METHODS OF SOUNDING

The International Hydrographic Bureau has recently undertaken a study of the methods used in various States for sounding from ships and boats during hydrographic surveys in shallow water off the coast and in harbours.

Circular Letter No. 5-H of 1933 was accordingly sent to the States Members asking for latest information on the subject, and the following is a summary of the replies received, grouped under the headings of the nine questions contained in the Circular Letter :—

(a) LEAD LINES USED — MATERIAL AND MARKING — WEIGHTS OF LEADS USED IN SHIPS AND BOATS

NETHERLANDS.

The lead line consists of small untarred ratline rope, 32 m/m (1.26 in.) circumference, formed of three strands of three yarns each. For depths of 15 to 30 metres (8 1/4 to 16 1/2 fms.) the DOUGLAS-SCHAFER sounding traveller is used (*). For sounding, use is also made of galvanised steel wire, 9 m/m (0.36 in.) circumference, similar to airplane cable, formed of four strands of 19 threads each. Hand lead lines are marked as follows :

3, 13, 23	metres.....	red cloth ;
5, 15, 25	»	white cloth ;
7, 17, 27	»	blue cloth ;
10, 20, 30	»	leather with one, two or three holes.

The first ten metres are sub-divided every 1/4 metre by small pieces of rope, leather or wire.

DOUGLAS-SCHAFER lead line marked as above, but without 1/4 metre marks. Hand leads for boats weigh 3 kgs. (6.6 lbs.). Ship's hand leads, 6 kgs. (13.2 lbs.). DOUGLAS-SCHAFER lead, 9 kgs. (19.8 lbs.).

GERMANY.

For depths down to 30 metres (16 ½ fathoms) the HAEKESCHE HANDLOT (Haeke's hand lead) is used almost entirely both in ships and boats. The lead line is of copper or bronze covered and served with cotton. It is 50 or 90 metres (27 1/4 or 49 fms.) long, marked every 2 metres with coloured pieces of material attached to the line by removable brass clamps. The leads are pear-shaped, made of castiron, 2.5 and 5 kgs. (5 ½ and 11 lbs.) in weight. At the bottom of the lead there is a recess to hold tallow or soap for obtaining specimens of the bottom.

(*) This instrument is described in document H. D. N° 239 published by the British Admiralty in July 1912.

ITALY.

The lines used are as follows :

(1) Galvanised steel wire of 0.9 m/m (0.36 in.) diameter, breaking strain 180 kgs. (396.8 lbs.), for sounding at all depths, with the LUCAS machine. (2) Small sounding line of galvanised steel, 1.5 m/m (0.06 in.) diameter for soundings to 200 metres (109 fms.) with the modified MAGNAGHI apparatus. On neither of the above are there any marks, the depth being recorded by a counting mechanism. (3) For sounding down to 20 metres (11 fms.) a line consisting of 18 steel strands, each of 0.3 m/m (0.12 in.) diameter, covered with a double sheath of rubber, bringing the diameter of the line to 8 m/m (0.314 in.). It is very easy to handle, without in any way affecting its flexibility and lightness. The line is marked each decimeter (4 in.) for the first 5 metres, and each half metre for the remainder, by means of small cylindrical bands of brass, keyed and shrunk round the rubber line.

The leads for sounding are as follows :

(1) For the LUCAS machine, pear-shaped cast iron weights of from 10 to 15 kgs. (22 to 33 lbs.). Down to 200 m. (109 fms.) the 10 kgs. suffices and for deeper water that of 15 kgs. is found sufficient.

(2) For the modified MAGNAGHI machine, cast iron cylindrical weights of 4 to 10 kgs. (9 to 22 lbs.) and conical and pear-shaped weights of from 10 to 13 kgs. (22 to 28.7 lbs.).

It has been found that the 4 kgs. weight is sufficient for depths down to 20 or 30 m. (11 or 19 fms.). In deeper water gradually increasing weights of 5, 7, 10 and 13 kgs. are used down to 200 m. (109 fms.).

(3) For sounding by hand, truncated conical lead weights of 3 kgs. (6 ½ lbs.) down to 10 or 12 m. (5 ½ or 6 ½ fms.) and of 5 kgs. (11 lbs.) down to 20 or 22 m. (11 or 12 fms.).

(4) Fish-lead weighing 15 kgs. (33 lbs.) for depths down to 20 m. (11 fms.) and 30 kgs. (66 lbs.) for depths down to 50 or 60 m. (27 or 33 fms.).

U.S. OF AMERICA (Hydrographic Office).

For lead line material the U. S. Navy uses SAMPSON TILLER rope, a waterproof braided rope having a phosphor bronze stranded wire core. The lines are marked in fathoms with coloured rags and leather tabs, the fathoms being divided into feet, usually up to 10 fathoms for boats and 15 fathoms for ship use, using twine markers. Leads weigh 9 lbs. for use down to about 4 fathoms and 14 lbs. for deeper water.

U.S. OF AMERICA (Coast & Geodetic Survey).

The hand-lead line is the same as that used by the U. S. Navy, SAMPSON TILLER rope size 8. The line is soaked for two 24-hour periods, between which it is kept under tension for several hours. The lead is then attached, the line (still wet) placed under tension equivalent to weight of lead, and the following marks inserted :

1, 6, 11, 16 fms	.....	piece of leather with one strip.
2, 12	»	piece of leather with two strips.
3, 13	»	blue rag.
4, 9, 14, 19	»	piece of leather with four strips.
5, 15	»	white rag.
7, 17	»	red rag.
8, 18	»	piece of leather with three strips.
10	»	piece of leather with a hole in it.
20	»	two knots.

For intermediate marks between the fathoms (which are inserted afterwards by averaging the distance between fathom marks) a seizing of white linen thread is used for each foot except the half fathom which is marked with black thread.

The leads used for hand-lead sounding weigh not less than 8 lbs. for depths down to 8 fathoms; for greater depths a 10-12 lb. lead is used.

To extend lead-line sounding beyond the depth limit of hand-lead work a line of No. 10 cord and a lead of not less than 30 lbs. is used. A standard wire stray line 10 fms. in length is inserted between the lead and the sounding line.

The lead is hove forward by means of a sounding machine installed near the bow, the wire from which is rove through suitable fair-leads forward, thence through a sheave at the end of a sounding boom and aft to the lead, to the eye of which it is attached.

SPAIN.

The lead lines used are of steel wire 3 $\frac{m}{m}$ diameter (3/8 inch circumference) without any graduation, the depth being read directly from the counters of the machines.

In auxiliary steam launches the hand lead has also been used to 100 metres (54 ½ fms.); in the smaller boats a hand lead line graduated in decimeters up to 15 metres (8 1/4 fms.) and of a total length of 20 to 35 metres (11 to 19 fms.) is used.

For sounding down to 10 metres (5 ½ fms.) in motor or pulling boats, the weight of the leads used is from 3 to 5 kgs. (6.6 to 11 lbs.); from 10 to 100 metres (5 ½ to 54 ½ fms.) in launches 10 kgs. (22 lbs.), and on board ship with the LUCAS machine, for greater depths, from 15 to 25 kgs. (33 to 55 lbs.).

PORTUGAL.

Soundings of less than 20 metres (10.9 fms.) are taken with a hand line graduated in metres and half metres; beyond that depth a small model LUCAS sounding machine is used in boats and large model in ship. Boats leads weigh 4.5 kgs. (10 lbs.), and ship leads 9.5 kgs. (21 lbs.) with extra weights of 1 kg. (2.21 lbs.) for depths above 500 metres (273 fms.). For depths above 5,000 metres (2,734 fms.), detachable weights, usually old shells, are used.

GREAT BRITAIN AND AUSTRALIA.

For hand sounding a specially prepared lead line of 1 1/16 inch, made of three stranded hemp treated with turpentine and beeswax, and with a fine wire heart inserted to prevent stretching, is used. Weight of lead, 7 to 14 lbs.

For ship sounding with SOMERVILLE SOUNDING GEAR a 3/16 or 1/4 inch extra-flexible galvanised steel wire rope is used as a sounding line. Weight of lead, 100 to 200 lbs.

