These posts are shown in the engraving. A common, medium sized lamp chimney is procured and fitted to a circular piece of wood ¾ inch thick. The wood is screwed to the base and the coils are fastened to the wood. The mirror must be placed one meter (39·37 inches) from the scale.

Another circular piece of wood is fitted to the top of the chimney, as shown in Fig. 1. A detail plan and section of this piece is shown by Fig. 3. It is bored out to fit on the chimney, and a ½-inch hole is bored in the center completely through the wood. A wire with a sort of thumb head is bored into the wooden cap so as to pass through the center of the ½-inch hole. A bit of cardboard is glued into the bottom of the large hole, and a pinhole, punched through the exact center, permits the suspension fiber of the needle system to be carried to the wire and wound up by turning the thumb head above described. The coils may be made according to the work to be done. I have three sets of coils with my instrument. The first is made of about 50 feet of single silk copper magnet wire, of such size that it has a resistance of about 8 ohms to the 1,000 feet, about No. 18 or No. 19 B. & S. gage.

A form for winding the coils is shown by Fig. 4. It is made of wood, held together with two screws. A couple of binding wires are laid in before the coil is wound. About six layers of the wire above mentioned can be made out of one-half the 25 feet mentioned. Two of these coils are used, connected in series and to the binding posts. After winding, the binding wires are fastened, the coil is drenched with shellac and placed in the cook stove oven for an hour. The core is then removed, additional binding placed on the coil if found necessary, and again baked at low heat for two or three hours. This holds the coils permanently. Two coils are to be used, and the needle system suspended between the coils, which are placed ⅜ inch apart.

I have three coils with my instrument, two in each set, and use either set, as the work demands. I have also three sets of needles, which will be described later. The second set of two coils is wound of No. 33 or No. 34 wire, and has a resistance of about 10 ohms, or 20 ohms for the complete set of two. The third coil is wound with No. 36 wire. Nearly ¼ pound was put on the two coils, and the combined resistance of the complete coil is about 1,000 ohms—500 ohms each.

For the needles with the low-resistance coils I use a common sewing needle. The temper was drawn, the eye and point filed off, leaving a bit of wire 1¼ inches long. A nick was filed in the center, then the needle was hardened and magnetized, and broken through the nick, thus giving two needles magnetized pretty nearly alike. A piece of cardboard 2 inches by ½ inch was pierced, and the needles stuck through it, as in Fig. 5, and held by a drop of hot sealing wax.

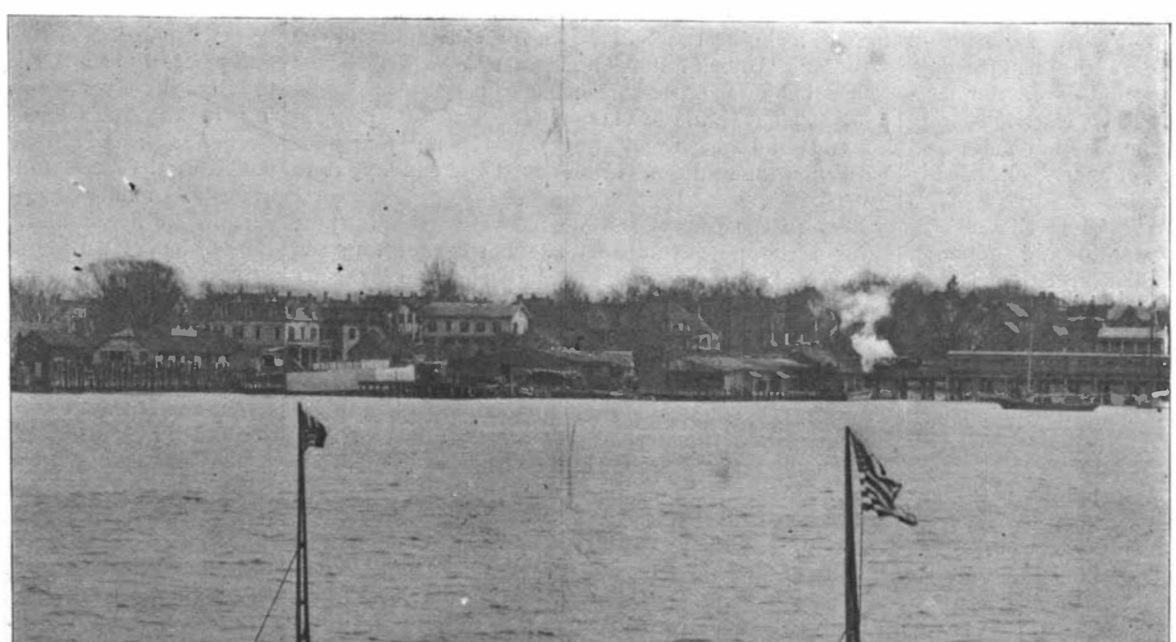
A bit of mirror, m, was waxed to the top of the cardboard, and the suspension fiber fastened between the mirror and the cardboard, as shown. The upper end of the fiber is carried to the cap on the top of the chimney, attached to the thumb head wire, and wound up until the lower needle hangs in the middle of the coil and the upper needle clears the top of the coil about ¼ inch. The instrument is now ready for setting up and adjusting in the usual manner.

