EMPLOYMENT OF FLOATING MARKS (BEACONS) BY THE ALGERIA-TUNISIA HYDROGRAPHIC EXPEDITION

(Extract from the Report of INGÉNIEUR HYDROGRAPHE PRINCIPAL M. P. MARTI, published in the *Annales Hydrographiques*, 3e Série, Vol. de 1927-1928, Imprimerie Nationale, Paris, 1928.)

USE OF BEACONS.

The use of beacons was avoided as far as possible on account of the difficulties in connection with their manipulation. It was found possible to dispense with their use during the sounding operations off that part of the Algerian coast where the bottom is regular, the secondary marks on the coast enabling the small craft and vessels to fix their positions satisfactorily throughout area under survey. Recourse to beacons was found necessary, on the one hand, for the purpose of detailed exploration of shoals at some distance from the coast where difficulty was encountered in fixing the positions of the boats by points on land, and, on the other hand, for the exploration of areas at a great distance off shore, where the sounding-vessels could fix their positions during very clear weather only. Beacons enabled soundings to be taken even when visibility was low.

For the purpose of exploring shoals lying at a distance from the land, after a general survey of the area had been made, beacons were moored on the shoal a mile, at most, apart. Thus the sounding-boats were provided with a sufficient number of suitably situated marks to enable their positions to be determined without difficulty. This method was employed on the 27 metre shoal N.E. of Djidjelli, for the Le Sec Shoal (45 metres) N.E. of La Calle, for the Sorelles Reefs and the chain of 30 metres shoals connecting these reefs with the Islands of La Galite, and for the Mazarilles Bank (23 metres) north of La Galite Islands. (See Fig. 1, system of moored beacons employed for these various surveys).

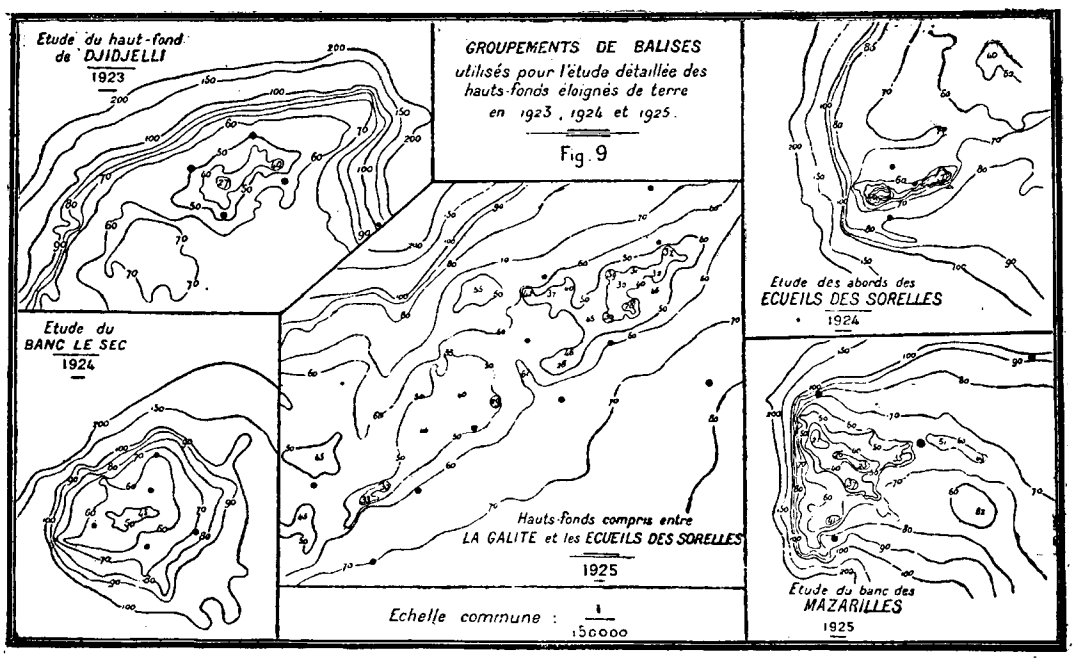

Fig. 1

The distances between the beacons should not exceed 4 miles in order not to make the fixing of position by the sounding-vessels too difficult, as these worked, as will be seen later, at normal speed. On the other hand, the beacons should not be moored

closer to each other than 2 miles apart in order to avoid confusion in their identities and above all when taking angles with the *sounding-circle.* This system was employed in all work carried out at a distance from the land northward of the Algero-Tunisian frontier and on the different parts of La Galite Bank, as is shwon by Fig. 2, system of moored beacons used for these investigations.

