## Direction-finding Wireless and Marine Navigation.

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THE use of wireless telegraphy for direction-finding purposes, which came into vogue in the Navy during the war, seems likely to remain as a permanent auxiliary to sea navigation. France, the United States, and Canada have each adopted the system, and it is understood that Germany is maintaining some of the stations which she erected for war purposes, although definite information on the subject is lacking. So far as Great Britain is concerned, the Admiralty has established direction-finding wireless stations at the Lizard and at Carnsore Point; and it is also continuing for the present the stations at Berwick and Flamborough. Although a nominal fee of only five shillings is charged for giving a vessel a bearing by wireless, our merchant service does not appear so ready to take advantage of this assistance as it was anticipated it would be. This attitude of indifference is probably due to the value of the system not being understood sufficiently. Nevertheless, direction-finding wireless has proved of great help to the seaman on many occasions, and, beyond all doubt, will grow in favour as the mercantile marine becomes more familiar with its working.

The principal use of the system is to enable the bearing of a vessel in open waters, or when approaching pilotage waters, to be determined from one or more fixed points by intersection. All bearings thus obtained are the Great Circle bearings at the place of observation, which may be on shore or aboard ship, according to the method employed. If proper care be exercised, the average of error will be very small—less than one degree. Experience has shown that day readings over water are always trustworthy, and, unless high land is close to the vessel, day readings over land are approximately accurate. Night readings over water are approximately correct at short ranges of about one hundred miles; but night readings over land and over long distances are liable to error. Sunrise and sunset times should both be avoided, as bearings then obtained by wireless cannot be relied upon for accuracy.

There are at least three methods of using directional wireless to give ships their bearings and position. One requires no special apparatus in the ship, the others do. In the case of the first-mentioned, any vessel fitted with wireless telegraphy can call up a shore station and ask for a bearing. The station signals back that it is ready to give the bearing; then the vessel makes her call sign continuously for a short period, during which time the shore station ascertains the bearing by means of its direction-finder, or radiogoniometer, and then transmits to the vessel her true bearing with the time at which it was observed. Responsibility for accuracy rests, in this instance, upon the station. If the vessel requires simultaneous bearings from two stations in order to obtain her position, she calls up the controlling station of the shore group and states her need. Both stations then determine simultaneously by their direction-finders the respective bearings of the vessel; the controlling station collects both bearings, and either transmits them to the vessel, with the time at which they were determined, or, if equipped with the necessary instruments for the purpose, the station fixes the position of the vessel as obtained from the bearings and sends the information to the vessel. The main disadvantage of this method is that only one ship at a time is able to call up a station. If more than one tried to do so, "jamming" might result. Further, the distance over which bearings can be obtained is limited to one well within the maximum range of the ship's installation. If the bearing only is transmitted,

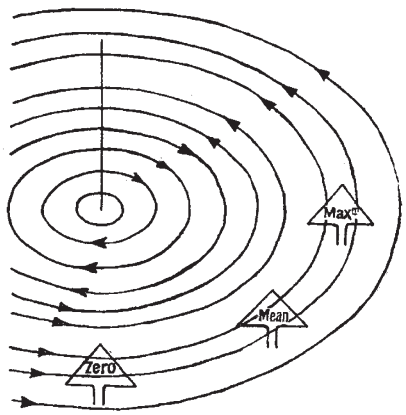


FIG. 1.—Field of magnetic lines of force through a loop aerial. This aerial may be regarded as inductive to the field of magnetic force of the advancing waves in certain positions, but as non-inductive in certain other positions. In the figure, for the sake of simplicity in drawing, it is assumed that the loop is being moved round the transmitting station so that its plane is pointing at the station at the right hand or maximum current position, and is facing the transmitter at the lower or zero current position.

the ship must be furnished with special charts or special tables of correction, as the bearings obtained are the Great Circle bearings at the shore station.

As to the station itself, it must have a direction-finding plant, as well as an ordinary wireless transmitting installation. The plant consists of wireless direction-finder set, tuning apparatus, receiving and amplifying set with accumulator batteries, dry batteries, etc., and a small power plant for charging purposes. Where two or more stations are grouped together for co-ordinate direction-finding work, the controlling one may be equipped with wireless transmitting apparatus, the others with direction-finding apparatus only, and be connected with the master station by telegraph or land telephone. Any ordinary shore transmitting station is suitable for undertaking communication with ships requiring bearings, so

that, as an alternative, two or more direction-finding stations of a group covering a certain area may be equipped with receiving gear only, and an ordinary separate transmitting and receiving station may undertake the controlling duty. A station may be self-contained. In such case the aerials for the direction-finding receiver and for the transmitter must be spaced a short distance apart, whilst the receiving and the transmitting apparatus must be housed in separate buildings, the whole of the receiving being done on the direction-finding receiving apparatus, and the transmitting apparatus being operated electrically from the direction-finding room.