Hand and ship lead lines are marked in fathoms as follows :

1, 11, 21, 31, 41	fms.....	one piece of leather.
2, 12, 22, 32, 42	»	two pieces of leather.
3, 13, 23, 33, 43	»	blue.
4, 14, 24, 34, 44	»	green and white.
5, 15, 25, 35, 45	»	white.
6, 16, 26, 36, 46	»	green.
7, 17, 27, 37, 47	»	red.
8, 18, 28, 38, 48	»	blue and white.
9, 19, 29, 39, 49	»	red and white.
10	»	piece of leather with a hole in it.
20	»	piece of leather with hole in it and two strips.
30	»	piece of leather with hole in it and blue.
40	»	piece of leather with hole in it and four strips.
50	»	piece of leather with hole in it and white.

In addition yellow is inserted at every half fathom and one knot at every 1, 2, 4 and 5 feet of each fathom for a sufficient length to ensure that at least 63 feet (reduced) may be measured.

For machine sounding, galvanised steel piano wire of 20.5 gauge is used. Leads for wire in depths up to 1,000 fms., and recoverable, are of various patterns weighing from 14 to 28 lbs. Leads for wire in deep water, and not recoverable, are specially shaped sinkers, consisting of "tops" and "bottoms" 25 lbs. each, and "middles" of 20 lbs. each, the whole making one homogeneous sinker of 70 lbs.

DENMARK.

The lead lines used are of the ordinary AMERICAN type of phosphor-bronze wire with cotton covering. They are marked as follows :

1, 6, 11, 16, 21	metres.....	a leather mark.
2, 7, 12, 17, 22	»	white.
3, 8, 13, 18, 23	»	blue.
4, 9, 14, 19, 24	»	red.
5, 10, 15, 20, 25	»	a marline mark.

Moreover, the lead lines are painted in different colours for every 5 metres of the line as follows :

0 to 5. Red.	10 to 15. Red.
5 to 10. Blue.	15 to 20. Blue.

The weights of leads vary from 3.75 to 5 kgs. (8 1/4 to 11 lbs.) according to the depth of water. The hand lead is not used for depths exceeding 15 to 20 metres.

FRANCE.

Soundings down to about 25 metres (13.7 fms.) are taken by means of the FISH-LEAD (*plomb poisson*) from boats, launches or ships according to the distance off-shore. (See *Annales Hydrographiques* 1925-1926). Boats generally use a fish-lead of 15 kgs. (33 lbs.), the launches one of 30 kgs. (66 lbs.) and the ships one of 30 or 50 kgs. (66 or 110 lbs.). A special recording apparatus can be used with this gear (see *Hydrographic Review* Vol. X, No. 1, May 1933, p. 103).

The lead lines used with above are generally made from running-rigging wire 3.5 or 4.5 m/m (0.14 or 0.18 in.) diameter for the 15 kg. leads or 10.5 m/m (0.4 in.) for the heavier ones, but sometimes the wire of the WARLUZEL sounding machine is used in lieu, this having the advantage of being more resistant in spite of a lesser diameter of 1.7 m/m (0.07 in.).

A first attempt at metallic marking of these lines was not followed up: they are now marked in a similar manner to the hemp lines.

For examining rocks, cast-iron olive-shaped leads 7 to 8 kgs. (15.4 to 17.6 lbs.) in weight are often used with a hemp line from 7 to 8 m/m (0.3 in.) diameter.

Hemp sounding lines are marked as follows: Every five metres a piece of bunting: blue for 5 metres, white for 10 metres, red for 15, yellow for 20; above 20 metres the series begins again in the same sequence; the bunting is 10 c/m long and 3 c/m wide.

Intermediate metres are marked by means of a piece of leather 8 c/m long.

Each 20 c/m is marked, from 0 to 20 metres only, by means of a piece of marline with a knot at both ends. Above 20 metres, half-metres only are marked, in the same way.

CHINA.

The lead line is of 1 1/8 inch best quality material. It is marked as follows:

1, 6, 11, 16	fathoms	.....	one strip of leather.
2, 12	»	.....	two strips of leather.
3, 8, 18	»	.....	three strips of leather.
4, 9, 14, 19	»	.....	four strips of leather.
5, 15	»	.....	white bunting.
7, 17	»	.....	red bunting.
10	»	.....	piece of leather with hole in it.
13	»	.....	blue bunting.
20	»	.....	two knots.

From 0 to 6 fathoms a seizing of white linen thread is used for each foot except the half fathom which is marked with a piece of blue bunting.

The weight of the hand lead, for use in depths of less than 20 fathoms, is from 16 to 18 lbs.

POLAND.

Uses both hemp and wire sounding lines. In launches untarred hemp lines 6 to 8 m/m (1/4 to 1/3 in.) diameter and about 50 metres (27 fms.) long are exclusively used. On board the surveying ship the lines used are made of aviation wire, 2 to 3 m/m (about 1/10 in.) diameter according to the weight of the lead.

Hemp lead lines are marked by a coloured rag every 5 metres, blue for the 5, red 10, white 15 and yellow 20; above 20 metres the colours are repeated in the same order as before but two rags are tucked in instead of one. Each metre is marked by a piece of leather, with twine every 20 centimetres up to 20 metres and above that every 50 centimetres.

Wire lead lines are marked each metre and decimetre by means of copper wire seizings.

For sounding from launches a 2.5 kgs. (5.5 lbs.) lead is used. For sounding from the surveying ship the PLOMB POISSON is used: 30 kgs. (66 lbs.) for depths to 30 metres (16 ½ fms.), beyond which leads of 50 kgs. (110 lbs.) are used.

It was intended to fit the surveying ship with acoustic sounding apparatus during 1933.

SWEDEN.

The shallow water lead lines are of woven cotton 7 m/m (0.28 in.) in diameter with a phosphor bronze stranded wire core. They are the same as that used by the United States Coast and Geodetic Survey and are manufactured in America. The length of the lines is 25 or 30 metres and they are marked as follows:

1, 6, 11	metres.....	leather.
2, 7, 12	»	white.
3, 8, 13	»	blue.
4, 9, 14	»	red.
5, 10, 15	»	marline.

The 10 and 20 metre marks carry 1 and 2 knots respectively.

In addition, every half metre up to 10 metres is marked with a small marline mark.

Between 5 and 10 metres the line, which is red in itself, is painted yellow; between 15 and 20, blue; and between 25 and 30 metres, black.

The weight of the lead used in boat sounding is 3 kgs. (6.6 lbs.) for hand soundings and 4.5 kgs. (10 lbs.) for machine sounding.

NORWAY.

Hemp lead lines are used in depths of less than 20 metres; in greater depths sounding machines are used.

Hand lead lines are marked every metre. The hand leads weigh from 2 to 3 kgs. (4.4 to 6.6 lbs.) and those for the sounding machines 4 and 5 to 7 kgs. (8.8 and 11.0 to 15.4 lbs.).

SIAM.

Hemp lead lines for use in ship and boats are constructed of log-line material. They are marked as follows : —

A knot at each metre except at :

2	metres.....	a system for handling the lead line.
5	»	white.
10	»	leather with hole and one strip.
15	»	black.
20	»	leather with hole and two strips.
25	»	red.
30	»	leather with hole and three strips.
40	»	leather with hole and four strips.

In addition, for the first four metres each metre is subdivided into four equal parts ; and between the 4 and 10 metre marks each metre is subdivided into two equal parts.

In depths of over 40 metres (22 fms.) the BATHOMETER is used. Leads weighing from 6 to 12 lbs. are used in depths of less than 30 metres (16 ½ fms.) and of 16 lbs. in depths of from 30 to 40 metres.

(b) SOUNDING MACHINES AND OTHER APPLIANCES USED

NETHERLANDS.

Sounding machines used comprise the THOMSON, KELVITE, LUCAS (small and big), LEBLANC. Apart from these and the lead lines mentioned in (*a*), a pole of 6 metres (19.6 ft.) sub-divided in decimetres is used in shallow water by both ships and boats.