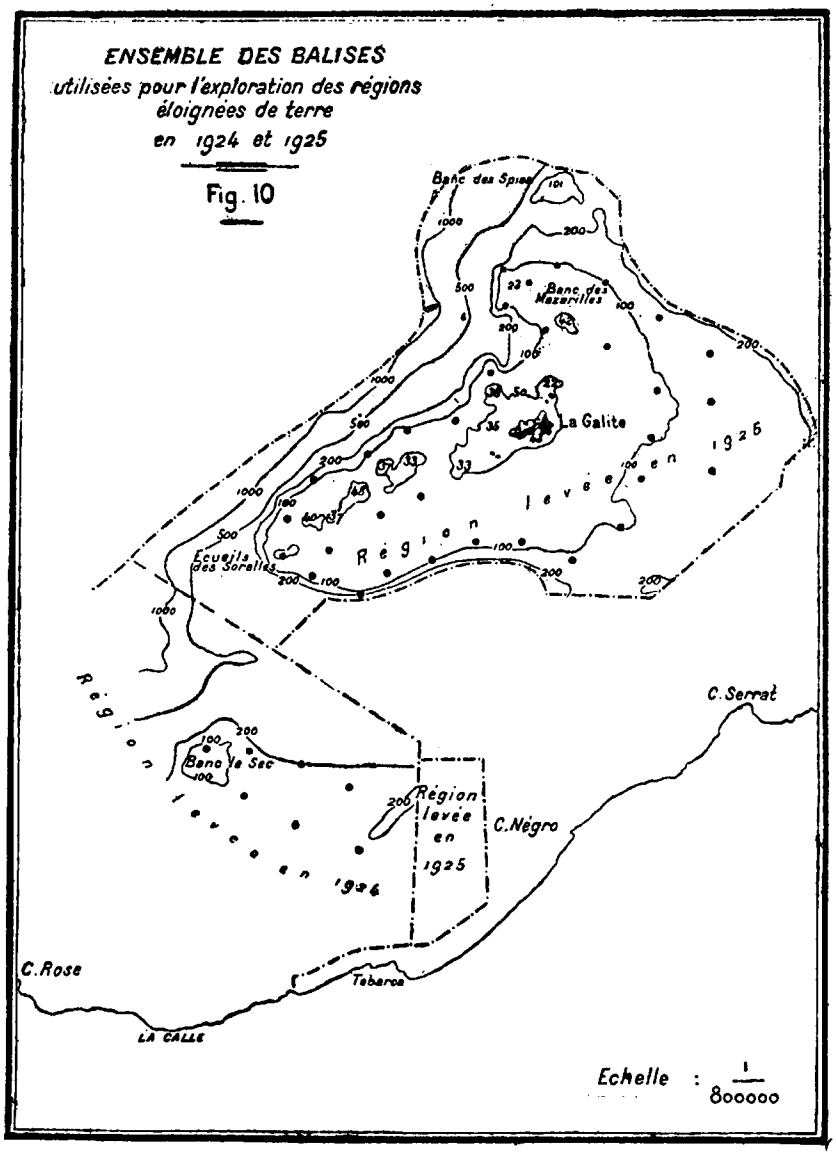

Fig. 2

TYPE OF BEACON EMPLOYED.

The beacons used were of the type known as "dredging beacons large model", which are modifications of the beacons formerly constructed from the designs of Ingénieur Hydrographe en Chef HANUSSE, and employed in the hydrographic expedition to Madagascar (see *Annales Hydrographiques,* 1903, Report on the Hydrographic Expedition to Madagascar, 1899-1901, p. 95, Report by M. FIHCOT, September 1899 to October 1900) (*). These beacons, which are now in current use in the French Navy, are com-

(*) *See* Hydrographic Review, *Vol. V, N° 2, November* 1928, *page* 101.

posed of a riveted or oxy-hydrogen welded steel drum of barrel or cylindrical form, through the axis of which a large iron tube is passed; another large iron tube, forming a tail rod weighted at its extremity, extends below the drum-tube and is attached to it either by a collar or by two pins; this makes the drum ride practically vertically. A wood or iron mast, on which is a top-mark and flag, is stepped into the top part of the drum-tube or is attached to it by means of a clamp (fig. 3). The beacon is held by one or more steel cables attached to eye-bolts on the collar or to the pins which connect the tail rod of the apparatus to the drum; the cables are provided with appropriate mooring gear.

