to depth, rough water, swift tides, or width of channel, it will give the nearest approach to absolute protection now known to the board. The boat can lie for an indefinite time adjacent to the point to be defended, in either cruising, awash, or submerged condition by its anchors being upon the bottom. It is thus ready for instant use, practically independent of the state of the water, and in telephonic connection with the shore. It can also patrol a mined or unmined channel, invisible to the enemy, and able to discharge its torpedoes at all times. It possesses the power of utilizing its engines in every condition except the totally submerged, and can always charge its storage batteries while so doing, necessitating its return to shore only when gasoline must be replenished. In narrow channels the boat or boats would have a fixed position, with a telephone cable buoyed or anchored at the bottom. In wide channels they would patrol or lie in mid-channel, or where they could readily meet approaching vessels.

As a picket or scout boat, outside the mine field or even at extreme range of gun fire, telephone communication can be sustained, and information received and instructions sent for attacking approaching vessels.

The test at Newport demonstrated the ease with which the boat can locate and pick up cables and, with minor alterations in the present model, junction-boxes, etc., can be taken into the diving compartment and repaired at leisure while absolutely protected from hostile interference. The faculty possessed by the boat of maneuvering on the bottom and sending out divers, leaves little or nothing to be desired in its facilities for doing this work.

For Attack.

The boat shows great superiority over any existing means of attacking mine fields known to the board.

It can run by any mine field, as at present installed, with but little or no danger from the explosion of any particular mine or from gun-fire, durin the few seconds it exposes the sighting-hood for observation, and can attack at its pleasure vessels in the harbor.

The board personally witnessed the ease with which cables can be grappled, raised, and cut, while the boat is maneuvering on the bottom. Mine cables can be swept for, found, and cut, or a diver can be sent out for that purpose.

It should be noted that, with one exception, no seamen are needed aboard, this exception being the man who steers and handles the boat.

The crew is as follows: One navigator, who is also the diver; one chief engineer, one assistant engineer, one electrician, one machinist, one deck hand, one cook.

The board recommends consideration of the foregoing by the General Staff. The question of the use of the Whitehead torpedo as part of the fixed mine defense, fired from tubes on shore, is now receiving consideration. Where channels are wide and waters swift, this use of the Whitehead will be very limited. With boats of this type the Whitehead can, it is believed, be carried within certain effective range in all ordinary channels, and this, alone, will warrant the consideration asked.

The board recommends, in consequence of its conclusions, that five of these boats be purchased for use in submarine defense, as follows:

One for the School of Submarine Defense, for experimental work.

One for the eastern entrance of Long Island Sound.

One for the entrance to Chesapeake Bay.

One for San Francisco Harbor.

One for Puget Sound.

The necessity for this kind of defense in the four localities named, needs no demonstration, to those acquainted with them.

Narragansett Bay will be entirely free of ice in about four weeks, and then the naval board will try out the "Protector."

RESULTS OF RECENT EXPERIMENTS WITH N-RAYS.

M. Blondlot has now succeeded in measuring the wave length of the new N-rays, and finds that the wave lengths are shorter than for light rays. In the first place, he shows that the rays are equally refracted by a prism. To study the dispersion and the wave lengths of the N-rays, M. Blondlot uses a method similar to that employed in the case of light. Prisms and lenses of aluminium are used, as this metal does not store up the rays like some other bodies. For the dispersion experiments, the rays are produced by a Nernst lamp inclosed in a sheet-iron box having an opening closed by an aluminium shutter. The rays are then passed through an inch thickness of pine, a second aluminium sheet, and two thicknesses of black paper, so as to eliminate all other radiation. In front of the screens and at 6 inches from the burner is placed a large screen of wet cardboard, which cuts off all the rays except a beam passing through a slit 1-5 inch wide and 1.4 inch long, cut out of the cardboard. The beam falls on an aluminium prism whose refracting angle is 27 deg., 15 min. One face of the prism is perpendicular to the beam. With this arrangement, it is found that several beams of N-rays are dispersed horizontally from the other face of the prism. To locate them, a narrow band of sulphide of calcium is moved about the region. Its increase in brightness shows the presence of the rays. Different beams were found and their index of refraction measured. These indices are 1.04, 1.09, 1.29, 1.36, 1.40, 1.48, 1.68, 1.85. To check up the results, the images of the burner were formed by means of an aluminium lens, measuring their distance from the lens. The latter (plano-convex) had a 2.6-inch radius of curvature. A 2-inch hole was made in the cardboard screen. The lens was placed at a known distance from the incandescent burner, and the image of the burner was explored by the phosphorescent screen. This method gave similar results for the indices of refraction of the different beams.