GERMANY.

The small LUCAS machine is but little used off the German coast owing to loss of time in stopping the ship. For checking soundings already taken, the various Echo-sounders and the ELEKTROLOT (Freilot) are used.

In depths from 30 metres (16 ½ fms.) to about 80 metres (43 3/4 fms.) on board the *Meteor* a semi-automatic transporting apparatus, which brings the lead from abaft the chains and automatically drops it at the bows, is used in conjunction with the HAEKESCHE HANDLOT described in (*a*).

ITALY.

The following appliances are used for sounding :

(1) Sonic apparatus of the FATHOMETER type has been used with good results in depths from 1,000 to 3,200 metres (546 to 1,750 fms).

(2) Ultra-sonic apparatus of the LANGEVIN-FLORISSON type, with MARTI recorder, in small and medium depths, i.e. from 12 to 1,000 metres (6 ½ to 546 fms.).

(3) The magneto-striction ultra-sonic apparatus made by HUGHES of London is under trial, and preliminary tests have given satisfactory results, but it has not yet been used on a survey.

(4) An ultra-sonic apparatus for boats, recently supplied by the firm of S.C.A.M. of Paris.

(5) The large electrically driven LUCAS Machine for all depths.

(6) A modified MAGNAGHI appliance for depths down to 50 or 60 metres (27 or 33 fms.).

Of the above, 1, 2, 5 and 6 are used in surveying ships and 3, 4 and 6 in boats in addition to the hand line described in (*a*).

U.S. OF AMERICA (Hydrographic Office).

The U.S. Navy is not committed to any particular makes of sounding machines, but the TANNER, TANNER IMPROVED and the LIETZ machines have been much used in depths between 10 and 200 fathoms ; the LEITZ on board ship and the TANNER on tenders ("sub-chasers") and launches, using various weights of sinkers up to 50 lbs. In channels and fairways short and long wire drags are used, accompanied by hand lead soundings.

U.S. OF AMERICA (Coast & Geodetic Survey).

The Sounding Machines used have been designed by the Coast and Geodetic Survey. The *L* type (C. & G.S. Sp. Pubn. No. 143. Fig. 12) holds about 1,000 fathoms of stranded wire and is used in depths up to 200-500 fathoms. The *S L* type is similar, but is driven by steam instead of electricity. The deep-sea machine (Fig. 13 of the same publication) holds about 6,000 fathoms of piano wire, is electrically driven, and is used in depths of over 500 fathoms. The above are used in ships.

For sounding from boats a hand sounding machine is supplied and this is usually connected to a small steam engine in steam-boats by a belt or gearing.

In depths up to from 200 to 500 fathoms the wire used generally consists of 7 tightly twisted strands of double-galvanised wire, each No. 24, *B* and *S*. gauge, with a breaking strain of not less than 500 lbs., supplied in sealed tins containing 300-fm. lengths.

For greather depths, steel piano wire No. 21, *B*. and *S*. gauge, is used. This wire will stand a strain of about 140 lbs., but should not be subjected to a pull of over 100 lbs. when reeling in. It is supplied in sealed tins containing 2,000-fm. lengths.

A satisfactory installation is shown in Fig. 16 of C. & G. Survey Sp. Pubn. No. 143. The tie rods of the accumulator springs in the boom topping lift are marked to show each 25 lbs. of tension up to 150 lbs.

PRESSURE TUBES. — The sounding tube in use was designed by the C. & G. Survey (see C. & G. S. Sp. Pubn. No. 143, page 53, Fig. 17). The tube consists of a 2-foot length of standard brass tubing of ½ inch internal diameter with one end permanently closed. The open end is covered by a brass cap in which a small winding hole forms a capillary tube about 3 inches long. This opening will admit water to the tube under pressure without allowing the air to escape. When brought to the surface, the water is trapped in the bottom of the tube and the air escapes through the cap. The depth is obtained by removing the cap and measuring the amount of water in the tube with a brass rod. For greater accuracy an electric measuring device has been designed for use with this brass tube (Fig. 17). For tube sounding, stranded wire and a 30 or 40 lbs. lead are used with a hand or power sounding machine.

ECHO SOUNDING. — Apparatus used are the FATHOMETER and the SONIC DEPTH FINDER (see C. & G. S. Sp. Pubn. No. 143, pp. 55-69).

WIRE DRAG. — C. & G. Survey pattern (see C. & G. S. Sp. Pubn. No. 143 page 76 and Sp. Pubn. No. 118).

A light wire drag has also been developed by the C. & G. Survey, capable of being stowed on board a surveying vessel. The WIRE SWEEP is also of C. & G. S. Survey pattern. All the above are described in C. & G. S. Sp. Pubn. No. 118 as well as various other well-known devices which have been used on occasions by the C. & G. Survey.

SPAIN.

Uses the large and small size LUCAS machines, and for acoustic soundings the ECO ALMIRANTAZGO (presumably the British Admiralty Echo Sounding Machine) shallow and deep water types.

PORTUGAL.

Uses the large and small LUCAS machines, the depth counters of which are obtained from the Hydrographic Laboratory of Copenhagen, those for use in boats being modified so that the pointer reads to 40 metres (22 fms.) instead of 400 metres (219 fms.).

For depths of less than 20 metres (11 fms.) soundings are taken by hand line marked in metres and half metres.

GREAT BRITAIN AND AUSTRALIA.

The following LUCAS Sounding Machines are used :

For ship's use : 6,000 fathom machine, steam driven.
» » » 6,000 fathom machine, hand and portable electric motor.
» » » 1,000 fathom machine, hand driven.

Also on board ship the ADMIRALTY PATTERN ECHO-SOUNDING MACHINE, shallow and deep water types, and the SOMERVILLE SOUNDING GEAR, a semi-automatic transporting apparatus mentioned in (*a*), are used.

An echo-sounding apparatus has been designed for use in boats, a description of which will be found in *Hydrographic Review*, Vol. X, No. 2, November, 1933.

DENMARK.

Previous to 1926, the CLAUSEN BATHOMETHER, a Danish machine similar to the Kelvin, was used on board ship in depths of more than 15 to 20 metres (8 1/4 to 11 fms.). Since 1926, the surveying work carried out has consisted of sweeping operations and minor surveys from boats for which a sounding machine of Swedish pattern, VELODET, has been used; a description of this machine appears on page 281 of *Hydrographic Review*, Vol. V, No. 1, May 1928.

FRANCE.

For depths to 25 metres (13 3/4 fms.) sounding is carried out by means of the PLOMB-POISSON as stated in (*a*). For depths between 25 and 1,000 metres (14 and 547 fms.) continuous echo-sounding, either ultra-sonic or by means of hammer blows, is adopted; various types of apparatus being used which are in a constant state of evolution, all of which are, however, fitted with graphic recorders on the MARTI system. Beyond 1,000 metres (547 fms.) non-continous echo soundings by means of rifle- or gun-shot are taken, graphic recorders and microphones being the essential parts of this apparatus.

Echo Sounding, so far, is only employed on board the principal surveying vessels and attached tugs.

CHINA.

Sounding machines, and mechanically operated lead line sounding, are employed on board surveying ships.

POLAND.

Hand lead sounding is carried out from launches and the PLOMB-POISSON method for ship sounding. Echo gear will be fitted shortly on board the surveying ship as mentioned in (*a*).

SWEDEN.

The sounding machine for inshore sounding is described in the *Hydrographic Review* Vol. I, No. 2, May 1924, page 55.

For offshore sounding the LANGEVIN-FLORISSON-MARTI self-registering echo sounding apparatus is used.

For sounding over shoals the French fish-lead (PLOMB-POISSON) is used, the wire being attached to the ordinary sounding winch and registering block.

The exact determination of least depth over shoals is carried out by means of an apparatus called the SPAR-SWEEP which is described in *Hydro-*

graphic Review Vol. I, No. 2, May 1924, pages 64-66; by the WIRE DRAG as used by the United States Coast and Geodetic Survey, or by the BAR SWEEP which consists of a steel bar suspended horizontally at the required depth below and athwartships of the surveying launch.

