The Leader Cable System.

SO far back as 1893 the idea was conceived of using electric signals transmitted through a submarine cable to guide ships past dangerous places. But it was not until Prof. R. B. Owens, of McGill University, began investigating the subject that what is now known as the leader cable system took practical shape. Prof. Owens took out certain patents in 1901–3, and these were later presented to the Admiralty, which has decided to allow anyone who wishes to do so to use them without paying royalty.

When Prof. Owens first began his researches the thermionic-valve amplifier was not in existence, and from lack of this important adjunct to its efficiency the leader cable could not be put to practical use, as the signals originated by it were not strong enough for navigational purposes. The invention of the amplifier enabled this defect to be overcome, with the result that during the war leader cables were employed both by ourselves and by the Germans. Such cables have since been laid at Portsmouth, New York, and Brest.

In all these installations the underlying principle employed is that devised by Prof. Owens, but considerable improvements have been made in the details of the apparatus and in the manner of using it. These advances are mainly the result of work carried out at various Admiralty experimental stations, particularly at Portsmouth, where a cable 17 nautical miles in length has been laid along the eastern approach to the harbour. The working of this cable was demonstrated to the foreign naval attachés recently.

A leader cable system comprises a submarine cable laid in any waters where it is desired to facilitate navigation. The sea end of the cable is earthed, whilst the shore end is taken into a transmitting station and there connected to one terminal of an alternating dynamo, the other terminal of the alternator being connected to earth or the sea. In the cable at the shore station a power-operated signalling key is inserted by means of which the current in the cable can be made or broken so as to transmit through the cable any pre-arranged signals or Morse letter. In order that a ship may be able to locate the cable and follow along it a receiving apparatus is fitted in her, or a portable set may be taken on board by the pilot. This apparatus consists of two coils of wire, one on the port and one on the starboard side, which are connected to an amplifier and telephones on the vessel's bridge through a change-over switch. In the telephones the signals given out by the cable are heard as a sharply pitched musical note.

The electric current in a leader cable is an alternating one, and the actual field distribution arising therefrom is complicated by the fact that the return current appears to be mainly concentrated between the cable and the sea surface. Considering the case of a continuous current in the cable and a return path through sea water in the vicinity of the cable, the resultant magnetic field in the air above the cable will contain circular lines of force due to the constant current in the cable and horizontal lines of force due to the return current in the sea water. Assuming the return current to be distributed uniformly and thus to constitute a sheet of current the magnetic field of which is horizontal and at right angles to the cable, the resultant field will be horizontal directly over the cable, vertical some distance away, and again approximately horizontal, but in the reverse direction, at a considerable distance from the cable.

If instead of a current of constant intensity an alternating current is passed through the cable, electric currents in a direction opposed to those in the cable will be induced in the sea water, and the intensity of these induced currents will be greatest near the cable. Above the surface of the water the lines of force due to these induced currents will be slightly curved to the surface, but the general direction of the field will be opposed to that due to the current in the cable. In the final resultant field the points of inversion are moved towards the cable. With increase in the frequency of alternation the induced currents increase in intensity, and as a result the points of

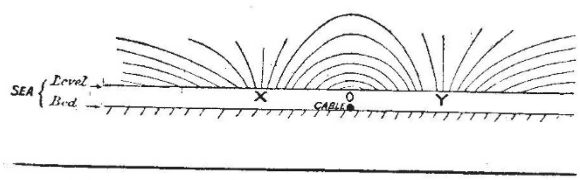

FIG. 1.—Approximate distribution of magnetic field caused by an alternating current in the cable.

inversion (X and Y, Fig. 1) move closer together as the frequency increases.

When the hull of a ship is brought into the vicinity of the cable that part of the ship—and the space adjacent to it—farthest removed from the cable will be screened to some extent. The ship being a good conductor, electric currents are induced in its outer surface when an alternating current flows through the cable. When the ship is broadside on to the cable these sheets of current flow fore and aft and give rise to a magnetic field parallel to the surface of the ship. If the intensity of the magnetic alternating field giving rise to these induced currents is greater on one side of the ship than on the other, then the resulting magnetic field will be greater on the former side.