The second set of needles is made in the same manner, except that I use pieces of fine watch spring, less than ⅛ inch wide, and place three pieces together, with a single thickness of paper between for each needle. The pieces were file-marked, hardened, magnetized and broken in pieces the same as the needles.

Finding that the light needles and the low-resistance coils gave an instrument readily affected by thermal currents, I made the third set of needles of steel tape about ⅜ inch wide, and used five pieces in each needle, separating each with paper. All the needles in the three systems were ⅝ inch long. The third set made a very heavy set, but in connection with the 1000-ohm coils proved very sensitive, although slow moving.

Different effects were secured by using either set of the needles with the other coils, making six possible combinations. Where extreme sensitiveness is not required, I found it desirable to use a directing magnet, and not depend upon the torsion of the suspension or over-strength of one of the needles, to return the beam of light to zero.

With 1000 ohms in each arm of the bridge and 6 volts in the battery, a considerable deflection is obtained by changing R a single ohm; and with the bridge arranged 1000 to 1, at a and b, the galvanometer readily deflects down beyond the capacity of the bridge, which was 0·001 ohm, with 1000 ohms galvanometer resistance.



THE HOLLAND BOAT AT HIGH SPEED WITH CONNING TOWER ABOVE SURFACE FOR OBSERVATION.

For the suspension in this instrument I used a hair. It was quite fine, micrometered about 0·002 inch in diameter, and was probably from the head of a dark-haired lady. From the needles to the point of suspension there were about 8 inches of effective hair. Just how much better the instrument would be with a raw silk fiber I have no means of knowing at present, but it was as delicate as will be required for any ordinary work.

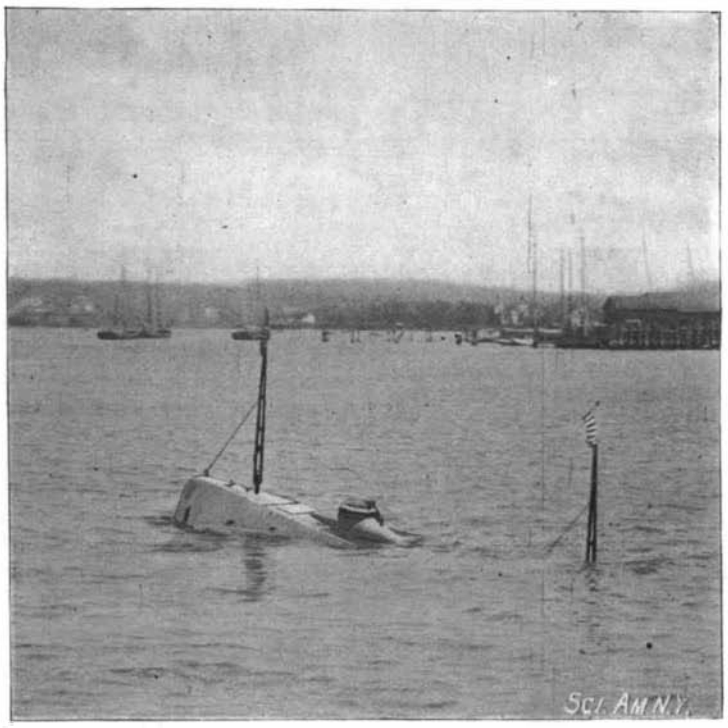
As to the "figure of merit," I have not had opportunity to determine that point, but will do so, and report later. The "efficiency" of the low-resistance instrument is rather greater than that of the high-resistance form, while the "figure of merit" is greater the more turns of wire are placed on. For measuring very low resistances, the low-resistance coils will give perhaps the best results.

SUCCESSFUL TRIALS OF THE HOLLAND SUBMARINE BOAT.

Extraordinary interest attaches to the trials of the Holland submarine torpedo boat which are now being carried out in New York Harbor, and it gives us much pleasure to state that the results thus far achieved have been very satisfactory. By the courtesy of Mr. John P. Holland, the inventor, our photographer accompanied the boat on her trial runs and secured the photographs which are herewith reproduced. In one of these the little boat is shown at her moorings beside the pier; another was taken when she was running at the surface, with only her conning tower above the water; a third view, perhaps the most striking of all, was taken when the boat was diving, and another view shows the stern torpedo gun and the tail-piece for protecting the rudders. These external views are supplemented by a longitudinal section which shows the construction and leading details of the interior.

