RADIO ACOUSTIC SOUND RANGING

Lecture delivered by Captain G. T. RUDE, *U.S. Coast & Geodetic Survey, before the Third International Hydrographic Conference, Monaco,* 22nd April, 1932.

Mr. President, Gentlemen of the Congress,

I am quite sure you will realise the impossibility of my presenting a Paper on this special subject in the short while I have at my disposal. I shall only touch briefly on the technique employed and not go into the details of the instruments nor into too great a detail as to the work. At the end I shall be very glad to answer any questions that may be of interest to the members of the Conference that I have not touched on in the Paper.

As I stated in the Committee meeting, the United States Coast & Geodetic Survey did not suggest this subject on the Agenda for long discussions, but to bring it to the attention of the Conference, and I am empowered by my Bureau to offer the co-operation of the Coast & Geodetic Survey to any of the Member States who may desire to adopt this method in their hydrographic surveys.

In determining position by radio acoustic sound ranging, two hydrophones are anchored along-shore outside the breaker line connected by a cable to a temporary radio station on the beach, through an amplifier which automatically actuates a radio transmitter through a relay or thyratron whenever a sound of sufficient intensity reaches the hydrophone.

For the determination of the survey vessel's position, a bomb, varying in size from a blasting cap to a pound of TNT, is dropped overboard. At the same time a two-pen chronograph is started on the surveying ship, one pen marking the seconds and the other the instant that the explosion from the bomb reaches the chronograph.

The sound from the explosion then proceeds to the two shore hydrophone stations and is automatically flashed back to the radio station on the ship and is recorded on the same tape recording the explosion at the ship. The lapse of time intervals determines the measurement of the distance from the ship to each shore station and can be measured from the tape to within one-hundredth of a second or about 30 metres.

Radio acoustic ranging has proved especially effective on the Pacific Coast of the United States where the narrow continental shelf and absence of off-lying shoals lends itself to position determination by this method. Positions are determined with ease 50 to 75 miles off shore, and in one case 206 miles from shore. On the Atlantic Coast, however, the continental shelf with off-lying rocks has presented difficulties which have not yet been overcome. It has been necessary on the Atlantic Coast to vary the technique somewhat from that used on the Pacific Coast, especially on Georges Bank. On this survey an origin buoy is anchored about 200 miles off-shore near the edge of

the continental shelf in about 30 fathoms of water. The position of this buoy was determined by a long series of star observations within a probable error of about 400 metres. This buoy is held fixed for the purposes of the survey.

A second buoy is planted about 10 miles distant at right angles to the direction of the proposed marine triangulation. A station ship with a hydrophone suspended under the keel is anchored at the origin buoy. The survey vessel then proceeds to the second buoy and passing close aboard drops a bomb in passing. The explosion from this bomb travels to the station ship and back again to the survey vessel in a method similar to that used in the ordinary surveying operations on the Pacific Coast. At least three determinations of this base line are made.

The determination of the azimuth of the line or angle is taken on the survey ship between the sun and the station ship during the day-time; if at night between a suitably located star and the searchlight of the station ship. From this inclined angle the azimuth of the line is determined.

Having determined the length and azimuth of the base line, the triangulation scheme is then extended shorewards along the ridge of the bank by means of quadrilaterals with sides from 10 to 12 miles long with a buoy at the vertices of each triangle. The length of these lines is determined in a similar manner to that in which the base was determined, with occasional azimuths observed along the line to check the computations.

At the completion of the marine triangulation two station ships are then anchored at any two of the buoys, not necessarily contiguous buoys, and the mobile survey vessel then steams along on her sounding line in a manner similar to the Pacific Coast survey, except that the station ships replace the inexpensive shore hydrophone stations. On the survey of Georges Bank many of these lines extended out beyond the edge of the continental shelf to one thousand fathoms, yet the sound travelled back 40 or 50 miles to the station ships and was flashed back by radio to the survey vessel, furnishing a quite accurate position.

Obviously the physical conditions on the Atlantic Coast making necessary two station ships instead of hydrophone stations renders the work more expensive. It is hoped that in a short while we may be able to find some other method than these expensive ships for the hydrophone stations, yet the work is done much more accurately and as cheaply as in the old days.

I should also mention the importance of the determination of the physical properties throughout the area that is being surveyed, since the velocity of sound depends to a considerable extent on the variation in the density and temperature of the water. For the area of Georges Bank serial observations were made well scattered over the area, so as to be able to draw density and temperature gradients for the whole of the working season. We do not find it necessary on the working sheets to make use of these data, but we did use it in plotting up the smooth sheets.

In closing, I might mention briefly the cost of the installation. On the survey vessel the cost is about 500 dollars; for the installation of the shore

stations about 550 dollars, allowing for the building of a small radio shaft. It must be borne in mind, however, that this method has freed the hydrographer from the limitations imposed by fog and darkness. Now we can sound through the thickest fog and all night. The method has decreased the cost on the Pacific Coast per mile of sounding by fifty per cent.

As stated before I should be glad to answer any questions and again offer the co-operation of the Coast and Geodetic Survey to any of my colleagues at this Conference.

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