The sentry sweep described on page 63 of the above mentioned Review is no longer used.

NORWAY.

The LUCAS sounding machine is used; also the WIRE DRAG, SUBMARINE SENTRY and FRAME.

SIAM.

In addition to the BATHOMETER mentioned in (*a*) the Mark IV NEGRETTI AND ZAMBRA Sounding Machine is used on board ships.

(c) METHOD OF CHECKING LEAD LINES, SOUNDING MACHINES AND APPLIANCES

NETHERLANDS.

Rope lead lines are checked (wet) by fixed marks between measured distances on the deck. *Indicator dials* of sounding machines are sometimes checked by control soundings with other machines.

GERMANY.

Has no special fittings.

ITALY.

Hand lead lines are compared directly with a metric tape; this however is not necessary as the rubber-covered line described in (*a*) cannot stretch and the marks on it are keyed and soldered.

Indicator dials of sounding machines are checked by comparison of the number of revolutions of the sheave of known diameter over which the wire passes.

The *sonic and ultra-sonic appliances* are checked occasionally by taking a simultaneous vertical wire sounding.

U.S. OF AMERICA (Hydrographic Office).

Lead lines are checked at standard tension, morning and evening, between brass marks at measured distances on the deck.

Sounding machines, such as the Fathometer, Recording Fathometer and Super-sonic appliances are checked against each other and by taking a simultaneous vertical wire sounding.

Sounding Tubes are tested against vertical wire soundings at the beginning of a survey season and periodically thereafter.

Wire Drags in operation are tested for lift.

U.S. OF AMERICA (Coast & Geodetic Survey).

Lead lines are checked at the beginning and end of each day's work by comparison with fixed marks between measured distances on the deck, the lines being under tension equal to that of the lead in the water. Corrections for *tube soundings* are obtained by simultaneous vertical wire soundings at least once each day, preferably in the middle of the working day. Two pairs of tubes are tested and compared at or near to a minimum depth measurement during the day, and each pair is tested at alternate ten fathom intervals throughout the depth range of the day's work.

Sounding Machines. — For deep sea soundings the time of running out and heaving in for each 100 fathoms is observed as a check. Sheaves are tested before use for the first time each season and several times during the season.

Echo Sounding. — Care is taken to apply the appropriate corrections for temperature and salinity as accurately as possible.

SPAIN.

The *steel wires* mentioned in (*a*) are checked against 5-metre metal tapes, and the *acoustic sounding machines,* after adjustment, by comparison with soundings taken with the LUCAS machine.

PORTUGAL.

The *counters of the sounding machines* are gauged on a 300-metre base ; the *lines,* by tape.

GREAT BRITAIN AND AUSTRALIA.

Hand lead lines are checked, before and after use, between marks at measured distances on the deck. With wire-hearted lead lines as described in (*a*) the error is practically negligible and checking is chiefly for replacement of marks.

Dials of sounding machines for boats' use are checked over shallow depths up to 20 fathoms by comparison with up and down casts of a standard lead line.

DENMARK.

As a rule the *lead lines* described in (*a*) do not shrink, nevertheless they are checked at intervals. The *sounding machines* are checked by means of lead line soundings.

FRANCE.

The markings of *wire lead lines* are checked periodically by means of permanent marks on the deck of the ships. *Hemp lead lines* are similarly checked before and after each day's soundings. The MARTI *recording appliances* are regulated during use by measuring the speed of the rotating arm, which must have a definite value.

CHINA.

Lead lines are checked by means of permanent marks on the deck of the ships.

Registering sheaves of sounding machines are checked by running the wire over them for a measured distance along level ground.

POLAND.

Hemp lead lines are checked every five metres by means of permanent marks (nails) on the deck of the ship. The arithmetic mean of the errors before and after sounding is used for the correction to be applied.

No check of the *wire lines* is necessary, except as to the condition of the markings, as they do not undergo any appreciable modification in length.

SWEDEN.

Lead lines and the *registering blocks of the sounding machines* are tested by comparison with fixed marks on board ship or ashore.

The *echo sounding apparatus* is tested by comparison with wire soundings in the following manner:

The control soundings embrace a considerable number of different depths within the limits of depth which may be expected during the survey. Every test is made by about 100 wire soundings.

The tests are made during fair weather and if possible always on an even bottom of sand or clay; the casts with the lead are taken as near to the ultra-sonic projector as possible.

With the aid of a minor number of control soundings a preliminary curve is constructed giving the depth correction to the ultra-sonic sounding for different depths. This curve is found to be a straight line, and on the basis of these values the speed of rotation of the time measuring apparatus is adjusted, and a new series of control soundings, embracing about 100 casts at different depths, is taken. As a rule this series will give a satisfactory agreement between supersonic and wire soundings and is generally used for about six weeks, after which time a new test is made.

NORWAY.

Hand lead lines are checked by comparison with a measured distance on deck of ship or wharf.

Sounding machines are checked by running the wire over the registering dial for a measured distance along a wharf or other level space.

SIAM.

When checking *lead lines*, they are first soaked in water for a considerable time and then compared with a standard one marked on the deck of the ship.

The *Bathometer* is checked by comparison with hand soundings.

(d) METHOD OF RUNNING LINES OF SOUNDINGS AND KEEPING ON THEM (e) METHOD USED FOR FIXING THE POSITION OF THE SOUNDINGS

NETHERLANDS.

The position of the sounding ship or boats is mostly fixed by means of sextant angles between three or more fixed points and solution of the Snellius problem, as often as is judged desirable.

The boat is kept as much as possible on the desired line by leading marks on shore ; by following, by means of the sextant, the arc of an angle ; or by compass course if those methods are not applicable.

GERMANY.

Positions of soundings are fixed by means of sextant angles to trigonometrically or graphically plotted points or buoys.

ITALY.

Normally, when there are at least three conveniently placed fixed objects visible, the positions are fixed by simultaneous observations of at least two angles between them. When less than three objects are in sight, the positions are fixed by compass bearings or by the system of altitudes used in navigation.

When soundings are taken by machine, necessitating stopping the ship or boat, the position of each sounding is fixed ; otherwise the position is fixed at as short intervals as possible and in such a way that the speed of the vessel in the interval between two successive fixes may be taken as being absolutely constant.

Keeping on the lines of soundings depends on the ability of the sounder who uses, as far as possible, such natural transits as he finds on the coast ; transit marks are never erected. Any gaps left on account of deviating from the lines are filled up later.

For the development of off-lying shoals, the coast still being in sight, the method which seems the most suitable is selected, according to circumstances.

For the Graham and Talbot Banks in the Sicily Channel, the ship was anchored on the shoal and her position was fixed by intersection from three points on shore ; this done, the sounding of the surrounding area was carried out by the boats which referred the positions of their soundings to that of the ship. Further away a group of floating marks was laid out and they were fixed by rangefinder distances and bearings from the ship's original position. Thereafter the ship sounded around these by starring, using the compass and range-finder for fixing.

Another method used in the Dahalak Islands for sounding out the extensive areas of shoals was that of laying out floating beacons on the various banks and, after having fixed them from land or from sea by accurate observations, to use them as points for sounding out the area.

U.S. OF AMERICA (Hydrographic Office).

The position of the sounding ship or boat is fixed by means of sextant angles observed simultaneously by two officers between three objects previously located by triangulation. In exceptional cases the method of intersection is used. This may be accomplished by employing two or three transits on shore, or two or more radio compass stations. Dead reckoning is rarely used except between ends of lines controlled by three-point fixes, and not then if strong currents are encountered.

The lines of soundings to be run having previously been marked on the sounding sheet, the officer stays on them, as well as may be, by fixing at standard intervals and oftener as may be necessary, and correcting the course which is run by compass. The positions of certain soundings are fixed and noted, those of intermediate soundings are found by maintaining a constant course and speed and, so far as is not prohibited by rapidly changing depths, a constant time interval between fixes. Frequently in drag work and in developing the edges of shoals and reefs, every sounding is fixed by angles.

U.S. OF AMERICA (Coast & Geodetic Survey).