The Holland submarine boat embodies the results of some twenty years of experimental work on the part of the designer, who firmly believes that this type is destined to become the most deadly weapon of future naval warfare. This is the first submarine boat of its type ever built and tested. Another and larger boat of the kind is now under construction for the government at Baltimore, and is practically completed; but the progress upon it was so slow that Mr. Holland determined to build at once a smaller vessel for use in harbor defense. The government vessel was described and illustrated in the SCIENTIFIC AMERICAN of April 25, 1896. She is a cigar shaped boat 85 feet long, 11½ feet in diameter and capable of 16 knots speed on the surface and 10 knots when submerged. Her displacement is 168 tons.

The "Holland" (as she is called) is much smaller, being only 55 feet long, 10¼ feet in diameter and of 75 tons displacement. The steel hull is cigar-shaped and approximates somewhat to the model of the Whitehead fish torpedo, being blunter at the head than the tail. Two sources of motive power are furnished, a gas engine being used at the surface and a motor run by storage batteries when the boat is submerged. The storage batteries, which are of great weight, are located amidships, down below the axis of the boat, and as their center of gravity comes well below the center of buoyancy of the hull, the boat is kept at all times on an even keel. Above the storage batteries on each side of the ship are located the compressed air tanks from which fresh air is supplied to the crew when the boat is submerged. The motive power is furnished by a gas engine and an electric motor, both of which operate a common shaft, the gas engine being located just ahead of the motor. The gas engine is used mainly when the boat is running at the surface and the


DIVING.

motor when it is entirely submerged. This arrangement, it will be seen, enables the motor to be utilized as a generator for charging the batteries.

The cellular bottom of the little vessel is utilized for the storage of the liquid fuel, and here are located the water ballast tanks which assist in trimming and in the operation of diving or rising to the surface. With the tanks filled and all the crew aboard there is a reserve buoyancy of 250 pounds, and the boat is caused to sink by altering the pitch of the horizontal diving rudders, the forward motion of the vessel, combined with the downward pitch of the rudders, combining to force her below the surface. She is maintained at the required depth by means of delicate automatic mechanism, similar to that used in the automobile torpedo.

The offensive powers of the Holland are, considering the size and her methods of attack, far greater than those of any other engine of war, whether ashore or afloat. In the first place, she carries in her bow or nose an under-water discharge-tube for launching the deadly Whitehead torpedo. Of these she carries several stowed in a suitable chamber. They are automobile, or self-propelling, carrying their own compressed air engines and a storage tank of compressed air. They are shot out of the bow by a small charge of gunpowder, and as they pass from the discharge tube, a catch releases the little engines and starts the propellers. The torpedo then travels with the speed of the fastest torpedo boat for a distance of from 600 to 1,000 yards. Automatic steering mechanism keeps the flying vessel at the proper depth and on a wonderfully true course.