Practical experience showed that it was important that all the gear employed should be in perfect condition. It proved to be poor economy to utilise material in mediocre condition, for the failure of any part during bad weather always entailed serious inconvenience (for example a beacon becoming invisible at considerable distance, and thus useless, on account of the carrying away of the mast), and frequently even the loss of the beacon itself.

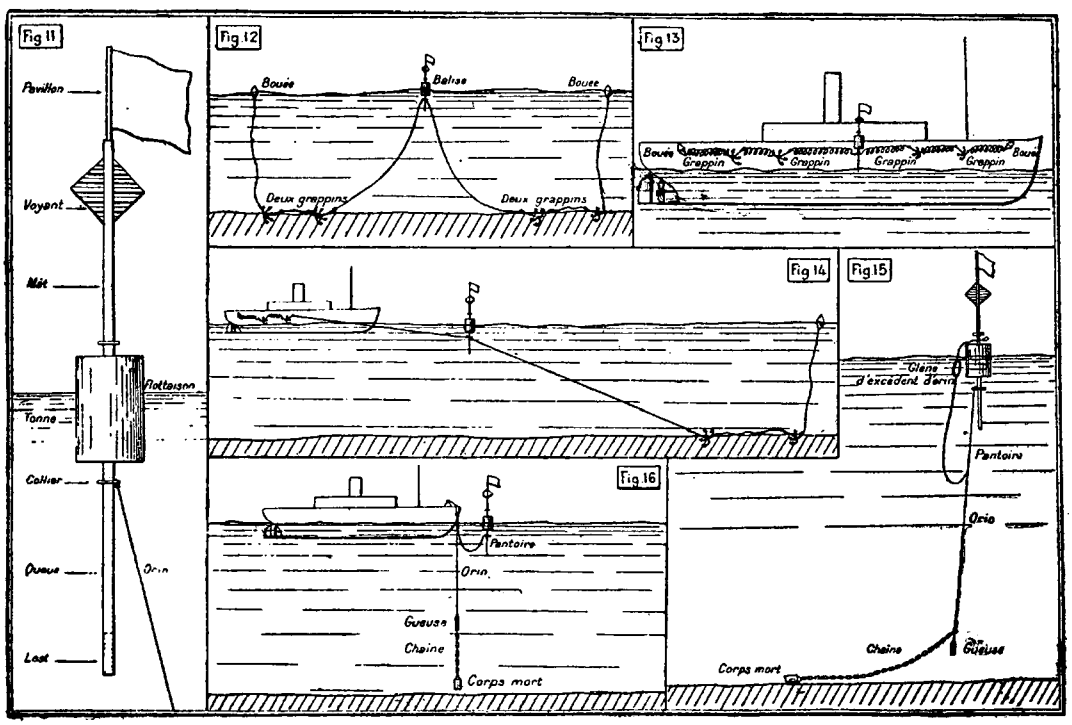

Fig. 3

With regard to the assembly of the beacons, precautions must be taken to avoid all accidental parting owing to the continual action of the swell; the connecting pins of the tail rod to the drum to which the cables are attached must be provided with fore-locks; all shackles of the cables and of the mooring gear should also be fitted with fore-locks; splices in the cables should be made with more tucks than usual. Quite a number of beacons were lost on account of non-observance of these precautions, which appear unnecessary in current practice, but which are of importance if the devices are to withstand the action of the sea without inspection for months.