(1) In harbours and inshore along the coast within sight of previously fixed shore stations, positions are fixed by the graphic solution of the three-point (Snellius) problem.

In these cases positions may also be obtained by theodolite angles to the vessel from two shore stations; by measuring distances on established ranges; by sextant angles, observed on board the vessel between three stations; or by combinations of these methods.

(2) Along the coast, beyond the range of visibility of tall hydrographic signals, positions are fixed by any of the following means:

(*a*) Graphic solution of three-point (Snellius) problem, used in connection with hydrographic buoys located into a net of buoy control either by radio-acoustic triangulation or by sextant cuts from vessels anchored within sight of tall hydrographic signals on shore, or by courses and distances by well-rated logs on vessel by double runs, or by means of taut wire measuring apparatus.

(*b*) Radio-acoustic ranging used in connection with hydrophones on station ships anchored at hydrographic buoys located into the net of buoy control as described in (*a*) above.

(*c*) Radio-acoustic ranging used in connection with hydrophone stations at suitably located positions along the coastline.

(*d*) Dead-reckoning supplemented by wider spaced signals beyond the ten fathom curve, bearings of a line of floating signals parallel to the sounding line, vertical angles to floating signals, precise dead-reckoning (C. & G. S. Sp. Pubn. No. 143, p. 97), or by means of astronomical positions.

SPAIN.

The course of the sounding boat is directed from the shore by theodolite and communicated to her by means of flags or heliograph.

The positions of the boat are fixed by theodolite angles to her from two, three or sometimes four shore stations every time she signals that she is taking a sounding.

Deeper soundings are taken by the ship which fixes her position, and regulates her course accordingly, by horizontal angles when possible, otherwise astronomically or by radio bearings.

PORTUGAL.

Having laid off the required lines of soundings and measured by protractor the angles subtended by a few points at various positions on them, the ship or boat is subsequently navigated by observing the sextant angles.

The direction of the required line is found by measuring the angle between its direction and a fixed object, setting this angle on the sextant and observing the reflected point on shore which coincides with the object: this point indicates the required direction.

Positions are nearly always plotted by the mechanical solution of the Snellius problem, otherwise by leading line and angle, bearing and angle, several bearings, wireless direction-finding, or by astronomical observations.

GREAT BRITAIN AND AUSTRALIA.

The required lines of soundings having been laid off on the sounding board, the boat is navigated along them using transits where obtainable, either natural or artificial according to scale, combined with constant fixing of positions.

Positions when in sight of land are plotted by station pointer fixes of three or more fixed marks; when out of sight of land by moored floating beacons previously triangulated and fixed either by "taut-wire" methods, sound ranging or astronomically.

DENMARK.

Lines of soundings are run as a net of parallel lines spaced from 50 to 200 metres (55 to 218 yds.) apart according to the importance of the area being surveyed and the nature of the bottom. Soundings are taken at intervals of 40 to 60 metres (44 to 65 yds.). Positions of boats are fixed for every 5 soundings.

When the necessary number of fixed points can be seen from the boats, positions are fixed entirely by station pointer fixes to them. In localities where fixed points are few, the ship is anchored in a suitable place and the boats use the ship as a base. The positions of the boats are then fixed by measuring the distance to the ship from the boats and horizontal angles between the boats and a fixed point measured on board the ship.

FRANCE.

The lines of soundings are usually segments of a circle containing a known angle between two conspicuous objects. The boats are kept on the line by clamping the angle on the hydrographic circle and keeping those two objects in contact in the field of the telescope of the instrument.

Sometimes, chiefly when sounding some distance off shore, conspicuous objects are used as leading marks, use being made of transits and of the course set, allowing for drift.

Out of sight of land the courses are straight and generally fanwise in such a way as to be somewhat crowded at the shoreward end of the lines.

Within sight of land, the positions of the soundings are fixed every 4 or 5 minutes by a minimum of three simultaneously observed angles to shore stations.

Out of sight of land floating beacons are used, or standard navigational methods, or again radio-acoustic (sound-ranging) methods, according to circumstances. When using beacons their positions are either connected to shore stations and to one another or fixed by astronomical or acoustic methods ; the ship's position being fixed by angles between the beacons.

CHINA.

Lines of soundings are generally parallel to one another at equal distances apart and either at right angles to the coast or in a North & South or East & West direction. Positions of every so many soundings, as the case may be, are fixed either by simultaneous angles between three fixed objects or, in the case of boat soundings when circumstances permit, by erecting transit marks ashore, keeping the boat on them and fixing her position by one angle between two fixed objects.

POLAND.

Lines of soundings are run either on leading marks ashore or on segments of a circle containing a known angle as described under *FRANCE.*

Fixes are obtained by means of at least three angles between shore objects every four minutes at speeds of 2 to 3 knots and every two minutes at greater speeds.

SWEDEN.

For method of running lines of soundings and fixing positions on them, see *Hydrographic Review*, Vol. I, No. 2, May 1924, pages 52-66.

NORWAY.

The method of taking up and running a line of soundings depends on whether there is shore line on both sides of the area, or whether the lines run off-shore towards the open sea.

In sheltered waters. — In narrow waters the intersection between sounding line and shore-line is determined on both sides of the channel relative to the nearest shore-line marks, and for two sounding lines simultaneously.

In open, wide channels, fjords, etc., one may not always see a mark from one side to the other, besides which practical reasons may suggest that sounding is carried out on one side at a time; in that case the direction of the line is determined by measuring with a protractor the angle between the line and some well defined object. With the sextant set to this angle a suitable conspicuous object or formation on shore is selected for a head mark.

After having thus established the sounding line in the landscape the boat is kept on the line by the aid of a 180° prismatic mirror (see (*f*). As the least deviation from the proposed line may be recognised at once, the lines are run without drift of any kind.

In open waters. — When sounding with the shore on one side only, ranges of shore objects are determined for running lines, the intersection of sounding line and shore line being used as the front range object. The position of the boat is fixed by sextant angles at the outer end of the line or so far off shore as to have a sufficiently far view inland and a suitable object or formation as far inland as possible is selected as the back range object. If this back object disappears from sight when running in towards shore a nearer back object must be selected in lieu.

The sounding line is controlled at intervals by sextant positions.

The method of fixing the position of soundings.

Two schemes of parallel sounding lines, at right angles to one another, having been laid off in pencil on the sounding sheet all soundings are taken at the junction of these lines thus making the sounding interval equal to the spacing of the lines. The positions are fixed: (*i*) by resection with the sextant to a signal or triangulated point. The angle between the line and the signal is considered effective down to 45°.

From the signal a set of radii is laid off in pencil on the sounding sheet usually intersecting the sounding lines at every second degree. The value of the resection angle is taken from the sheet by graphical interpolation and set on the sextant.

(*ii*) Another method for fixing positions on a sounding line is: the angle between two signals or triangulated points (one on each side of the system of lines) is plotted for every second degree along the sounding line, and the corresponding arcs are laid off in pencil. As in the previous method the value of the angle for each sounding is taken off the sheet by graphic interpolation.

The procedure in both cases therefore is that the boat is kept running exactly on the proposed line and the sextant is set to the angle corresponding to the desired sounding position, and the boat stopped when the objects are in contact in the sextant.

When the distance from the shore or fixed objects is less than 400 metres (about 400 yds.) the Telemeter is also used for reading distances.

In addition to the above mentioned methods of fixing positions on a line, an extensive use is made in sheltered waters of the 180° prismatic mirror to obtain intersection lines.

In the relatively few cases on the Norwegian coast where dependable

ranges for sounding lines are not obtainable, the lines are run by compass course with sextant positions for every fifth sounding, the intermediate soundings being plotted by time.

SIAM.

Lines of soundings are run by compass. In addition a small raft of bamboo with a flag is moored between the lines to be run.

Positions of soundings are fixed by the "two angle method" (two simultaneous sextant angles between three fixed objects). Sometimes however the masthead angle is used in lieu.

(f) INSTRUMENTS USED FOR FIXING AND PLOTTING SOUNDINGS

NETHERLANDS.