When a steel or iron ship lies directly over the cable the intensity of the magnetic field is appreciably increased because of the presence of the ship, but the intensity is small over the deck because of the screening effect of the hull. If on each side of the ship a square frame is placed, and if on these frames a number of turns of wire are wound, thus forming a coil, some of the lines of force will pass through these coils. When the ship lies directly over the cable the number of lines of force passing through each coil will be equal, and the strength of the signals heard in each coil will be equal also. But when the ship is on one side of the cable the strength of the signals received in the coil nearest the cable will be the louder. By this variation in the strength of signals the navigator is able to tell which side of the cable his ship is on.

Experiments made at Portsmouth show that the best position for the coils to be placed is with their centre not farther than within 18 in. from the ship's side and the bottom edges of the coils inclined outward at an angle of 15° to the vertical. When they are so placed screening is satisfactory up to 400 yards, the maximum range is approximately 600 yards, and fairly good signals are obtained even if the cable is approached at a steep angle.

The range at which signals from a leader cable can be received will be largely increased if in place of coils being used two electrodes are towed astern of the ship, these being insulated cables of approximately 50 and 150 yards in length, with the insulation at the outboard ends of the cables stripped back for a distance of 6 ft. so as to make good electrical connection with the sea. The inboard ends of the cables are connected to the receiving apparatus on the bridge through a twin wire led from the stern. The chief difference when using the electrodes instead of coils is that, as with the former there is no screening effect, the signals received do not indicate which side of the leader cable the ship is on. To ascertain this it is necessary to maintain a steady course for some few minutes and to observe whether the strength of the signals increases or decreases.

In the receiving apparatus aboard ship two leads are taken from each coil to a change-over switch installed on the bridge in such a position that it is easy of access to the navigating officer. Two leads are taken from this switch to an amplifier of the three-valve low-frequency transformer type, using a 4-volt filament battery and a 60-volt anode potential. The telephones are connected directly with the amplifier, and can be fitted with a head-piece or a single receiver. By using a more powerful amplifier it is possible to install a loud-speaking telephone repeater which will enable the signals to be heard by all standing on the bridge. By

