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HYDROGRAPHY

DESCRIPTION OF LONG WIRE DRAG

(REVISED EDITION)

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THE LONG WIRE DRAG.

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Sweeps or drags have long been employed in hydrographic work for finding pinnacle rocks or small ledges when the location of these obstructions to navigation are approximately known. Intended to meet some present emergency, they were of primitive design and hastily constructed of material at hand. For the systematic investigation of areas like channels or anchorages the "harbor and channel sweep" was constructed and employed in 1902. To investigate still larger areas economically, it became evident that a very much longer drag would have to be used, so as to traverse a much wider path and thus reduce the area of overlapping work, it being necessary that adjacent strips should overlap to insure that no area has been neglected.

The long-rope sweep introduced by the French hydrographers was improved by the Lake survey, as described in the Report of the Chief of Engineers, United States Army, 1903. The earlier development of this form to meet the conditions found on coast work is described in Appendix 6, Report of the Coast and Geodetic Survey for 1905, Appendix 7, Report for 1907; and The Description of Long Wire Drag, published in 1910, gives the general details of the wire drag as at present used.

Since the date of the last-named publication, wire-drag work has been carried on continuously on the coasts of New England, Florida, Porto Rico, and the approaches to Panama Canal. It has continued to disclose many dangers to navigation which other methods failed to detect and to do this work rapidly and economically. In consequence it is recognized that wire-drag surveys should be undertaken on a more extensive scale in other regions as rapidly as conditions will permit. The methods have become standardized and the adoption of machinery has introduced sufficient changes to make a new description of the wire drag necessary.

IMPROVEMENTS.

In consequence of successive improvements the drag is now adapted to the different requirements of the three classes of work—first, to determine whether an apparently open sea is free from obstructions; second, to find the least water in a shoal area; third, to develop the maximum safe depth in a channel.

In the first class of work the great increase in the length of the drag has reduced the unit cost of such work.

In the second class, which is always the most difficult and expensive, the unit cost has been reduced by the adoption of the practice of setting different parts of the drag at different depths to follow as closely as practicable the contour of the bottom, as indicated by existing information. While apparently a simple change, this method requires complete and rapid control of the launches and tenders and the adoption of method for recording and plotting the results. A longer drag averaging 3000 feet is used, and either more shoals can be located or a greater area dragged in a given time. In such areas a large tender and two small sounding tenders can be used to great advantage.

The third class of work resembles the second, except that it is better to use a short drag set to the same depth throughout.

Since 1910 the improvements in the machinery for taking up the wire drag have resulted in the use of greater lengths than those formerly used. These improvements included hoisting engines, with an arrangement for a wide variation of speed to suit conditions, and anchor-hoisting engines which make it practicable to anchor as often as desired without undue effort or delay in hoisting the anchor, and engines for the small sounding tenders which make them independent, so that they can be left at work on a shoal after the dragging has been resumed. In addition, a very complete apparatus has been devised for signalling from the guiding launches to the subordinate launches and tenders. This replaces the wigwag system in regions where shoals are numerous.

Improved details of construction of the drag itself include a new form of depth-adjusting apparatus on the large buoy, which permits a fixed length of towline base; a new form of small buoy, which is shaped to produce a minimum resistance when passing through the water; an arrangement of the uprights, better adapting them to the depth-adjusting apparatus of the large and small buoys; devices for attaching the upright to the bottom wire and sinker, which save time and prevent kinking of the upright; the use of wire of larger size with longer life; arrangement of the metal towline to give a fixed towline base; a tripping device for instantaneously detaching the wire from the rope towline, a necessary feature when large launches are used in regions of strong tidal currents; an arrangement of the rope towline, which permits one-man control on large launches and facilitates maneuvering of the launches; a system of leaders, to lead the wire to the reel, in setting out and taking up; and changes in minor details to give increased speed, safety, and economy.

The system of control has been improved by the adoption of the improved signaling apparatus; the more accurate defining of the ends of the towline base; a device for eliminating eccentricity of the observer on the launch when the working conditions of the launch requires such eccentricity; and the elaboration of a signal code which provides for every situation that arises.

The complications involved in controlling the movement and depth of a long drag used in variable bottom are solved by the use of a celluloid sheet on which the available information is placed, and on which a graphic record of progress can be kept without removing the original data. The instruments used in determining and plotting the position of the ends of the drag have been improved and constructed of durable materials.