Protractor, compasses and station pointer.

GERMANY.

Station pointers of various sizes.

ITALY.

For observing angles, the Amici MAGNAGHI reflecting circle (for description see *Hydrographic Review* Vol. VI, No. 2, 1929, p. 146); and for plotting, the HYDROGRAPHIC INSTITUTE STATION POINTER.

U.S. OF AMERICA (Hydrographic Office).

Instruments used include sextants, transits, station pointers, and 11 point spacing dividers.

U.S. OF AMERICA (Coast & Geodetic Survey).

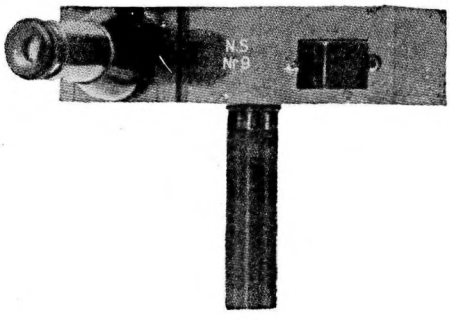
Sextant, station pointers (steel and celluloid) (see C. & G. Survey Sp. Pubn. No. 143, Fig. 23) and spacing dividers for inshore work; bomb explosions, chronographs, beam compasses (for distance arcs) and spacing dividers for off-shore work.

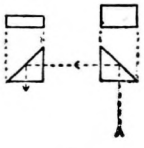
SPAIN.

The instruments used are: theodolites, compasses, bearing plates, sextants, wireless direction-finders; and for plotting, protractors, rulers and station pointers.

PORTUGAL.

Usually the sextant, but sometimes the compass, wireless direction-finder, etc.; and the station pointer for plotting.





180° Prismatic Mirror

Miroir prismatique de 180°

GREAT BRITAIN AND AUSTRALIA.

Sextant and station pointer.

DENMARK.

Instruments used for plotting are station pointers, either LINDBLAD (Swedish) type with vernier reading or HUGHES (British) with micrometer reading.

FRANCE.

When soundings are fixed by means of angles observed with the hydrographic circle their positions are plotted by means of an alidade-protractor, each angle being drawn separately. The cocked hat gives an indication of the accuracy of the fix.

In other cases the appropriate geographical constructions are made after working out the necessary elements.

CHINA.

The sounding sextant is used for observing angles and the station pointer for plotting them.

POLAND.

The positions of soundings are fixed with the aid of a hydrographic circle as used in the French Hydrographic Service. To plot each position an alidade protractor is used exclusively.

SWEDEN.

Instruments used are described in *Hydrographic Review* Vol. I, No. 2, May 1924, page 55.

NORWAY.

Instruments used for fixing positions of soundings.

(1) 180° Prismatic Mirror (see figure opposite). By this instrument a stationary image of the rear object is obtained in the ocular prism.

(2) Sounding sextant.

(3) Telemeter.

Instruments used for plotting soundings.

(*a*) Metal protractor.

(*b*) Celluloid protractor.

One quarter metre scale and celluloid squares.

SIAM.

Instruments used for fixing and plotting soundings are sextants, station pointers and spacers.

(g) METHOD OF OBTAINING SPECIMENS OF THE BOTTOM

NETHERLANDS.

Specimens of the bottom are obtained either by means of a cavity in the bottom of the lead filled (armed) with grease, or by a tube fixed in the lead.

GERMANY.

Specimens of the bottom are obtained by the following means :

(1) By the GRUNDZANGE (literally "ground-tongs", probably similar to the "Bulldog Snapper" lead).

(2) By the BODENGREIFER (literally "bottom-grab").

(3) By driver tubes.

(4) By the "armed" lead.

ITALY.

Specimens of the bottom are obtained by the LUCAS bottom sampler and by the MAGNAGHI lead dropping apparatus in both soft and rocky bottoms.

U.S. OF AMERICA (Hydrographic Office).

Specimens of the bottom are obtained by arming the lead with tallow.

U.S. OF AMERICA (Coast & Geodetic Survey).

Methods used for obtaining specimens of the bottom are : for hand-sounding by arming the lead, and for deep sea sounding by the BELKNAP-SIGSBY Specimen Cylinder and the "snapper" type of lead. For descriptions see C. & G. Survey Special Publication No. 143, pp. 76-78.

SPAIN.

Specimens of the bottom are obtained by means of bottom samplers or by arming the lead.

PORTUGAL.

Does not specifically answer this question.

GREAT BRITAIN AND AUSTRALIA.

Various methods of obtaining bottom samples are used, chiefly by arming the lead, by means of valve or snapper attachments to leads or by means of BAILLIE rods.

DENMARK.

Specimens of the bottom are obtained by arming the lead with tallow.

FRANCE.

In boats specimens of the bottom are obtained at each station, every four or five minutes, by arming the lead.

In ships a RONDELEUX bottom sampler is generally used (see *Annales Hydrographiques* 1921, p. 239), or a LEGER Sounder.

CHINA.

Specimens of the bottom are obtained by arming the lead.

POLAND.

Specimens of the bottom are obtained by arming the lead.

SWEDEN.

The nature of the bottom is obtained by arming the lead with a special tallow mixed in the following proportions :

Tallow	30	parts.
White zinc	2	»
Chalk powder.....	2	»
Boiled linseed oil.....	1	»

NORWAY.

Specimens of the bottom are obtained by arming the lead with tallow and by means of a SNAPPER Lead.

SIAM.

Specimens of the bottom are obtained by arming the lead with tallow.

(h) SYSTEM USED FOR REDUCING SOUNDINGS TO CHART DATUM

NETHERLANDS.

For reducing soundings to chart datum, tide gauges are used.

When inserting soundings on the fair sheet they are rounded off to the quarter metre for depths to 13 metres (7 fms.), to the metre and half metre for depths to 23 metres (12 ½ fms.), and to the metre beyond that depth ; always to the next lowest subdivision ; the reduced soundings are never increased.

When inserting soundings on the chart they are rounded off to the nearest quarter metre down to 12 metres (6 ½ fms.) on bars and dangers and in shallow channels ; in all other cases they are rounded off to the next lower metre. (On a few charts, as an exception, depths are shown in decimetres).

(See *Hydrographic Bulletins*, July 1930, pp. 158 and 160, and March 1931, pp. 58 & 59).

GERMANY.

In German waters the soundings taken are reduced to chart datum by means of observed level of the sea. In places where tides occur the area to be surveyed is divided into "Flood Hour" and "Rise" zones.

Datum of Soundings. — In tideless waters the chart datum is, in the Baltic the ordnance datum (0.144 metres = 5 ½ ins.) above Mean Water Level on tide-gauge at Amsterdam, and in colonial surveys Mean Water Level.

In tidal waters the chart datum may be either the lowest observed L. W. Springs, Mean L. W. Springs, Mean L. W. or Mean H. W.

From 0 to 14 metres (7 ½ fms.) soundings are taken and recorded in metres and decimetres, from 14 to 21 metres (11 ½ fms.) in metres and half metres, and below 21 metres in whole metres. The depths so determined are reduced to chart datum as follows :

(*a*) The tide reduction is made to tenths of metres.

(*b*) From 0 to 14 metres the reduced depth is rounded off by neglecting the next decimetre downwards.

(*c*) From 14 to 21 metres the reduced depth is rounded off by neglecting the next half metre downwards.

(*d*) Beyond 21 metres the reduced depth is rounded off to the next lowest whole metre.

The reduced sounding thus obtained is then plotted on the survey sheet and shown thus on the chart, except that in the latter case whole metres only are shown for depths greater than 14 metres.

(See *Hydrographic Bulletins*, July 1930, p. 161, and March 1931, pp. 57 & 59).

ITALY.

For reduction of the soundings taken to chart datum, whenever possible a self-registering tide-gauge is erected in the area to be surveyed. The datum adopted by Italy is mean level of L. W. springs.

On charts soundings from 0 to 20 metres (11 fms.) are shown in metres and tenths ; beyond 20 metres they are rounded off to the nearest lower or higher metre.