The next step was to measure the wave lengths of the various beams, and it was found, contrary to expectations, that these are much shorter than light waves. With the above disposition, the beams obtained were quite distinct from each other. The beam to be observed is let fall on a second screen of wet cardboard having a narrow slit of 0.06 inch. To explore this narrow beam, an arm moving around a circular transit scale holds a vertical sheet of aluminium having a slit 1-400 inch wide, filled with the phosphorescent sulphide. Placed in the path of the beam, the exploring screen shows that the beam is narrow and uniform, and not accompanied by diffraction fringes. After this preparation, the beam is let fall upon a diffraction grating on glass (one of the Brunner pattern was used, ruled to 1-200 millimeter). The rays coming through the grating are explored by turning the phosphorescent screen through different angles, and it is found that a system of diffraction fringes exists, as in the case of light. However, the bands are closer together and are practically equidistant. This shows that the N-rays have much shorter wave-lengths than those of light. By rotating the exploring screen, the distance between the bands is measured. The angle of rotation is very small, and it is measured by a mirror and telescope, preferably between every tenth ray. From these distances and the ruling of the grating, the wave length is deduced by the usual formulæ. Different gratings gave practically the same wave-lengths, which are as follows for five of the beams:

Index of refraction.	Values of μ
1.04	0.00815
1.19	0.0099
1.4	0.0117
1.68	0.0146
1.85	0.0176

The Newton's ring method was also used and gave similar results. These measurements show that the wave lengths of the N-rays are considerably shorter than those of light rays. It is a noteworthy fact that the wave length of the N-rays increases with the index of refraction, which is the contrary to the case of light rays.

In a paper recently presented to the Académie des Sciences, M. De Lepinay shows that the N-rays are produced by sonorous bodies in vibration. The fact that compression or bending of a body causes it to emit N-rays (as M. Blondlot found) led the author to suppose that sound vibrations should produce the same effect, seeing that a sounding body undergoes alternating strains which, although very slight, are, on the other hand, repeated many times per second. This was found to be true, using a phosphorescent screen to detect the rays. The bodies used were a tuning-fork, a bronze bell, and, especially, a large steel cylinder suspended by two cords and vibrating transversely from the blow of a hammer. The latter gave the best results. The phosphorescence increases on producing the vibrations, and diminishes progressively when the vibrations are suddenly stopped. It is found that the sonorous body is not the exclusive source of the N-rays, but also the air which surrounds it and transmits the vibrations. The air, in fact, undergoes alternate strains and forms a source of the rays. It is found that the action of the vibrating cylinder upon the phosphorescent screen still keeps up if a lead plate 0.1 inch thick or a screen of distilled water 1 inch thick is disposed so as to absorb all the N-rays coming from the vibrating body, without hindering the propagation of the vibrations to a point near the phosphorescent body. Still more striking are the experiments made with a siren as the source of sound, as in this case there are no metal parts engaged in the vibration, this being produced by the air alone. The action on the phosphorescent sulphide is clearly observed when it is placed a little above the revolving disk. Seeing that the N-rays have the property of increasing the brightness of a body which is feebly illuminated, an interesting experiment is the following: The revolving disk of the siren itself is used as the illuminated screen, and it receives a dim light from a window at a distance, so regulated that none of the details of the disk can be distinguished by the eye. The disk having been set in rotation beforehand, the experiment consists in passing the air through the siren and suppressing it again. Each time the air passes and the vibrations are produced, the disk appears with a stronger light, and at the same time the details are perceived, together with other parts of the siren. On stopping off the air, the whole goes back to obscurity. The effect is the same when the observer stops his ears, and it is not due to reflex action, as has been proved in different ways.