In the preparation of the final results a method has been adopted for indicating in the record the portions of the drag set to different depths and for plotting the corresponding areas on the sheets, with the effective depths over each portion. This makes the sheet a duplicate of the record, thus providing a safeguard in case of loss. A celluloid curve which indicates the position of the buoys is used, and an improved instrument for use in plotting is under consideration.

DEFINITION OF TERMS.

For the sake of clearness the following definitions of terms used in this paper are given:

Length of upright.—The distance from the water line of the buoy when the drag is at rest to the point of attachment of the upright to the bottom wire.

Drag depth.—The distance between the surface of the water and the bottom wire of the drag when in use.

Effective depth.—The distance between the plane of reference, such as mean low water or mean of the lower low waters, as the case may be, and the bottom wire of the drag when in use.

Depth to be verified.—The depth below the plane of reference, above which obstructions are sought.

Length of drag.—Length of bottom wire between ends of drag.

Division.—That part of drag between two launches.

Section.—That part of the bottom wire between two uprights.

Unit.—That part of bottom wire between fittings which break its continuity.

GENERAL PRACTICE.

For a certain region to be examined a maximum depth is adopted (45 or 50 feet) and the drag is set for this depth for areas of greater depth. Areas of less depth are dragged as closely to bottom as conditions will permit, usually within a foot or two. When the bottom is very irregular the guiding launch carefully follows a prearranged line, and the different parts of the drag are set to approximate the bottom. It is customary to adopt a minimum depth in order to prevent a too close approach to land and known shoals and reefs, which in rough water would be dangerous for the launches with the drag in tow.

The amount of area which can be fully developed within a given time depends on the number and grouping of the shoals. In this class of surveying more than any other the extent of the results depends on the judgment used in planning the work and its skillful execution.

Ordinarily the lifting power of the cedar floats is negligible when the drag is under tension, but when the shoals are very numerous it is found necessary to increase the reserve buoyancy by adding to the number of floats so that the drag can be readily removed after striking a shoal. In this case the buoyancy is so great as to leave no margin for a factor of safety, and it is wise to adopt as the actual drag depth one less than that indicated by tests. On the other hand, with too little reserve buoyancy, instead of the danger of missing shoals the drag, by sagging, may catch on obstructions below the required depth. To arrange the floats to suit a particular area requires experience and the exercise of good judgment.

As the drag is at its proper depth only when under tension, whenever the launches stop for any reason the plotted strip on the sheets is ended, and a new strip is started when the drag resumes its onward course under proper tension.

DRAG LENGTHS.

Lengths of drag under 3000 feet are rarely used except in channels with less width than this. Sections with 6 to 50 foot units are used with such lengths. With lengths from 3000 feet to 12 000 feet, sections with 8 to 10 units are employed.

Lengths in ordinary use are shown in the following statement:

Length of drag	Length of sections	Average width of drag		Floats per section	Power launches	Conditions
		Feet	Meters			
[1]12 000	500	10 200	3100	4 lg	3	Open sea.
8000	500	6800	2060	4 lg	2	Do.
6000	400	5100	1550	3 lg	2	Open water close to bottom.
3000	300	2550	775	2 lg, 3 sm	2	Shoal area.

[1] Not considered maximum length of drag possible. It has been the greatest used to this time, but the length has been limited by the capacity of the reels and the character of the work.

SPEED AND AREA COVERED.

The rapidity with which an area can be examined is one of the most valuable features of the drag work. The average speed of a drag is from 1¼ to 1½ miles per hour through the water. The component of the average current with or against the progress must be added or subtracted from this speed.

Several records were made in Panama Bay. An area of 14 square miles was covered in a single day with a 12 000-foot drag. An area of 36 square miles dragged very close to bottom but not rocky was completely covered in six working days. For the season of 85 working days an average area of 2½ square miles per day was maintained. Comparatively open water was characteristic of this region. The season of 1913 at Key West, Fla., furnished a different kind of record which exemplifies the other important use of the drag. During a season of 40 working days an average of 8 soundings per day on uncharted shoals was made, though the average finished area was only three-fourths of a square mile per day. The greatest number of shoals found on a single day was 15. There was no open area in this region.

CAUSES OF DELAY.

The area that can be covered in a day or season is limited by a number of adverse conditions, some of which exist only in certain localities, while others are common to all regions. On the coast of New England, lobster pots, fish trawls, and stakes marking oyster beds are in the former class. The lobster pots, which are the principal obstructions, owing to their great numbers, cause the most delay. It is necessary to buoy out sections of about 4 by 1½ miles, with a small spar buoy at each corner. These buoys are distinguished from navigation buoys by having colored flags attached. The general localities of these buoys are reported to the Bureau of Lighthouses for publication, and the owners are notified to remove their pots from the area so marked until the wire-drag examination is completed. It is estimated that the resulting delay increases the cost of the work 20 per cent.