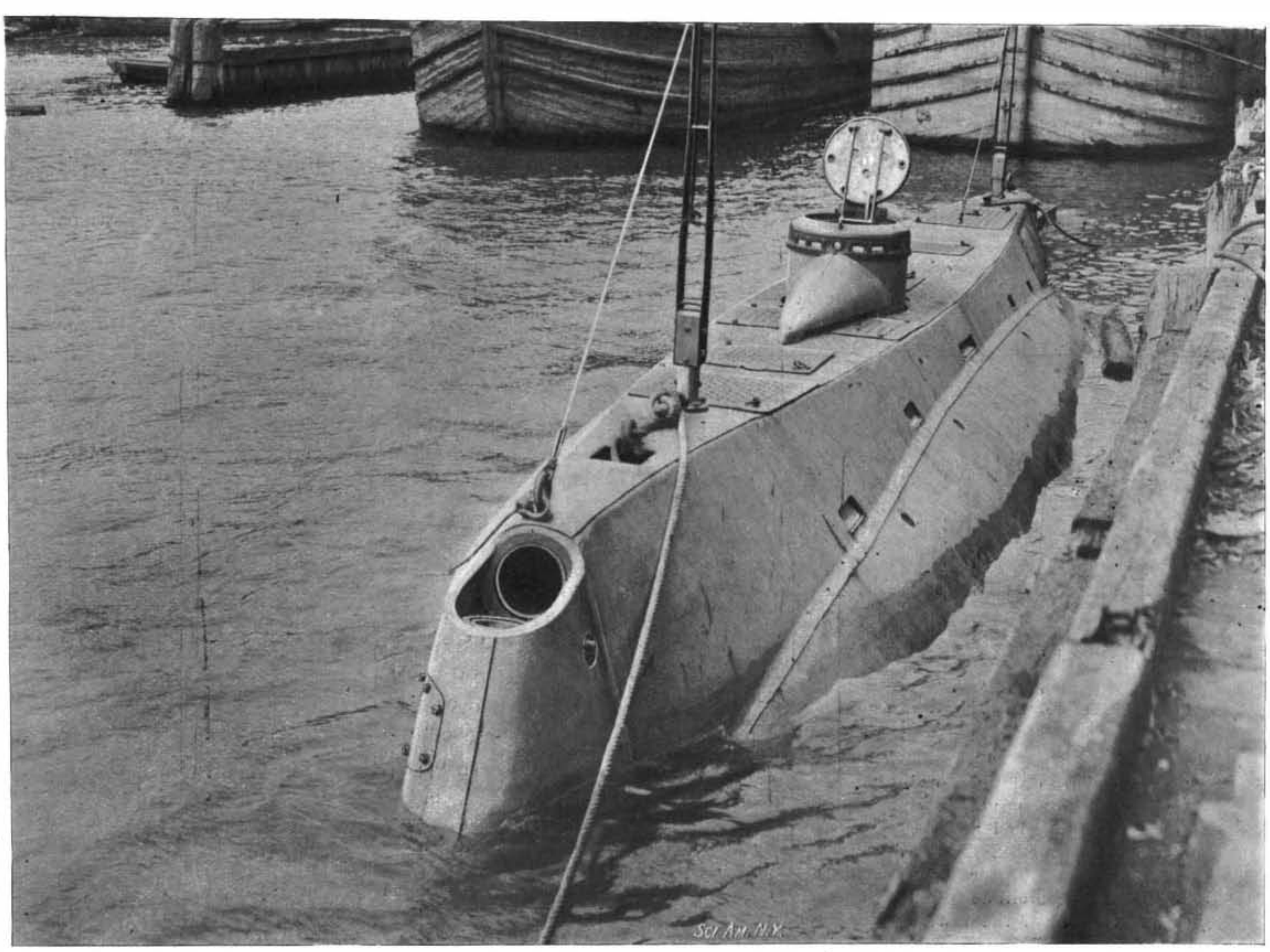
In addition to the Whitehead torpedoes the "Holland" carries two other discharge tubes for firing guncotton projectiles. Unlike the one just described, which lies in the longitudinal axis of the boat, these are upwardly inclined, one pointing forward and the other aft. The mouths of the tubes terminate at the ends of a kind of superstructure deck which is built up above the cylindrical portion of the boat and carries at the center of its length an armor-plated conning tower. The mouth of each of these tubes is closed by a sliding cover which is operated by means of a worm and pinion controlled by shafts leading into the interior of the vessel. The forward tube is called an aerial torpedo gun. It is capable of throwing a 100-pound guncotton shell a distance of three-quarters of a mile. The other tube, astern, is called an underwater torpedo gun, and it is capable of driving its shell with accuracy for a distance of 200 yards under water.

When the boat is at the surface of the water, she can be steered by observation through the port holes of the conning tower. When she sinks below the surface, a small tube, carrying at its top an inclined mirror or prism, in the manner of the camera lucida, will throw a picture of the surrounding waters upon a board in the conning tower. The vessel also carries a compass and an automatic gage showing the depth below the surface.

In making an attack upon a ship the "Holland" would advance, with her small and scarcely discernible conning tower above water, until she was within range for the use of her aerial torpedo gun. A shell containing 100 pounds of guncotton would be discharged, and she would at once sink below the surface, to avoid retaliation. At the moment of discharge an ingenious system of compensating weights will automatically admit to the tanks a sufficient amount of water to preserve the trim of the vessel. This is an entirely new device, and the "Holland" is the first submarine boat which has succeeded in overcoming the difficulty. When the boat had run up a little nearer to the hostile ship, she would discharge one, and if the first missed, two of her torpedoes. In the unlikely event of missing with the bow torpedoes, she would fire her rear torpedo gun at the enemy as it swept by overhead.

Our illustrations were taken during a series of tests which were carried out on March 27, for the benefit of Lieut. Sargeant of the Naval Auxiliary Board. The work was done in 30 feet of water and gave full satisfaction both to Mr. Holland and the government expert. The first trials consisted of a series of surface runs at a speed of 10 knots, in which the boat showed great maneuvering power, changing her course through 90° with astonishing rapidity.

The diving test was made at the same speed, and upon the diving rudders being thrown into position, the boat buried her


BOW VIEW OF THE "HOLLAND," SHOWING MOUTH OF AERIAL TORPEDO GUN, THE SUPERSTRUCTURE DECK AND THE CONNING TOWER.