As to the stability of the beacons, it was found necessary to ballast the extremity of the tail rod to the extent of about 80 kilogrammes (= 175 lbs.). 50 kilogrammes (= 110 lbs.) of ballast was insufficient to maintain the requisite uprightness in a strong wind; but the ballast must not reach 100 kilogrammes (= 220 lbs.) as this would render the beacon unnecessarily heavy and awkward when laying it out in fairly great depths, when the weight of the cables becomes considerable. It was also found that steel wire

must not be used for attaching the ballast to the lower end of the tail rod of the beacon, for in every case the continuous oscillation of the suspended weight broke the steel wire, and the unballasted beacon immediately lay horizontal, thus becoming almost invisible from a distance. At a pinch the ballast can be suspended to the tail rod of the beacon by a short piece of chain, but by far the safer method is to keep to the system originally devised *i.e.*, to place the ballast inside the iron tube which forms the tail red of the beacon, a long bolt being then passed through the tube at its lower end to keep the ballast in place. As ordinary square section pig-iron would not fit into the tail rods of the beacons, special cylindrical cast-iron pigs were made by the *Constructions Navales* for this purpose, similar to the concrete blocks formerly used for the purpose; these pigs weighed 40 kilogrammes (= 88 lbs.) and two of them were placed in the tail rod of each beacon as ballast.

With reference to the visible portion of the beacon, masts of good quality wood (similar to telegraph poles) were found to stand the action of the sea better than metal masts such as are sometimes supplied by the *Constructions Navales* with the beacons; the latter are sometimes oxyhydrogen welded half-way up and the weld often gives after several days of bad weather. On the other hand, the jointed square top-marks fixed to the masts by three collars, supplied by the *Constructions Navales*, proved satisfactory in every case; care must be taken not to place them too high on the mast in order to avoid too great a strain on the latter; it is in fact the mass of the top-mark which causes the mast to break in bad weather. Usually a large calico flag of from 4 to 10 square metres (5 to 12 square yards) was at the upper end of the mast, attached by tacks to a wooden staff which is nailed to the mast. The flags and top-marks were sometimes white and sometimes of different colours in order to make the beacons distinguishable one from another. In opposition to that which might be expected from experience with marks on land, it is not white flags and top-marks which are most visible at great distances. In fact, the beacon is more often seen against the sky which gives a light background, and, under these conditions, it is more easily distinguishable if it is dark coloured. At the same time, in certain lights and when the beacon is seen against the coast, a white flag or top-mark is visible, whereas if it were dark-coloured, it would tend to become invisible against the background. Thus when it was necessary to distinguish the beacons from a distance, it was customary, in order to meet every eventuality, to paint the top-marks dark (black or red) and retain white flags; thus, according to the light, either the dark top-mark or the white flag was visible. The beacons were identified by means of a number painted in white on the upper part of the drum and by bands, differing in number and colour, painted on the mast; sometimes a distinctive sign was painted in black on the white flag.

METHOD OF DROPPING, MOORING AND WEIGHING THE BEACONS.

The method of anchoring the beacons by means of 4 cables to which backed grapnels are bent, as described in the *Manuel de l'Aide-hydrographe*, was found to be inappropriate to the work undertaken. This method of mooring certainly ensures good holding for the floating mark, but it is more appropriate for shallow waters. As the beacons had to be moored in depths to almost 200 metres (= 110 fms.) the number of cables per beacon was reduced in order to avoid sinking it by excessive weight. It being unnecessary to carry the system of beacons so far to seaward as to necessitate the fixing of the outer beacons by observations from the inner ones (*i.e.*, by means of a triangulation of beacons), there was no objection to a little play being allowed in the position of each floating mark. An effort was made to reduce the time spent in laying out the marks, they being generally moored and weighed by the parent vessel, whose immobilisation outside the field of work was usually found to be annoying.

During the 1923 expedition and the first half of that of 1924, the beacons used were generally in depths of from 40 to 70 metres (= 22 to 38 fms.). They were moored by means of two steel cables each with a backed pair of grapnels of 50 kilogrammes (= 110 lbs.) each. The length of the mooring was nominally about 2.5 times the depth; between the grapnels on the same cable there was a 15 metre (= 50 ft.) length of steel cable. Buoy-ropes, also of steel-wire but of smaller diameter, and only 1.5 times the depth long, were secured to an arm of each of the backing grapnels and to them were attached ordinary sheet-iron buoys, to facilitate weighing (fig. 3). All the cables were of galvanised steel rope such as is in use in the French Navy under the name of "*cordage souple en fil d'acier pour manœuvres courantes*"; the cable usually used for the beacon moorings was 33 millimetres (= 1.3 ins.) in circumference and for the mark buoys 19 millimetres (= 0.75 ins.) in circumference.