Other causes of delay that are met in all localities may be mentioned. In shoal areas and important channels, in order to obtain the greatest available depth of water, the drag wire is set so as to pass very close to bottom, and under these circumstances even a moderate breeze will make a sea having troughs sufficiently pronounced to allow the buoys and drag wire to drop below their proper level and the latter to catch on obstructions that it should pass over. There is also danger of lifting on the crest so as to pass over obstructions that should be caught. In open water all these difficulties are minimized and work can be carried on in a fairly strong breeze.

The varying conditions of wind and tide make it advisable to select each day the areas where they will prove most favorable, though this is impracticable in regions containing lobster pots, as there the areas must be selected at the beginning of the season and rigidly adhered to. It is important to study the tidal currents of the region so that the drag may proceed with the current as much of the time as is possible.

COST.

Regions	Conditions	Working days per month	Average cost per square mile
Coast of Maine	Deep water, high range of tide, bowlders, granite pinnacles, frequent lobster pots.	18	$125
Block Island Sound and Buzzards Bay.	Shoal water, bowlders, few ledges, moderate tide, lobster pots only at certain seasons.	16	160
Florida Reefs	Shoal water, numerous coral heads, small tide	12	400
Panama Bay	Open water, few ledges, great range of tide, high operating expenses	25	70

DETAILS OF COST, LIFE OF SERVICE, ETC., OF EQUIPMENT IN WIRE-DRAG OPERATIONS.

Cost of buoys and appurtenances:		
Large buoys	dollars	16.00
Hoisting apparatus	do	12.00
Fittings, including towlines, spring balances, blocks, tripper, wire cable, rope	do	50.00
Sinkers	do	7.00
Small buoys	do	13.00
Hoisting apparatus (including oak leader)	do	5.00
Uprights and fittings	do	3.50
Sinkers	do	2.00
Other wire-drag equipment:		
Best double galvanized No. 7 wire, per inch	do	.0045
Cedar floats with swivel snap hooks and treated to render impervious to water—		
Large	do	.30
Small	do	.25

