RESULTS OF THE TESTS MADE ON THE LOTH CABLE IN THE HARBOUR OF CORUNNA

Extract from the *Revista General de Marina* — Madrid, Oct. 1928.

The Naval Commission which assisted in the tests conducted on the Loth cable in the port of Corunna has submitted its report, from which we extract the most interesting paragraphs.

On July 24th, 1928, tests were conducted in the Port of Corunna on piloting a vessel by means of the cable installations made by the Spanish Company having the agency for the Loth cables in Spain.

These consisted of the following elements :—

A cable led from the port of Corunna, one end of which was located in a house situated near the military Hospital while the other end started in a direction normal to the coast and then followed the directions indicated on the plan of the port of Corunna.

Further, on each side of the Orzan, two lines were stretched on poles in the ground, not only for the purpose of aviation tests, but also for the more important applications, from which it derives the name of "coast guard cable".

1°) *CHANNEL-PILOTS.*— One installation of the "pilot cable" (see Fig. 1) comprises a single phase alternator having a musical frequency, to one pole of which is attached a large plate and to the other the pilot cable. This cable is submerged and terminates at its other extremity in a claw, to the ends of which are attached two plates in contact with the sea.

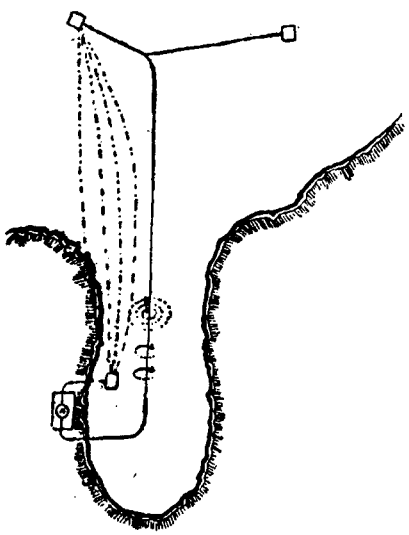

FIG. 1.

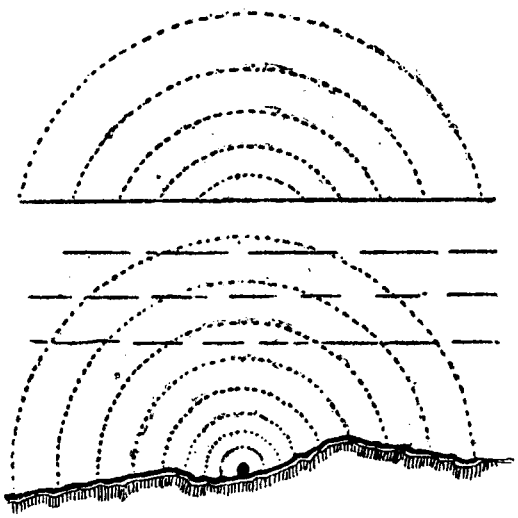

FIG. 2.

In the proximity of the cable, the magnetic field produced by the current has an approximately circular form and the lines of force lie in planes normal to the flow of the current, as shown in Fig. 2.

It is evident that the presence of a wreck or other magnetic body in the proximity of the cable will cause the lines of force to become distorted.

The current which leaves one pole of the alternator, after having passed through the cable and the terminal plate at its extremity, returns through the sea to the other terminal, following paths more or less widely separated, owing to the repulsion between the two currents, and gives rise to lines of force distributed somewhat as shown in Fig. 3.

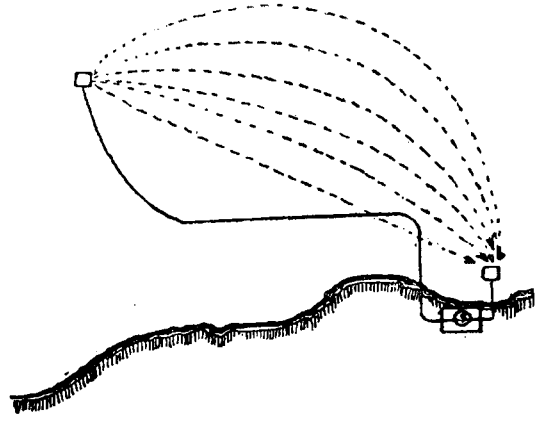

FIG. 3.