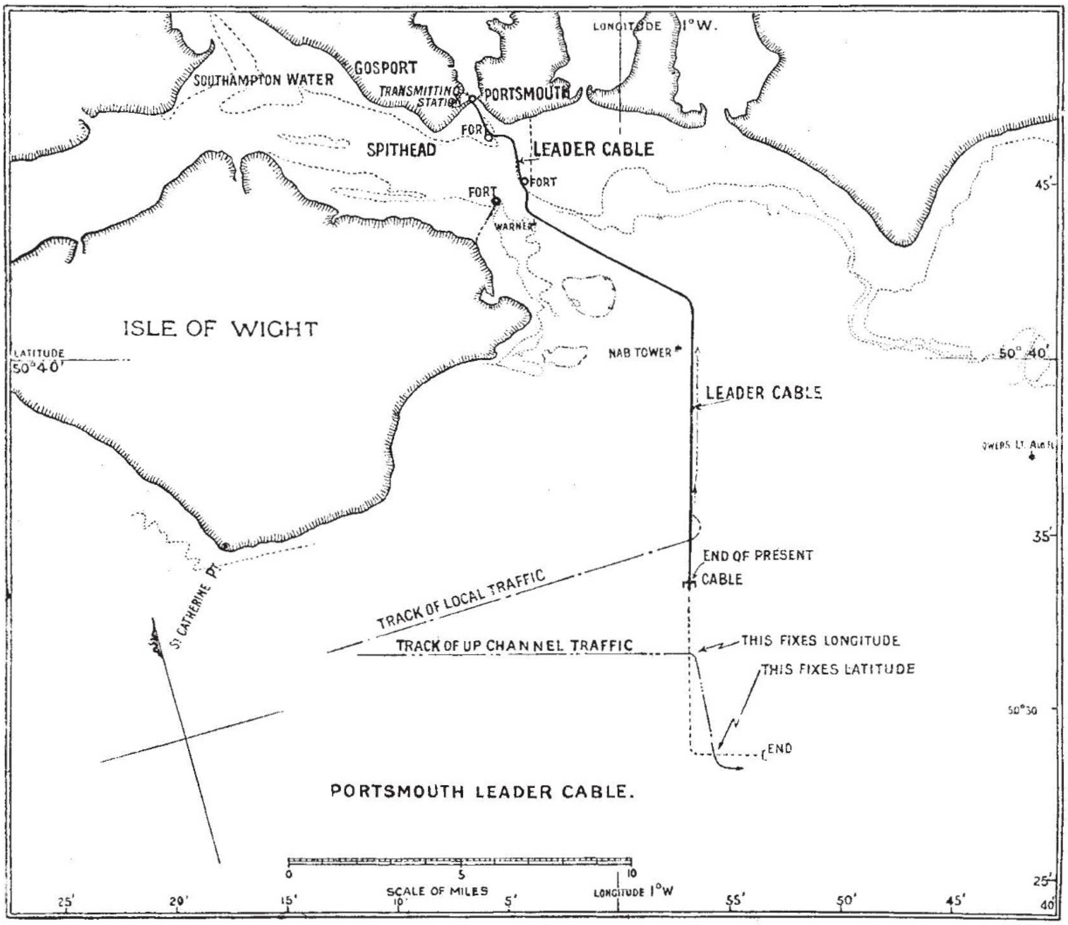

FIG. 2.—Position of Portsmouth leader cable. The broken line turning east from the end of the cable indicates the direction of a proposed extension of the cable which would enable ships proceeding up-Channel to fix their position in thick weather by crossing the cable twice at the points indicated.

working the change-over switch the navigating officer is able to detect, from the strength of the signals in the coils, which side of the cable his ship is on, as the signals will manifestly be loudest in the coil nearest to the cable.

The greatest length of leader cable in use is forty miles. For a longer distance than this it would be necessary to pay special attention to decreasing the continuity resistance of the cable and the capacity between the core and earth in order to reduce the current attentuation. This would probably lead to a very expensive cable being required. So far experiments have not been carried out in a greater depth than 30 fathoms, but there is evidence that as the depth of water increases, the strength of signals to one side (say 300 yards) from the cable does not decrease so rapidly as is the case directly over the cable, but the motion of a ship does not materially affect the reception of cable signals by her. It is also possible for a ship to receive visual signals, instead of audible ones, from a leader cable. In that case electric lamps are lighted by the current from the cable. But the visual system has not been developed to such a practically useful stage as the system described above.

Lake Victoria and the Sleeping Sickness.[1]

ONE need not yet have reached extreme old age to remember something of the extraordinary interest excited by the discovery of the great Victoria Lake and the unveiling of the sources of the Nile by Speke and Grant. A wide field for the imagination was opened up by the news of a vast expanse of water, second only to Lake Superior among fresh-water lakes, in the interior of the African continent. Dr. Carpenter's narrative enables us to substitute reality for romance, and to make the acquaintance of a country of great beauty and charm, marred, unfortunately, by the terrible plague of sleeping sickness.

The main object of the author in his visit to the great lake was the investigation of the bionomics of *Glossina palpalis*, the tse-tse fly which carries the trypanosome of sleeping sickness. This important work, which was carried on under the auspices of the Tropical Diseases Committee of the Royal Society, involved a residence of about four years on one or other of the numerous islands which stud the northern part of the lake, preceded by a stay of some months at Jinja, on the mainland. The outbreak of war in August, 1914, caused an unfortunate interruption in Dr. Carpenter's labours; for the exigencies of active service kept him employed in various parts of German and Portuguese East Africa until November, 1918, when he was released from duty and returned to Uganda.

FIG. 1.—Fly beach on Damba Isle; a favourite breeding ground is under the bushes at the gap on the right. From "A Naturalist on Lake Victoria."

In spite of this and other intermissions, the author has been able to put upon record, as Prof. Poulton remarks in his preface, a really wonderful body of observations. The earlier chapters of his work contain a useful *résumé* of our present knowledge of the natural history of *G. palpalis* in its relation to other factors which contribute to the spread of the disease, such as the presence of game. It is needless to say that for the greater part of this now intimate knowledge we are indebted to the admirably devised and painstaking observations and experiments of Dr. Carpenter himself, as may be seen at greater length in the official reports of the Sleeping Sickness Commission. It is satisfactory to know that the author, as a result of his careful study of the habits of the pest, sees some hope, if not of exterminating the fly in certain regions, yet of diminishing its numbers to a point at which it may cease to be dangerous. This, it appears, can be done by constructing artificial shelters which are highly attractive to the fly, and systematically destroying the pupæ that are formed therein. An alternative plan, viz. the extermination of the Situtunga antelope (*Tragelaphus Spekei*), the

1 "A Naturalist on Lake Victoria: with an Account of Sleeping Sickness and the Tse-Tse Fly." By Dr. G. D. H. Carpenter. Pp. xxiv+333+2 plates. (London: T. Fisher Unwin, Ltd., 1920.) Price 28s. net.