some of it, perhaps, for export to Europe, as soon as the Panama Canal is open for traffic. They are building a fleet of ore-carrying steamers.

Guns for submarines.

Some of the later United States submarines will carry guns, and the Bureau of Ordnance placed contracts for twelve guns for the purpose. This was decided upon as a result of a long investigation of the subject, and it has been concluded that a 3-in. gun of much the same type as the Ehrhardt landing gun for naval purposes will meet all the requirements of the situation. This gun will be mounted in a well in the submarine and will be installed on an elevating apparatus, which, as the gun is raised, will carry with it a part of the deck plating, which will serve as a metal covering and protective shelter for the gunner, who will also have a position on the gun platform. There will be a device for lowering the gun whenever it is necessary to carry it below deck; it will not disappear by operation of its recoil as in the case of the disappearing guns of the coast defences. Every consideration has been given to the question of saving weight as far as may be, and the installation will be on the basis of sustaining the pressure at a depth of 200 ft.

**Start**

Gyroscope applications.

In the United States Navy, and many others, the gyroscope is being applied in many directions, and not least to secure the extreme accuracy and precision which are necessary for successful work in gunnery and torpedo. The torpedo-directors now used in the British Navy are connected through automatic operation with the gyro-compass. The compass also serves to operate range clocks, and is in some cases applied to keeping the range-finder on the target. It is found to be of much value in gunnery, not only because of the fact that it lends itself to the fire-control instruments, but also because the ship can be kept on an even course, thus making it easier for the gunlayers to keep on the target.

In some modern Dreadnoughts, where the standard compass is near the forward smoke-stack, a shift in the wind from forward to aft will cause a change in the deviation of from 2 deg. to 5 deg., by reducing the cooling effect of the air on the steel of the smoke-stack. Records show that when steering by even the best magnetic compasses the constantly changing deviation gradually leads the ship from her true course.

In submarines, where accuracy in under-water navigation is absolutely essential, little dependence can be placed upon the magnetic compass because of the inaccuracies introduced by stray magnetic fields from the cables. The deviation caused by these stray magnetic fields changes with the load on the cables and with the changes in the fore and aft inclination of the keel.

The gyro-compass.

The gyro-compass has come much into use within recent years. It depends for its operation on a phenomenon which is absolutely changeless and undeviating—i.e., the rotation of the earth. The inertia of a large wheel is relative to space—that is, it will, if freely suspended, maintain its original plane of rotation in space. If any angular force is impressed on the rotating wheel, it will not turn in the plane in which the force is acting, but will turn in a plane at right angles to that of the impressed force. This movement is termed "precession." The wheel always "precesses" in such a direction as to place its plane of rotation in the plane of the impressed force by the shortest path. Because of these two characteristics, a rotating wheel, properly suspended, will, when subjected to any angular motion, place its plane of rotation coincident with the plane of that angular motion.

In the gyro-compass a rotating wheel, suspended with its axis horizontal, with freedom partly suppressed about its horizontal axis, and with perfect freedom about the vertical axis, is acted upon by the earth's rotation in such a manner that the earth's motion causes the gyro to place and keep its plane of rotation East and West, in which case its axis is in the North and South meridian.

Sperry type.

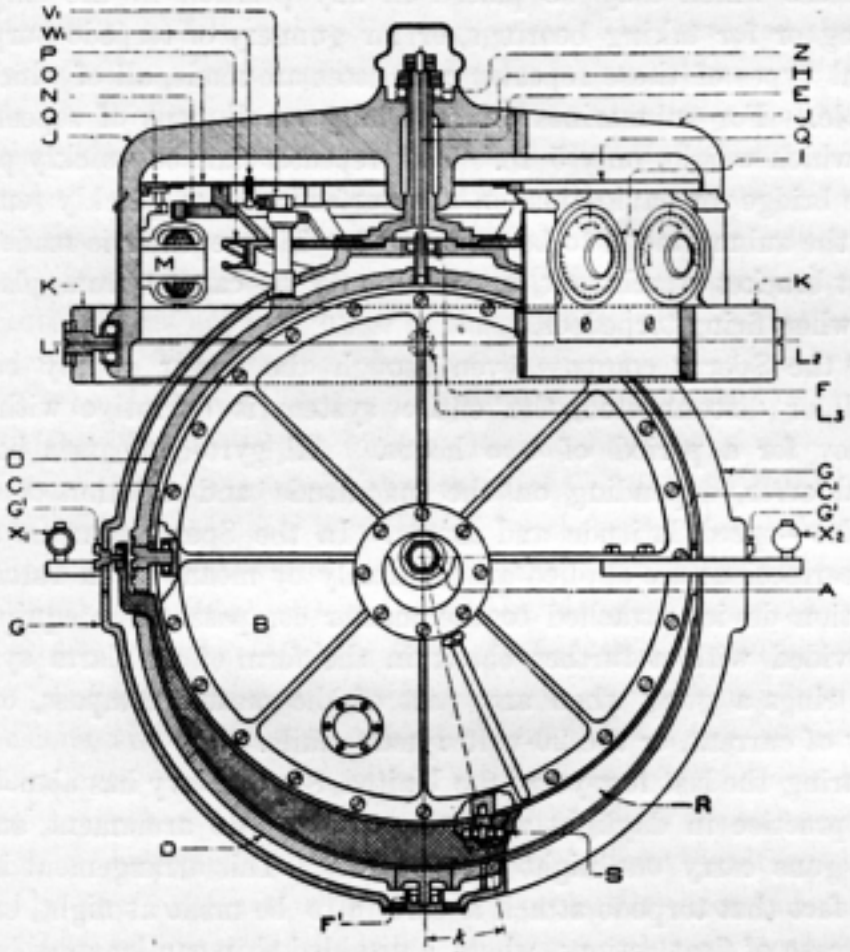
Notwithstanding the many difficulties surrounding the development of the gyro-compass, great progress has been made, and in the United States the solution of these problems is exemplified in the Sperry gyro-compass in a practical and successful manner. This instrument is now in operation or in process of installation in fifty-seven vessels of the United States Navy, thirty-five of which are battleships and twenty-two submarines. This compass has recently been installed in the St. Vincent, and in submarine E 1, and Australian submarines AE 1 and AE 2. Installations have also been carried out in ships in the navies of Germany, France, Russia, Italy, Denmark, Japan and Brazil.