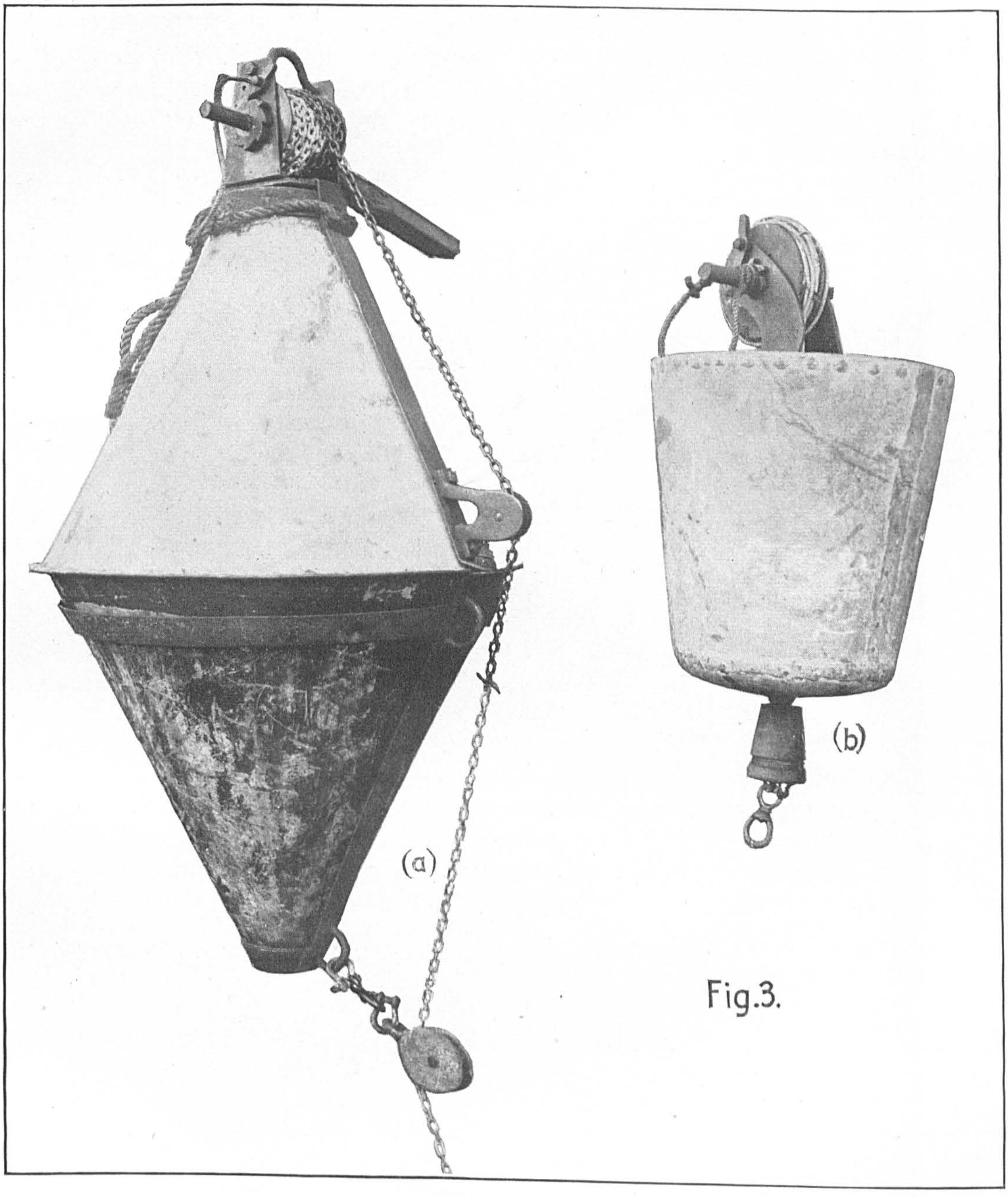


FIG. 3.—LARGE AND SMALL BUOY.

Service life of equipment:

Large buoys	years..	3
Small buoys	do....	1
Wire	weeks..	6
Fittings	year..	1
Towlines	months..	2
Floats, after first treatment	weeks..	6
Floats, after second treatment (then discard)	do....	4
Sinkers (except as lost and damaged in shipment)		Unlimited.

Space between buoys:

Drags over 4000 feet	feet..	500
Drags 4000 feet and under	do..	400 or 300

Analysis of total cost:

Aggregate cost of drag: Let L=cost of large upright complete, 1=cost of intermediate upright complete, n'=number of small uprights$=\frac{\text{drag length}}{\text{length section}}-1$, C=cost of 100 feet of bottom wire and fittings.

c=cost of cedar float, N=number of 100-foot units in drag, n''=number of cedar floats in rag$=N-(n'+1)$ for large floats only. With both large and small floats $n''=2\ N-(n'+1)$.

Cost of 2-launch drag$=2\ L+n'\ 1+n''\ c+N\ C$.

For 8000-foot drag (large floats only) L=\$85.00, 1=\$23.50, n'=15, C=0.70, N=80, n''=64; cost=\$617.70.

For 3000-foot drag (large and small floats) n'=9, N=30, n''=50; other items the same as above; cost=\$417.50.

CONSTRUCTION.

The drag consists of a horizontal member known as the bottom wire, composed of a number of units of No. 7 American gauge, double galvanized telephone wire, supported at intervals by uprights, made of flexible wire cable with suitable buoys and sinkers, and at intermediate points by cedar floats. (See Figs. 1, 2, 3, 4, 5.)

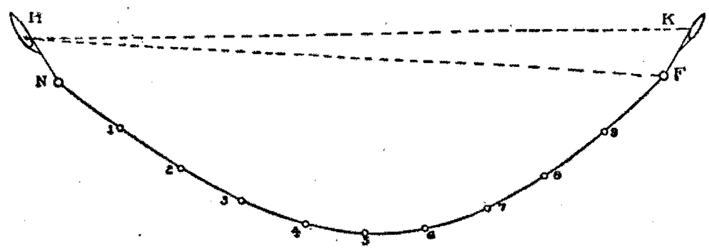


FIG. 1.—Plan of 3,000-foot wire drag.

At the ends of the drag and of each division the buoys are of such size that they will carry a large sinker when at rest with their bilge flanges at the surface of the water. The intermediate buoys are smaller and are of such size that the water line when at rest is about 6 inches below the top of the buoy. Towlines are attached to the large buoys and sinkers in such a manner (described later) as to permit the changing of the length of the upright by a tender when the drag is in use.