The mooring of the beacons by this method was carried out as follows: the complete beacons with all their gear were slung, in suitable order, over the ship's side; the vessel moved slowly astern and made leeway under the action of the wind blowing from the side on which the beacon to be laid out was slung; the various gear was dropped in succession, beginning forward, *i.e.*, in the following order:— the first pair of grapnels with its mark buoy, then the beacon, and finally the second pair of grapnels with its mark buoy. The two grapnels of the first pair must be dropped simultaneously, clear of each other, so that they shall reach the bottom at a suitable distance from each other; if this precaution be not taken the grapnels often reach the bottom foul of each other, sometimes even with the cable foul of the arms of the grapnels, in which case the beacon drags. The beacon may be streamed shortly after the first pair of grapnels, but the second pair with its buoy should not be let go until the vessel, still slowly going astern, begins to put a strain on the first pair.

Once the beacon is moored, it may generally be said that it is in position if the two mark buoys lie symmetrically with regard to the beacon at a certain distance from it. Should one buoy be close to the beacon or should the two buoys lie on the same side of it, it is a sure sign that the moorings are not clear and often that the beacon has dragged its grapnels.

In order as far as possible to reduce the influence of current on beacons moored with two cables only, the moorings were laid in line with the direction of the prevailing current (*i.e.*, in Algeria parallel to the coast).

This method of anchoring was found to be satisfactory in average depths (40 to 70 metres = 22 to 38 fms.); the beacon did not generally move more than 30 to 40 metres (= 100 to 130 ft.). The hold of the moorings was good if properly laid. A badly moored beacon does not usually remain in position; it drags its grapnels when the wind or current is strong.

The weighing of beacons moored in this manner is generally done from a pulling boat, manned by 6 to 8 men; a roller is fitted in the bows in order to facilitate hauling in the cables by hand. The boat tripped the two pairs of grapnels in succession by their respective buoy-ropes; the beacon mooring was always hauled into the boat and cast off from the beacon. To facilitate this operation, the moorings had not been attached to the collar on the beacon (which was about 2 metres (= 6 ft.) under water when the beacon was afloat), but to small pendants 5 to 6 metres (= 16 to 20 ft.) long attached to this collar, which the boat could pick up without difficulty. Finally, the beacon was towed to the parent vessel where it was hoisted on board.

After the end of the 1924 expedition, it became necessary to moor beacons in greater depths, down to 200 metres (= 110 fms.). Anchoring by means of grapnels then became more difficult, as it was not easy to drop the anchor gear in such depths without fouling; also the weight of the two cables loaded the beacon considerably. From this time on a mooring was adopted which consisted of a single cable, attached to a sinker weighing about 250 kilogrammes (= 550 lbs.) which formed the mooring. However, the device was so arranged as to reduce the swing of the beacon at its moorings as far as possible. In order to attain this, a pig of iron weighing 50 kilogrammes (= 110 lbs.) was bent on to the mooring cable a short distance (about 8 metres = 26 ft.) from the bottom so as to keep this cable taut and practically up and down; between this pig of iron and the sinker there was a length of a bare 30 metres (= 100ft.) of cable; this portion, which chafed considerably owing to the swell, was composed of an odd piece of 14, 16 or 18 millimetre (= 0,5, 0.63 or 0.7 in.), chain or, if no chain were available, of a length of heavy steel wire, weighted with pig iron.

The sinkers employed were supplied by the *Constructions Navales* and were generally composed of 5 iron pigs, of 50 kilogrammes (= 110 lbs.) each, connected by iron bars; they gave complete satisfaction. The mooring cables were composed of steel rope about 33 millimetres (= 1.3 ins.) in circumference; with the object of not overloading the beacon in depths of 200 metres (= 110 fms.), cables of steel rope of only 28 millimetres (= 1.1 ins.) in circumference were used, but, after three months in water, the cables rusted slightly, and they were then not strong enough to weigh the moorings (first pig of iron, chain and sinker), the total weight of which amounted to about 500 kilogrammes (= 1100 lbs.); having lost a considerable amount of moorings thus, it is advocated that cables of 33 millimetres (= 1.3 ins.) in circumference be used even in depths of 200 metres (= 110 fms.), although this adds considerably to the weight of the beacon.