The currents produce a magnetic field which is horizontal, since it is actually a composite field produced by a group of currents.

The return current not only flows in the proximity of the cable but above it, the magnetic field produced being every where the resultant of the current flowing in the cable and the other currents in that vicinity. If these groups of currents were extended indefinitely, the resultant field would become horizontal; but in accordance with the present theory, if the group is limited, the lines of force should be located on curves more or less crowded together. This means that below the cable (that is, on the ground) the field will also be horizontal, but in the inverse sense from the field in the water.

This being established, let us consider the operation of the cable.

If aboard the vessel there is mounted a frame with several coils, having three degrees of freedom, and the terminals of these coils are attached to a telephone, it is possible, by exploring the magnetic field, to obtain a certain position of the coil frame in which the sound received is a maximum. The normal to this position gives the direction of the field. From the variations in the intensity of the sound it is possible to judge whether the vessel is approaching or receding from the cable.

2°) *COAST-GUARD CABLE.*— The inventors attach the greatest importance to the employment of the cable for this purpose since, as may be readily conceived, the radius of effective action of the channel pilot cable is limited. When the cable at Corunna is operating with a current of 3 amperes, the effective radius of action is about 200 metres.

The principle of the coast-guard cable is as follows :

If we install an overhead wire parallel to the coast, with one terminal attached to a plate in contact with the sea and the other connected to the pole of a single-phase alternator, the other pole of which is connected to a plate submerged in the sea, a current flowing through the sea-water will result.

Let us suppose that vessels should keep clear of the coast in question on account of dangers to navigation. Aboard ship there is installed a frame with a movable coil. If the coil is then turned in such a manner as to cut the lines of current normally, a sound will be heard

in the telephones, which is an indication that the vessel is approaching the coast. If the coil is then turned horizontally to one side and the other it is possible to determine by the difference in tone, whether the vessel is crossing a definite path of the current.

The inventors state that numerous experiments in trial balloons and submarines have permitted them to determine the exact distribution of the lines of force in the magnetic field of an aerial wire of definite length operating on a definite frequency. (These lines have been drawn in the form of an abacus). The distribution of the lines in the field is entirely independent of atmospheric conditions; both for those occasioned by climatic variations, such as fog and squalls, as well as those occasioned by the rising and setting of the sun. In order that their system might function to greater advantage they employ frequencies which remove all danger of the sound being confused with atmospheric static or sound generated by radio signals.

The inventors claim that the determination of the position of the vessel with respect to the path of current may be accomplished by means of a special apparatus which indicates the inclination of the magnetic field at any point. In this apparatus they make use of three planes of reference: horizontal, bow to stern, starboard-port; the last two planes being vertical. In this manner it is possible to determine the tangent to the respective lines of force by two observations made with the apparatus, which is based on the same principle as that of the goniometer having a fixed frame with two spools arranged as a variometer.

If two coast-guard cables are employed instead of one, and each is supplied with current of a different frequency a distribution of the lines of force as indicated in fig. 4 will result. It is possible therefore to determine the position of the vessel from their intersection and if these intersections are conveniently disposed, according to the claims of the inventors, the vessel may make use of them in entering port.

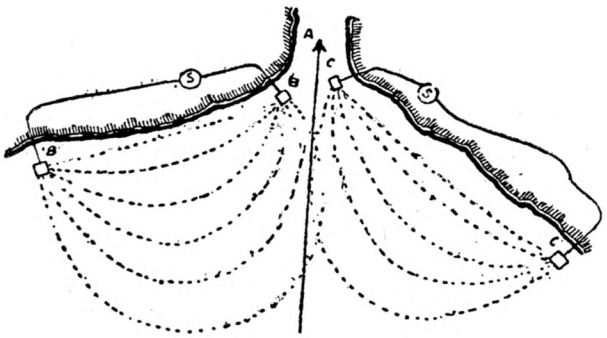

FIG. 4.