Large upright and towing device. The large buoy and depth-adjusting apparatus are shown in Figs. 3 (a), 4, 6, 7. The buoy, Fig. 3 (a), is made of No. 18 special rustproof galvanized

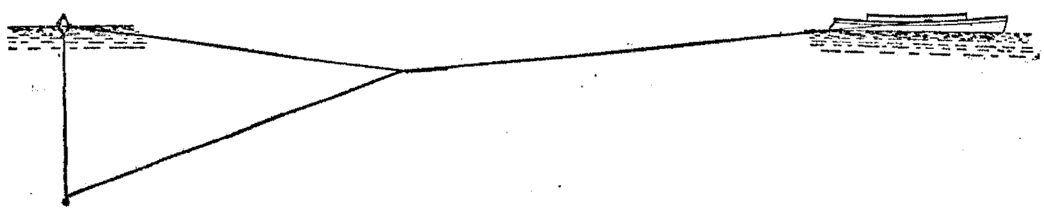


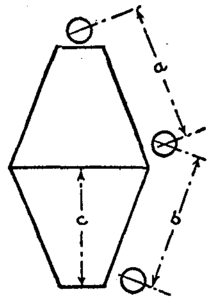
FIG. 2.—End upright and towline arrangement.

iron riveted at all the joints and soldered to prevent leaking. The total weight of the buoy and the depth adjusting apparatus which is detachable is about 80 pounds.

The chain used for adjusting the length of upright is one-eighth inch link, one-half inch wide, galvanized, with a shackle in the lower end. The manner in which the chain passes from the weight to the drum on the buoy is shown in the Figs. 3 (a) and 4 (a) and 6. The top of the drum is the index for setting the length of the upright and a line painted on the buoy 1 foot below gives the setting for the intermediate feet. The chain is painted in 10-foot sections blue, black, white, red, blue, in order named. Each 10-foot section has colored rags in black, white, red, blue, inserted at 2-foot intervals from the bottom of each color. The blue sections are not 10 feet in length but the system of graduation corresponds to the others. By this arrangement when the bottom of the black section is set at the index of the buoy the length of upright is 10, 20, 30 feet, 10 feet if no additional upright is used, and 20, 30 feet if one or more are added. In this way the length of upright can be varied to meet various required drag depths, both for the changes in the charted depths or for tidal changes. For the intermediate feet the proper rag—white, for example—on any section means that the depth is 4 feet greater than the reading for the bottom of the same section.

In order to find the distance from the bottom of chain to the point where the first 10-foot section begins, it is necessary to consider the shape of the buoy and assume the water line.

Measure A B from the index A to center of pulley B; call this a. Then measure from B to C, this block being held in same horizontal plane as staple to which it is attached (buoy vertical); call this b. Measure C the vertical distance from bilge flange (assumed water line) to the staple to which C is attached. h is a certain portion of the height of the large sinker, as described below.



Then let L = distance from end of chain to 10-foot mark, giving length of upright 10 feet (no additional upright).

Then $L = 10 - (c + h) + (a + b)$.

For buoy now used, $a = 2'\ 11''$, $b = 2'\ 6''$, $c = 2'\ 0''$, $h = 6''$, $L = 12'\ 9''$.

Actual height of sinker from swivel in rod to lower staple where the wire is attached is 18″ when vertical. It was found that with pull used for drag 2000 feet or more in length, the average angle of weight and rod when towed is 20° with horizontal, indicated both by tests and by observations in very clear water.

In order to have the lift table the same for the large and small buoys, it was found necessary to modify the rule for length of upright by using only one-third of the total length of the weight in computing length of upright. The only objection to this is that when the large sinker is aground less depth is likely to be indicated than is found, and when a very short drag without small buoys is used the drag is likely to be actually a foot deeper than it is set. It is advisable to adjust this allowance for the average length of drag used and vary the lift table for special conditions.

The towing device consists of two essential parts—the rope towline (Figs. 6 and 7) arrangement and the metal towline (Figs. 4, (a, b, c, d)). While their general purpose is to transmit the tension from the launches to the drag, their specific purpose is different. The rope towline arrangement is necessary in order that the towing strain may be direct from any one of the three points of attachment or may be distributed in any way between them, so as to make possible the maneuvering of the launches to keep them on definite lines. It provides for all ordinary maneuvers and for special uses when the drag is aground or when there is a strong wind or current, and provision is made to keep the towline from getting under the launch and catching in the propeller. The metal towline is made of wire cable. It serves the double purpose of keeping the towline base invariable in length and of keeping the large buoy directly over the large sinker and holds the latter at the proper depth.