(See *Hydrographic Bulletins*, December 1930, p. 282, and March 1931, p. 59).

U.S. OF AMERICA (Hydrographic Office).

An automatic tide gauge is set up at the base station ; at other stations nearer the work similar gauges or tide-poles are erected, their zeros being connected to that of the base station. These furnish the necessary information for reducing the soundings taken to the chart datum.

The U. S. Navy does not make charts in the field. After the return of the parties, the triangulation having been adjusted and tidal records worked up, the whole work is replotted and it is from these "smooth sheets" that the chart is constructed. It follows that the provisional adjustments and tidal corrections made daily in the field undergo some modification.

U.S. OF AMERICA (Coast & Geodetic Survey).

Soundings are reduced to the "plane of reference", usually in the field, but sometimes at the Washington office.

Tables are drawn up of high and low waters and of hourly heights.

On the Atlantic coast the reference plane is that of Mean Low Water; on the Pacific coast, three feet below Mean Lower Low Water. After the plane of reference has been derived the tide reductions are obtained by subtracting the value which corresponds to the height of the plane of reference on staff from the recorded or tabulated heights of the tide for the time that the soundings were made.

Rules for Reducing Soundings.

Soundings are reduced by applying to them corrections determined by tests of the sounding apparatus, and also by applying the tide reductions; i.e. corrections for height of tide above or below the reference plane.

Corrections to sounding apparatus.

These may be omitted if less than 1 % of the depth below the reference plane. When over this amount they are entered in integral feet for open-ocean areas. In all other areas they are entered to the nearest half foot for 10 fathoms or less, and in integral feet for greater depths.

Tide reductions.

Same considerations, except that they are not entered when the general depths exceed 100 fathoms.

Equivalents used for corrections and reductions.

When entered in integral feet and to be added,

0 to 0.7 ft. = 0 ft.
0.8 to 1.7 ft. = 1 ft. etc.

When entered in integral feet and to be subtracted,

0 to 0.2 ft. = 0 ft.
0.3 to 1.2 ft. = 1 ft. etc.

When entered in half feet and to be added *or* subtracted,

0 to 0.2 ft. = 0 ft.
0.3 to 0.7 ft. = ½ft.
0.8 to 1.2 ft. = 1 ft. etc.

When entered in fathoms and to be added,

0 to 4.7 ft. = 0 fms.
4.8 to 10.7 ft. = 1 fm. etc.

When entered in fathoms and to be subtracted,

0 to 1.7 ft. = 0 fms.
1.8 to 7.7 ft. = 1 fm. etc.

When entered in half fathoms and to be added *or* subtracted,

0 to 1.7 ft. = 0 fms.
1.8 to 4.7 ft. = ½ fm.
4.8 to 7.7 ft. = 1 fm. etc.

Units for reduced soundings.

Lead-line soundings in *Pacific:* soundings are entered in fathoms and feet. *Elsewhere* in feet.

In *both cases* fractions of feet are shown where they result from the reduction.

By other methods in *Pacific:* soundings are entered to conform with the depth units in use (fathoms or half fathoms). *Elsewhere* in integral feet.

Rules for plotting soundings.

Pacific. — Soundings are plotted in fathoms and sixths of a fathom up to 6 5/6.

Soundings are plotted in fathoms and quarters of a fathom from 7 to 10.

Soundings are plotted in whole fathoms above 10.

Fractions of a foot are disregarded, and 3/6 fm. and 2/4 fm. are entered as ½ fm.

Other Regions. — Soundings are plotted in feet; but in oceanographic and offshore work, in fathoms.

On bars, etc., and in depths of 42 feet or less, soundings are plotted to the nearest half foot; otherwise fractions of a foot are not used.

On off-lying dangers, fractions of a foot are not used.

Elsewhere, no fractions unless soundings are reduced to tenths of a foot, in which case 0.7 or less is omitted and 0.8 or more counts as 1.

When soundings are plotted in fathoms and quarters,

1 ft., 2 ft. } = 1/4 fm.
3 ft. = 1/2 fm.
4 ft., 5 ft. } = 3/4 fm.

When soundings are plotted in whole fathoms, 1 to 4 ft. are dropped, 5 ft. count as 1 fm.

Minus soundings:

0 to —0.5 ft. = 0
—0.6 to —1.5 ft. = 1 ft. etc.

(See *Hydrographic Bulletins*, March 1930, pp. 40 & 41; January 1931, pp. 1 to 3; and March 1931, pp. 58, 59 & 60).

SPAIN.

When the readings corresponding to the Mean Level and the selected Low Water have been determined on the tide gauge, soundings are reduced to this latter by noting the reading of the gauge corresponding to the time of sounding.

In less than 10 metres (5 ½ fms.) soundings are inserted on charts in metres and tenths; beyond 10 metres in whole metres only. They are always rounded off downwards.

(See *Hydrographic Bulletins*, December 1930, p. 283, and March 1931, p.59).

PORTUGAL.

Reduction to "hydrographic datum" is generally obtained from tide poles observed at the time of sounding.

GREAT BRITAIN AND AUSTRALIA.

In *reducing* soundings the general principle observed is that soundings are never increased by more than one quarter of the unit employed. It therefore follows that the tidal reduction changes to the next higher foot when the decimal of the tide above datum is 0.3; i.e. if tide is 3.3 foot above datum the reduction is 4 feet.

In the case of *inserting the reduced sounding on chart*, the application of the same principle involves the omission of all fractions less than three quarters of the unit; i.e. 19 fathoms 4 feet = 19 fathoms, but 19 fathoms 5 feet = 20 fathoms.

Reduced soundings of less than one foot are considered as being awash.

(See *Hydrographic Bulletins*, March 1930, pp. 42 & 43; May 1930, p. 111; and March 1931, pp. 57, 59 & 61).

DENMARK.

For reducing soundings to chart datum, automatic tide gauges are used.

When inserting soundings on the fair sheet they are rounded off to the next lower decimetre, the next lower quarter metre, half metre or whole metre; they are never, in any way, greater than the reduced sounding.

When inserting soundings on the chart, from 0 to 12 metres (6 ½ fms.) tenths are shown; beyond 12 metres the sounding is rounded off to the next lower metre.

(See *Hydrographic Bulletins*, May 1930, pp. 110 & 111; and March 1931, pp. 57 & 58).

FRANCE.

The tide is observed either by tide pole or tide gauge at one or more points on the coast off which sounding is taking place, and the soundings taken are corrected for the height of the tide at the time of sounding.

When the sounding is obtained, the leadsman calls out the last *submerged division* marked on the line, for instance "five forty", which means 5 m. 40 c/m.

The recorder inscribes this sounding in black pencil on the sounding book where it is afterwards corrected to the nearest centimetre for lead line error. The corrected value is written in blue ink above the preceding number.

The tidal correction corresponding to the time of the sounding is then made, to the nearest centimetre, and the final sounding is written in red ink on the sounding book under the two preceding numbers.

Centimetres are not shown on the fair sheet, the soundings being expressed in metres and decimetres only; they are rounded off to the lower decimetre if the number of centimetres is less than 7 and to the higher decimetre if the number of centimetres is 7 or more.

On the chart, soundings of less than 10 metres (5 ½ fms.) are expressed in metres and decimetres as on the fair sheet.

Soundings of 10 or more metres are expressed in metres only; they are rounded off to the next lower metre if the number of decimetres on the fair sheet is less than 7 and to the next higher metre if the number of decimetres is 7 or more.

(See *Hydrographic Bulletins*, March 1930, p. 43; January 1931, pp. 4 & 5; and March 1931, pp. 57 & 59).

CHINA.

The system adopted for reducing soundings to chart datum is as follows:

If tide gauge reads 10.1 feet above datum, 10 feet are subtracted from the sounding taken.

If tide gauge reads 10.2, 10.3..... 11 feet above datum, 11 feet are subtracted from the sounding taken.

The times of taking soundings are recorded every 20 minutes of each hour and also when commencing and finishing the day's sounding.

POLAND.

As the level of the sea varies by a few centimetres only during the course of 24 hours, a daily mean is adopted and soundings are reduced to the mean level of the sea.