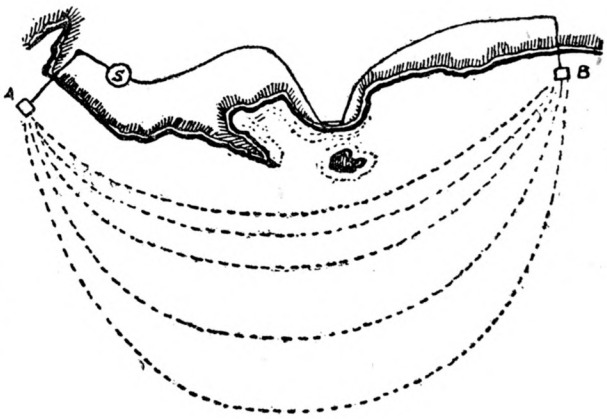

FIG. 5.

It may be objected to this that the lines of force might follow the path of least resistance, such as *BC* instead of *BB'*

There is still another application of the coast guard cables. With their aid it is possible for a vessel to depart from one port *A* in time of fog, and arrive at another distant port *B*, (Fig. 5) for example.

If there is a shoal near the coast, the inventors claim that the aerial wire may be led in this proximity and the modification of the field, at the point of entrance and leaving, due to the influence of the channel pilot cable, can be taken into consideration.

The distance to which the field due to the current will extend depends as we have stated, on the distance in a straight line, between the points *A* and *B*. It varies as a function of this distance, according to an exponential law, but remains constant under the various conditions mentioned above.

An airplane wishing to pass from point *B* to point *A* need only follow the aerial pilot cable.

The inventors state that the installation at Brest furnishes the entering vessels with an

indication of the height of the tide every half hour, the pilot cable installed by the inventors being employed for this purpose.

INSTALLATION AT CORUNNA.— At Corunna, there has been installed a pilot cable having a length of 5000 metres, supplied with single phase alternating current of 500 cycles, with a practical current consumption of 3 amperes. This current may however increase on occasion to 10 amperes. The normal zone, within which the presence of the cable may be determined when the current flowing is 3 amperes, is about 100 metres wide.

The coast-guard cables of the Orzan are as follows: that of Prageira (1400 metres; 3 amperes and 600 cycles) that of San Roque 700 metres, 2 amperes, 2200.

The small shed for the pilot cable situated near the Hospital contains an internal combustion motor which drives an alternator for emergency use. It is also supplied by the power system of Corunna through two small groups of threephase motor generators.

Owing to the limited length of the coast-guard cables, the lines of force may be determined at a distance of from 6 to 7 kilometres for the cable at San Roque and from 13 to 15 kilometres for that of Prageira. As stated before the channel pilot cable can be heard up to distances of 200 metres.

RECEIVING APPARATUS ABOARD THE GUN-BOAT "DATO" AND THE HYDROPLANE.— The installations made by the inventors were of an experimental type, but comprised all the apparatus necessary for making the demonstration.

Attached to the bow of the "Dato" by a spar, were installed the three frames forming what was called the lantern, while on each side of the vessel were attached two other horizontal frames. On the bridge, enclosed in a cabinet divided into compartments were the circuits and the receiving instruments, consisting of a primary aperiodic receiving circuit for the purpose of receiving the musical tones. The receiver is also fitted with a circuit which may be tuned to the desired frequency.

In another compartment connected to the one described above (located on the superstructure) is an amplifier having eight stages; of which any number may be connected in circuit by means of a switch-board. Finally, in the lower part, is a filter which permits disturbances due to the radio installations aboard to be eliminated.

Batteries of 80 and 6 volts furnish the necessary potential. In the upper part, to the left, is located the direction finder of the magnetic field. According to the inventors, the direction finder is constructed similar to a two-phase motor, the two stator windings of which are connected to the longitudinal and horizontal frames or to the transverse and vertical frames. The motor is connected in circuit with the amplifier and the telephones. A pointer indicates the direction or the inclination of the magnetic field.

In the centre are several condensers which may be connected in series and which serve the following purposes :—

They permit listening in with the system of frames in the bow or the installations on the sides of the vessel.