An elementary section of the Sperry gyro-compass is shown on page 361, of which the following is a description :—

The section is made through the vertical East-West plane. The spider J is suspended in ordinary gimbal rings K. The stem H is rotatably mounted in the spider J by means of ball bearing Z. Attached to the stem H are the compass card O, the large gear N and the ring G. Suspended from this stem by means of a wire E is a vertical ring D. The gyro wheel rotates about the axis A, held in ball bearings in the casing B. This casing is rotatably suspended in the ring D by means of horizontal pivots C. The gyro wheel with its casing and the ring D are collectively termed the sensitive or gyroscopic element. Rising from the ring D is a small post carrying the contact wheel $V_1$. This post passes through the outer ring G without touching it. The contact wheel rests on contacts $W_1$, which are attached to the frame fixed to the stem H. In turning to seek and maintain the meridian the gyro turns about its vertical axis. Any tendency to turn about this axis moves the contact wheel $V_1$ on to one side or other of the pair of contacts $W_1$. The contact wheel co-operating with the contacts $W_1$ controls the small motor M which, by means of the gear N, moves the stem H, the compass card O, the ring G, and all

attached parts, to hunt the sensitive element. All the work of turning in seeking the meridian is therefore assumed by the small motor M, so that all the directive force of the gyro wheel in its tendency to place its axis North and South is useful, and the compass is very accurate. The only friction which the gyroscopic element encounters when turning about its vertical axis to seek the meridian is the very minute friction of the contact wheel $V_1$ rolling on the contacts $W_1$. It will be seen that the ring G is held in practically constant relation to the gyroscopic element, but is nevertheless quite independent of it mechanically. The ring G may therefore be used as a base from which to suppress the freedom of the gyro wheel without interfering with its directive force. Freedom is suppressed by the pendulum R, which is suspended in the horizontal pivots $G^1$. It will be noticed that the arms of the pendulum pass through the vertical ring D without touching it, and that the pendulum is attached to the gyro casing at S eccentric to the vertical axis of the gyro wheel.

To understand the action of the compass, let it be supposed that the wheel has just been brought to full speed, and that the axle A is




VERTICAL SECTION OF THE SPERRY GYRO-COMPASS.

pointing East. The earth in turning moves our horizontal in space. The gyro, by reason of its rotation, tends to maintain its plane in space. This results in an apparent inclination of the axis of the gyro with relation to the earth's horizontal. The inclination takes place against the weight of the pendulum R, which presses downwards about the horizontal axis, thus causing "precession" of the axis of the gyro towards the North and South meridian. As the pendulum is

attached to the gyro casing at a point eccentric to its vertical axis, the pendulum will also act about the vertical axis, thus "precessing" the axis of the gyro back to the horizontal. Under these circumstances the gyro can have but one position of equilibrium, and that will be with its axis pointing North and horizontal. We therefore have a compass which constantly seeks and maintains the North and South meridian.

Master and repeater compasses.

The compass described is called a "master compass," and is placed in a protected position below the water-line and behind armour, and, by means of a step-by-step electrical system similar to that employed for electric clocks, it serves to operate repeater compasses which may be placed in any position in the ship, for steering or for taking bearings, or for gunnery or torpedo purposes. Several types of these repeater compasses are made, all of which are portable. For submarines an especially small type of repeater is used, which weighs only 5 lb. This repeater can be quickly placed on the bridge for navigation on the surface, and as quickly removed when the submarine is to be submerged. The repeater is made with a chest bracket attachment, so that it may be carried from place to place when firing torpedoes.

In the Sperry compass, even though the power supply be deranged or disconnected, the entire system is operative with fair accuracy for a period of two hours. All gyro-compasses have a natural error, depending on the magnitude and relation of three variables—speed, latitude and course. In the Sperry compass all of these corrections are applied automatically by means of an automatic correction device attached to the master compass. The equipment is provided with a further check in the form of an alarm system, which rings a gong when any part of the master compass, or the supply of current, or the 20-volt dynamo fails.

**End**

Night-firing in the U.S.

During the last few years the United States Navy has abandoned firing practice in daylight with the anti-torpedo armament, and all small guns carry out night practice only. This arrangement is due to the fact that torpedo attack is certain to be made at night, except in the case of fleet actions, where a disabled ship can be sunk by the torpedoes of light cruisers and destroyers after the remainder of the squadron has, in the course of the fight, been obliged to abandon its lame ducks. Another reason alleged for abandoning day firing is that with modern high velocity guns, firing pointed projectiles of flat trajectory, the hitting of a target at reasonable ranges becomes a comparatively simple matter.

On the other hand night practice calls for much more than the mere loading, laying and firing of a gun. The picking up of a target