A ship equipped with directional wireless apparatus can obtain bearings from any known ordinary wireless telegraphy shore station; but it is preferable that certain of these stations should be detailed to transmit, simultaneously or successively, signals on given wave-lengths at definite times during each hour. This is known as the Beacon Station method. Only vessels fitted with direction-finding apparatus are able to use it. The apparatus comprises a twin direction-finding aerial system consisting of either suspended fixed wires or large rigid frames, together with wireless direction-finder, tuning apparatus, and receiving and amplifying gear, with batteries and charging plant. A cabinet for the apparatus and operator, and telephone or buzzer communication with the ship's steering position, are also necessary. Such an installation costs about 300*l.*, apart from the expense of fitting it. Any number of ships can obtain bearings, or fix their position, at the same time from the same station by this method, and are able to do that over much longer ranges than is the case with the method first described. As, however, ships using their own direction-finding sets are responsible for the accuracy of the bearings obtained by them, their staffs require some technical skill in the work, and it is necessary that the instruments should be calibrated and checked occasionally.

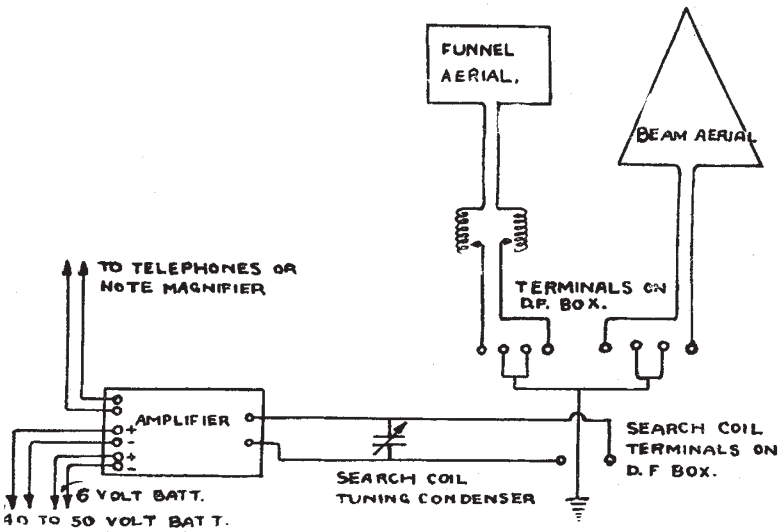


FIG. 2.—Simple circuit for aperiodic aerial and spark reception aboard ship. The beam aerial is rigged in the thwartship line so that it receives no induced signals from the ship. The funnel, or fore-and-aft, aerial receives signals direct *plus* induced signals from the ship. If the two aerials are adjusted to an equal sensitivity, they will always produce a resultant field in the direction-finding transformer in the same line as the incoming wireless wave, and the bearings obtained will be correct.

In the third method a rotating directional wireless beam having a fixed angular velocity is transmitted by a specially fitted fixed transmitting station. The rotating beam has a sharply defined zero direction which passes through North and South at given times. Knowing the angular velocity of the beam, and by observing the time interval between the given times at which the zero passes through North and South and the time at which the zero signals are received in the ship, the bearing of the station can be determined.

In order to ensure that the watches in the transmitting station and the receiving ship are synchronised, the station transmits a timing signal before commencing the rotating beam. To use this method, a ship must carry on her bridge a special watch, the face of which is marked in degrees, the scale corresponding to the angular velocity of the rotating beam. If this watch is started at the moment indicated by the timing signal, the bearing in degrees of the ship from the station can be noted from the watch at the moment when zero signals are received, and this bearing can be checked with subsequent zeros. During the war Germany had three stations working by this method, but Great Britain has none.

Aboard ship the simplest form of direction-finding apparatus is a single-loop aerial rotated round its vertical axis through a horizontal scale. To increase the current through the loop, it is usual to tune the loop with a condenser to the wave-lengths required to be received, and instead of a single loop a frame fitted with a multi-turn loop may be used. In the Bellini-Tosi system, in place of a rotating loop aerial two fixed loop aerials are employed, these being connected to an instrument known as the radiogoniometer, or direction-finder transformer. Inside the latter is a small revolving coil attached to a pointer moving over a scale by which the direction of the signals can be determined. Since, however, the receptive powers of a comparatively small loop aerial, such as can be employed in direction-finding aboard ship, are very much inferior to those of the ordinary type of ship or shore station earthed aerial, a signal-amplifying apparatus employing several vacuum valves is an essential feature of the direction-finding receiver.