To facilitate weighing the beacon, the mooring cable is not secured directly to the collar of the beacon, but to a pendant, 12 metres (= 40 ft.) in length, attached to this collar. The slack of the mooring cable is coiled up and attached to the foot of the

mast of the beacon, so that it is accessible when required for weighing the moorings. Naturally, care had to be taken that there was sufficient cable (16 to 20 metres = 9 to 11 fms.) between the coil and the point of attachment of the cable to the pendant, so htat the weight of the moorings should be supported by the pendant on the collar of the beacon and not by the coiled up slack at the foot of the mast, as this would cause the beacon to lie on its side. A useful precaution is not to secure the coil of mooring cable to the beacon above water at the foot of the mast, but to hang it some decimetres below the surface of the water by means of a small wire which is attached to the mast, so that the coil may not tempt unscrupulous persons who may sight the beacon.

This method of anchoring, which was the usual practice in 1925, proved to be entirely satisfactory to the exclusion of the former method; more than 50 beacons were moored thus in the course of the work on La Galite Banks in Tunisia, and not a single beacon was found to have dragged, even slightly. As to the swing of the beacon about its moorings, this is but 30 to 40 metres (= 100 to 130 ft.) in depths of 60 to 80 metres (= 33 to 43 fms.), in this case, the same as that with a two cable mooring; this amount of play is permissible in detailed surveys of shoals lying some distance off-shore. In depths of 150 to 200 metres (= 82 to 110 fms.), the play of the beacon at its moorings reaches 50 to 60 metres (= 165 to 200 ft.); this is still admissible in investigating banks and taking soundings in the open sea.

Since serious oxidation is caused when a steel cable is left too long in sea water, the beacon moorings may suffer and this oxidation may cause the cable to carry away, either when weighing the moorings, or during bad weather. It is now recommended that beacons should not be left at their moorings for periods of more than three consecutive months.

The dropping of the beacons is done in the following manner. Having sounded at the spot where it is desired to lay the beacon and thus knowing the depth H of the sea at this point, the pendant is bent on to the mooring cable in such a way that the 50 kilogramme (= 110 lb.) pig will be about 8 metres (= 26 ft.) from the bottom. For this purpose, the mooring cable is marked every 10 metres from the pig of iron; by means of a so-called "bull-dog" wrench, a halfcrown is made in the cable at the division H — 22 metres (= H — 72 ft.), and the end of the pendant is shackled to this halfcrown; the pendant being 12 metres (40 ft.) in length, and being secured to the collar of the tail-piece of the beacon (which is 2 metres = 6 ft. below water), the pig of iron is thus at a distance of 8 metres (= 26 ft.) from the bottom when the mooring is completed. The making of the halfcrown and the shackling on of the pendant takes two or three minutes, meanwhile the vessel must remain practically over the same spot in order that the depth H of the water shall remain, within 3 or 4 metres (about 10 ft.), the same; by means of some sounding gear or other (ultra-sonic apparatus or sounding line) the fact that this is so is determined until the beacon is finally streamed. This mooring is remarkably easy; first the beacon is streamed on the windward side of the vessel, the moorings remaining on board; when the wind has drifted the vessel a short distance from the beacon (if necessary a kick of the propeller either ahead or astern will move the vessel more rapidly away from the beacon), the 50 kilogramme (= 110 lb.) pig is then dropped, followed by the chain and finally the sinker.

The weighing of the beacons can be done from the ship herself, without lowering a boat; should the sea be slightly rough this is done as follows. After having gone alongside the beacon, the coil of mooring cable is picked up by means of a light grapnel and cast off from the foot of the mast (if necessary the beacon can be lifted slightly by the derrick after having been slung). The coil of cable then being inboard, its end is passed forward to the windlass (the beacon being lowered into the water again if it had been hoisted to detach the coil of mooring cable). When the halfcrown in the mooring cable and the pendant reach the windlass the pendant is unshackled; the beacon is then hauled under the derrick by means of the pendant and hoisted on board, and meanwhile the mooring cable is hove in with the windlass, the pig of iron got in, together with the chain, and finally the sinker. Two rollers have been fitted in the bows of the *Beautemps-Beaupré* to prevent the mooring from being cut when being hove in and a small davit also has been fitted for getting in the sinker.