SWEDEN.

A self-registering tide gauge is read after returning from a day's work. The level of reduction used is Mean Sea Level.

See also *Hydrographic Review* Vol. I, No. 2, May 1924, pp. 52 & 53.

NORWAY.

Soundings of less than 10 metres are reduced to the nearest ½ metre. The depths over sunken rocks and the least depths in channels are reduced to the nearest 1/4 metre.

SIAM.

For reducing soundings to chart datum, the lowest water level observed at the tidal observation station during the course of the whole surveying season, which lasts sometimes about three months, is used.

(i) THE SYSTEM USED FOR DRAWING UP THE SCHEME OF LINES OF SOUNDINGS, WITH PARTICULAR REFERENCE TO EXAMINATION OF DANGERS OR SOUNDING OFF SALIENT POINTS

NETHERLANDS.

Nil.

GERMANY.

When searching for shoals etc. the suspected area is covered by a close net of lines of soundings, besides which search lines and sweeps are used.

ITALY.

The director of the survey determines the density of the soundings, taking as the basis previous surveys or notes, or the information provided by those who take the preliminary soundings. In any case, it is laid down that, on whatever scale the sounding is being done, if the slightest irregularity in the form of the bottom be noticed, the soundings should be taken as closely as possible in order to develop the irregular area completely and to ascertain the position of the shoalest spot.

U.S. OF AMERICA (Hydrographic Office).

For information under this head and for greater detail regarding other questions, see U.S. Hydrographic Office "*Manual of Hydrographic Surveying—Sounding*", preliminary issue 1930.

U.S. OF AMERICA (Coast & Geodetic Survey).

Systems of parallel lines are used except in special cases where diagonal or zig-zag lines may be preferable for the development of certain features.

Lines of soundings are usually run at right angles to the coast, but close inshore, especially over an even and gradually sloping bottom, additional lines parallel to the coast are often run, thereby thickening up the soundings taken on the normal lines and enabling them to be taken closer to the shore. In important anchorages and channels lines are usually spaced 50 metres (55 yds.) apart or even closer if necessary. In general coast work, lines normal to the shore are generally spaced 200 to 300 metres (219 to 328 yds.) apart to the 10 fathom curve, thence one half mile apart to the 15 fathom curve or to the limit of visibility of control objects, and thence from 1 to 4 miles apart to the 100 fathom curve. When the bottom is broken or

uneven it is necessary to decrease this spacing. For work between the 100 and 1,000 fathom curves, lines are spaced from 2 to 5 miles apart, the closer spacing being used out to the limit of fixed-position work and the wider spacing for lines controlled by astronomical observations when the outer limit of work cannot be reached by other methods of control. For a system of lines parallel with the shore, the spacing varies with the depths. Thus the successive spaces, outside the 6 foot curve, may be 50, 100, 200, 300 and 400 metres. In rocky regions the above spacing is considerably decreased and shoal indications are developed with the lead line or wire drag. Alternatively only sufficient sounding lines are run to ascertain the general depths and configuration of the bottom, the entire region being then covered with the wire drag to the depth required for navigation. (See also pages 125-127 of Sp. Pubn. No. 143 of the U. S. Coast & Geodetic Survey).

SPAIN.

The corners of the dangers to be examined are marked by small buoys and the area enclosed is sounded by the grid method, increasing the number of soundings where lesser depths are found ".

For sounding off salient points the system of radiating lines and zigzagging is used.

PORTUGAL.

Does not specifically answer this question, but states that in order to obtain the shoalest depths the boats are rowed against the stream while two leadsmen obtain continuous alternate soundings. On any change in depth being found the lead is kept on the bottom, and the boat over it, while the position is fixed, after which the line of soundings is continued.

It is added that "in regions of shoals of very limited area an attempt was made a few years ago to sound in succession with two machines and then define, by sextant, the position of all the minimum depths found."

In certain circumstances such as when the bottom consists of scattered or pinnacle rocks, examination by sweeping is carried out.

Use is also made of information obtained from fishermen, etc.

GREAT BRITAIN AND AUSTRALIA.

In a detailed survey the usual practice is to run lines of soundings at right angles to the general direction of the coast to depths of 15 to 20 fathoms at a distance apart of 2/10 inch, whatever the scale may be.

Where irregularities of depth are found to exist or where, from the rocky nature or formation of the coast, they may be expected to occur, both intermediate or cross lines of soundings are always run and the slightest indication of danger thoroughly examined.

When sounding on a small scale, and a narrow tongue of shoal ground lying between two lines of soundings might exist, either isolated or running off from a reef or point of land, even though the lines are as closely spaced as the scale will permit, cross lines are run in order to diminish the risk of missing such a shoal.

Particular attention is naturally paid to the soundings within the 10 fathom line, where rigorous examination is made of any doubtful casts.

DENMARK.

The close examination of a shoal or danger is carried out by wire drag and spar sweep. Very rarely is a shoal examined by the lead only.

FRANCE.

Lines of soundings are run, as far as possible, at right angles to the contour lines of the bottom.

When searching for isolated dangers two perpendicular systems of lines are usually run.

For coastal soundings, at depths not exceeding 25 metres (13.7 fms.) the distance between the lines varies between 40 and 200 metres (44 and 218 yards) according to the nature of the bottom and the importance of the region. For greater depths, within sight of land, the lines are generally from 200 to 500 metres (218 to 547 yards) apart. Out of sight of land their distance apart is sometimes several miles, but the survey must then be considered as a hydrographic exploration only and not as capable of furnishing a complete representation of the bottom. The scale of the survey is then of the order of 1: 500,000.

In general the scale of the survey adopted is double that intended for the published chart.

The mean spacing of sounding lines adopted on the scale of the survey is 8 $^{m}/_{m}$ (0.315 inches).

The following scales are generally adopted :

Important harbours	1: 5,000
Other harbours and important coasts	1: 10,000
Approaches to harbours and coasts of secondary interest.....	1: 20,000 and 1: 25,000

Smaller scales are admissible for depths greater than 25 metres (13.7 fms.)

CHINA.

For the examination of dangers parallel lines of soundings from 25 to 200 feet apart are run at right angles to the coast or in a North and South or East and West direction.

When sounding off salient points the system of lines adopted is fan shaped.

POLAND.

In principle, the shape of the bottom off this coast is regular, the depths changing gradually. No submerged dangers or shoals have so far been found, and there are no salient points. The bottom of the sea is consistently sandy and almost without exception it deepens uniformly.

When scheming the lines of soundings the approximate contour lines in

the area to be sounded are drawn, and the sounding lines to be run are then inserted on the sounding board spaced from 100 to 150 metres (109 to 165 yds.) apart as necessary.

SWEDEN.

For the system of drawing up the scheme of lines of soundings, see *Hydrographic Review* Vol. I, No. 2, May 1924, pp. 53-66.

NORWAY.

The scheme of sounding lines is based on the system used to delineate the coast line. Prominent points on the coast line, 25 to 75 metres (27 ½ to 80 yds.) apart, are located by plane-table and marked with whitewash, such marks being given a form that will enable each individual one to be easily identified. In addition to these special coast-line marks and other previously located stations, all topographic features which may serve as conspicuous land-marks are located, thus further increasing the number of orientation objects.

Laying out the sounding lines.

Having completed the coast line of a certain area, two schemes of parallel lines, at right angles to one another, are laid off in pencil on the sounding sheet.

In depths of less than 50 metres (27 1/4 fms.) these lines are spaced a maximum distance of 50 metres (54 ½ yds.) apart; in depths of 50 to 80 metres (27 1/4 to 43 3/4 fms.) the spacing is 100 metres (109 yds.); for greater depths a spacing is used corresponding to twice the depth rounded off to the nearest 100 metres.

These sounding lines are laid off with one system normal to the general trend of the coast.

In addition to sounding, the wire drag and submarine sentry and frame are used.

SIAM.

Does not specifically answer this question but states that in drawing up the lines of soundings off salient points the method of triangulation and angle observation for position (and close examination for sounding around it) is used.