Listening on one of the three planes, horizontal, bow to stern, or transverse plane.

Listening on one of the frames to starboard or front.

The arrangement with the frame located outside of the vessel is the one which gives the best results. It is not impracticable to fit them in this manner since the frames in the side may be fitted into the hull and the three frames in the bow may be held in position by means of a spar, which is put over only during fog or when approaching land.

The transverse frame carries more coils than the other two and consequently serves to give the first indication of the presence of the cable. In navigating along the cable the longitudinal frame is used; *i.e.*, the one which is parallel, while for passing over the cable the horizontal frame is employed, the two transverse frames indicating the side on which the cable is located by the difference in the sound in the telephones.

The installation aboard the hydroplane consists simply of a spool, comprising several coils wound about a circular armature which extends almost to the bottom of the apparatus. It is electrically connected to a receiving device which is not so complicated as the one installed aboard ship. This consists of an aperiodic circuit, à tuned circuit, and a two-stage amplifier. The whole, including the batteries, occupies very little space.

THE TESTS CONDUCTED ON JULY 24 AND 25, 1928. — The tests conducted on July 24th were in the presence of the Minister and, at the request of the Naval Commission, they were repeated on July 25th.

On leaving port, passing over the pilot cable, it was possible to hear the noise of the cable without putting on the head phones. Mr. LOTH stated that the cable was being supplied with a current of 2.8 amperes. We steamed away from the cable in the direction of Gabeiras-Prior, and returned again towards the cable, using the frame on the sides of the vessel to fix the moment when the ship was directly above the cable. The instant before reaching the cable we heard almost the same indentical sound from each side and the moment when we were exactly over the cable all sound ceased abruptly. We were able to determine this moment easily, when suddenly the man on watch in the house left the cable without current, a signal having been hoisted from the ship.

Thereupon the coast-guard cables of Prageira and San Roque were put in operation and we were able to distinguish the difference in tone of one side from the other.

When the vessel was steaming on a course parallel about to one side of the path of the current, there was an appreciable difference in the sound obtained from the frames on each side. According to the inventor this difference is due to the fact that the inclined magnetic field, on reaching the side of the vessel undergoes a deviation which results in the sound being received with greater intensity on one side than the other. In this manner it is possible to determine on which side the danger lies. If, in spite of this, one insists on turning to that side, the lines of force of the magnetic field, being nearly hozizontal will slide along the sides and the frames on the sides cannot pick them up. They will however be received by the transverse frame.

By means of the variometer, the inventor determined the direction of the coast and he insisted upon the fact that the distance might also be determined by the inclination of the magnetic field.

A pointer fitted to the instrument moves over a graduated scale and indicates the direction of the coast. It is easy to determine the point of minimum.

RESULTS OF THE TESTS AND CONCLUSIONS OF THE COMMISSION.— The Commission considers that the results of the tests made on the pilot cable are both definite and conclusive, and that in view of the relatively slight expense of installation, these might be utilized for fishing vessels as well as for men-of-war and vessels of the merchant marine; assuring the possibility of entering port in any weather conditions. In view of the fact that the installation of channel pilots at great distances from the ports is relatively expensive, it would be necessary to employ the so-called "coast-guard cables" for the approaches to land. Not having been able to conduct tests of sufficiently long duration to be able to judge the value of these last cables, of which several have not only been studied but installed, the Commission finds it necessary to report that these latter tests cannot be considered conclusive. They are however rather satisfactory but it will be necessary to make a more detailed study of future applications, and according to the inventor, to make several more installations. The inventor demonstrated several of his instruments and the method of their employment and we have nothing to add regarding their utility. He then outlined the tests made under various conditions and under all circumstances and one could well appreciate the value of the cable as an auxiliary to the channel pilot. In addition to others, the cable gives indications of the existence of a danger in the vicinity. The observer in the hydroplane assured us that he could hear the pilot cable perfectly and could follow it exactly. When flying above the cable he was able to distinguish the sound athough his plane was not fitted with the special device for eliminating the noise of the magneto.