Should there be any wind or current, weighing must be carried out fairly quickly until the sinker is away, for fear of dragging it along the bottom as the vessel drifts with the entire anchor gear, evidently risking carrying away the moorings should the sinker catch on a rock. In such cases, it is advisable to keep the vessel head-on to the current or wind, with very little way on her, in order that she may remain as far as possible directly over the sinker until it is well away.

The risk of parting the moorings by dragging the sinker along the bottom renders it advisable to use the above-described method of weighing (without a boat) as a last resort only. Whenever possible the ship should be assisted by a boat (a small steam launch) in order that the sinker be weighed as rapidly as possible. If a boat be used, she goes ahead of the ship alongside the beacon and picks up the coil of cable casting it off from the mast; she then passes the end of the cable to the ship as soon as the latter approaches the beacon. The ship can thus begin to heave in the cable as soon as she is up to the beacon; the sinker, under these conditions, is always rapidly tripped and the risk of carrying away the cable by fouling the bottom with the sinker is avoided.

FIXING THE BEACONS.

When the method of mooring with two cables was used, it was generally found necessary to return to the beacon after having moored it in order to take angles with the sounding circle to fix its position. When a system of not widely separated beacons was used, intended for investigating shoals by boats, the fixing was done from a steam boat which, after the beacons were moored, secured herself to each one in succession. If, however, an extended system of beacons was employed for the purpose of exploring off-shore banks, it was only necessary for the parent vessel to pass very slowly close up to the beacons after they were placed and to take angles when at a point as close as possible to each beacon; the distance and bearing from the point of observation (the bridge) to the beacon was estimated at this moment. Naturally, in order to avoid loss of time at the moment of passing, the angles were roughly measured at a provisional station made some moments before reaching the beacon.

The method of mooring beacons by means of a single cable somewhat simplified fixing operations; the angles can be taken from the mooring vessel at the moment when the sinker is streamed, the vessel being practically stopped at this moment. Naturally, here again it is advisable to rough angles some moments beforehand in order to be able to take them all at the moment of letting go the sinker.

The method of fixing the beacons depended on the use for which they were intended.

For small systems, consisting of beacons approximately one mile apart to be used for detailed investigation of off-shore shoals, fixing was done by means of five or six angles to points on shore taken from the two end beacons of the system; in fixing the other floating marks, special weight was given to the angles to the two extreme beacons or those taken from them, in order to obtain positions of the beacons which, before all, are accurate relative to each other; it is necessary that this should be so in order to obtain consistent plotting of the work of the boats between the beacons which is done on a relatively large scale (for example 1 : 10,000).

For extensive systems, consisting of beacons situated approximately three miles apart for investigating banks in the open, an endeavour was always made to fix all the beacons by angles taken between points on land, the observations between beacons being mainly considered as checks. Naturally, in certain cases, this rule could not be applied, the angles taken between points on land being too few to give satisfactory fixes. In such cases angles taken between beacons were utilised, but the uncertainty of the positions thus determined was greater owing to the swing of the various beacons at their moorings. This method had to suffice for certain beacons laid out, when visibility was poor, for the purpose of completing the system and for the beacons of the second line moored to the north of La Galite Islands; with regard to the latter, it was recognised that, though the positions of the beacons in the second line, found by angles to those of another line in view of the land, are acceptable (the uncertainty in the positions obtained for the second line being only 50 to 100 metres = 160 to 328 ft.), it is not so for the positions of the beacons in a third line fixed by angles to those of the second line, as the uncertainty may become very great. In short, the method of anchoring by means of a single cable, as advocated here, does not allow triangulation between beacons beyond a certain limit; the method of mooring with four cables, employed in relatively shallow water, alone allows such triangulation to be carried out without a rapid increase in error.

The plotting of the beacon stations was done immediately by the Ingénieur Hydrographe in charge of the survey; if necessary, the selection of the point in the triangle of error was made as soon as possible.

Finally, it must be added that the Expedition for its investigation of La Galite banks, in 1925, was provided with sound-ranging gear for determining the positions of beacons moored far from land by means of submarine detonations. This gear was not used, however, during these investigations. The extension of the 1925 survey towards

the N.E.d, the necessity for which became apparent after the discovery, at the end of these investigations, of depths of less than 100 metres about 20 miles to the Northward of La Galite, will very probably necessitate the use of this gear in the near future, for the determination of the positions of the beacons by angles between land marks becomes mpossible in this neighbourhood.