EXAMINATION OF THE EMANATIONS GIVEN OFF BY RADIUM.

The fact that a part at least of the emanation from radium is transformed into helium is brought out in a striking manner by the recent researches of M. Curie and Prof. Dewar, which were presented to the Académie des Sciences.

A sample of 0.4 gramme of bromide of radium, pure and dry, had been left for three months in a glass bulb which communicated with a small Geissler tube and a mercury manometer. At the start of the experiment, a high vacuum had been made in the whole apparatus. During the three months, the radium salt gave off gas continuously at the rate of 1 cubic centimeter per month at atmospheric pressure. Spectroscopic examination of the gas by means of the Geissler tube showed only the presence of hydrogen and mercury vapor. No doubt a small quantity of water had been introduced into the apparatus at the same time as the radium salt, and it became decomposed gradually by the radium. The same sample of bromide of radium was taken to England and used in Prof. Dewar's laboratory at the Royal Institution for measuring the heat given off at low temperatures. In this case the salt had been transported in a quartz bulb provided with a tube of the same substance. A vacuum was made in the bulb and the quartz tube containing the salt was heated to redness, up to the fusing point of the salt. The gases given off by the bromide were collected by a mercury pump, and after passing through a set of U-tubes cooled by liquid air which condensed the greater part, the remainder of the gas was collected in a test-tube over mercury and examined by Prof. Dewar. The gases occupied a volume of 2.6 cubic centimeters at atmospheric pressure. They had brought over a part of the radium emanation and were radio-active and luminous. The light given off by the gases in the test-tube, after three days' exposure with a photographic spectroscope of quartz, gave a discontinuous spectrum. It consisted of three lines coinciding with the three principal bands of nitrogen, 3,800, 3,580, and 3,370. During the three days, the glass tube had taken a deep violet hue, and half the volume of gas had been absorbed.

When a spark was passed through the gas placed in a Geissler tube, the nitrogen bands also appeared in the spectroscope. Upon condensing the nitrogen in liquid hydrogen, a high vacuum was produced in the Geissler tube, and the spark showed the presence of nitrogen alone. The quartz tube containing the bromide of radium, melted and now deprived of all the occluded gas, had been sealed by the oxy-hydrogen blowpipe while a vacuum was made, and brought back to Paris. M. Deslandres examined it with the spectroscope about twenty days after the sealing of the tube. The gas inside the tube, illuminated by an induction coil using two rings of tin foil around the tube as the poles, was found to give the *entire spectrum of helium*. There were no other rays except those of helium after an exposure of three hours with a quartz spectroscope.

A YEAR'S BATTLESHIPS IN ENGLAND.

During the past year fourteen vessels, excluding torpedo craft, were added to the British navy, representing a tonnage of 149,340 and an indicated horse power of 262,800. The list includes five battleships, all of the "Duncan" class. These vessels are of 14,000 tons, and are the fastest in the British navy, their speed being 19 knots. Seven new armored cruisers have been commissioned, with the result that the cruiser squadron has been strengthened, and is now not only the most powerful but the fastest fleet in the world, all of the ships having a full-power speed of 23 knots. The ships commissioned this year include the "Drake" and the "Leviathan," of 14,100 tons, with engines of 30,000 indicated horse power. The five other cruisers commissioned are the "Kent," "Bedford," "Monmouth," "Donegal," and "Berwick," all, with the first exception, built on the Clyde. These vessels are of 9,800 tons and 22,000 indicated horse power. The remaining two ships commissioned during the year were the sloops "Merlin" and "Odin." The armament of the ships may be regarded as indicating the power of attack, and thus it is interesting to note that this year's newly-commissioned ships had in all twenty 12-inch guns, four 9.2-inch weapons, 106 6-inch quick-firers, and 239 smaller weapons.