The rope towline arrangement consists of four parts, each consisting of a symmetrical pair on both sides of the launch. Two arrangements are shown, one suitable for a large guiding launch (Fig. 6) and the other for an end launch (Fig. 7). The former will be described in detail.

1. A line from a forward bitt to a ring in the spring balance, the length of line depending on the peculiarities of the launch. This is for the purpose of distributing the strain on the launch and to allow all the strain to come from the bow if desired.

2. A line from the ring in the spring balance to a cleat in the side of the launch at the same distance from the bow as the spring balance. The spring balance is usually held close to the

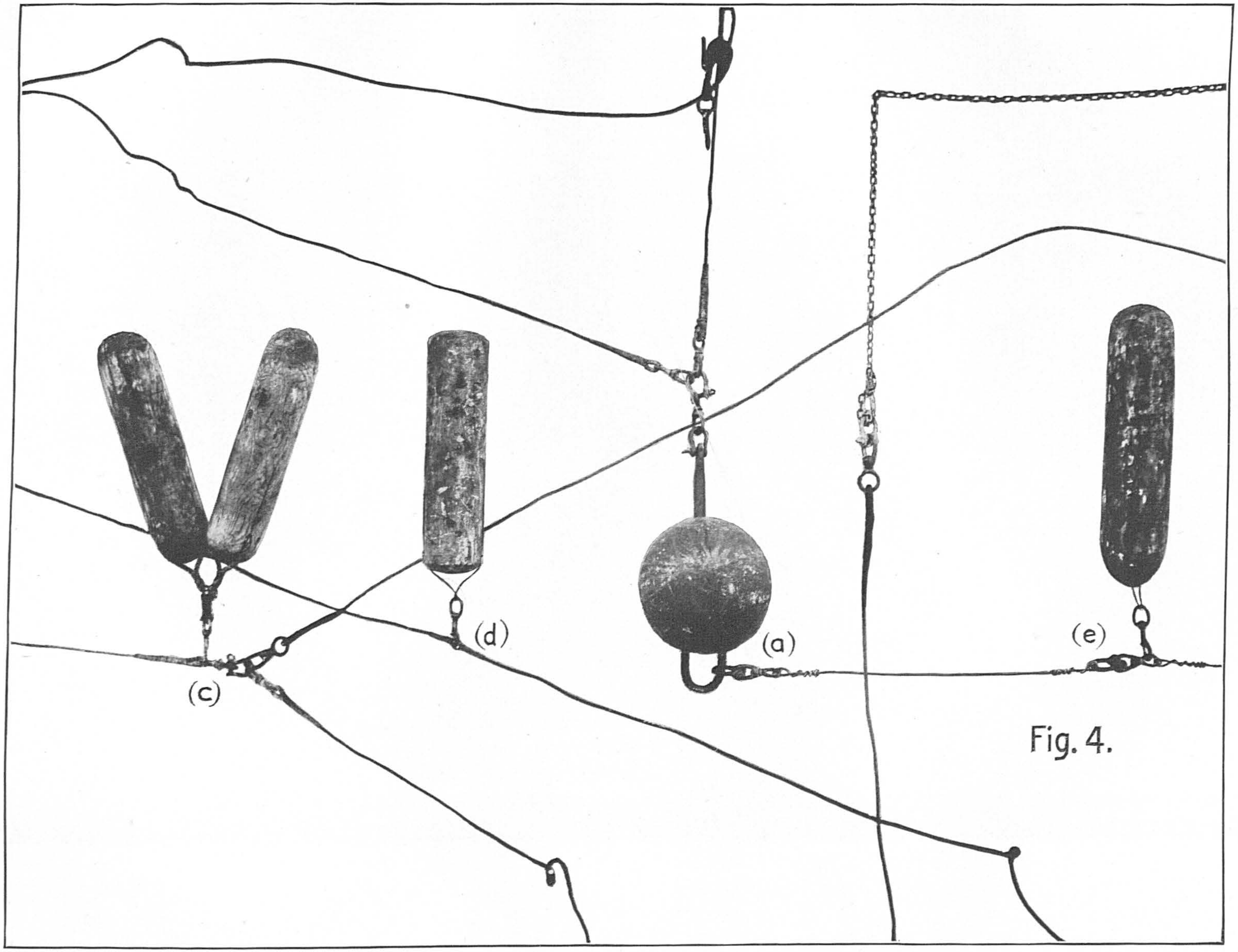


FIG. 4.—DETAILS OF METAL TOWLINE ARRANGEMENT.

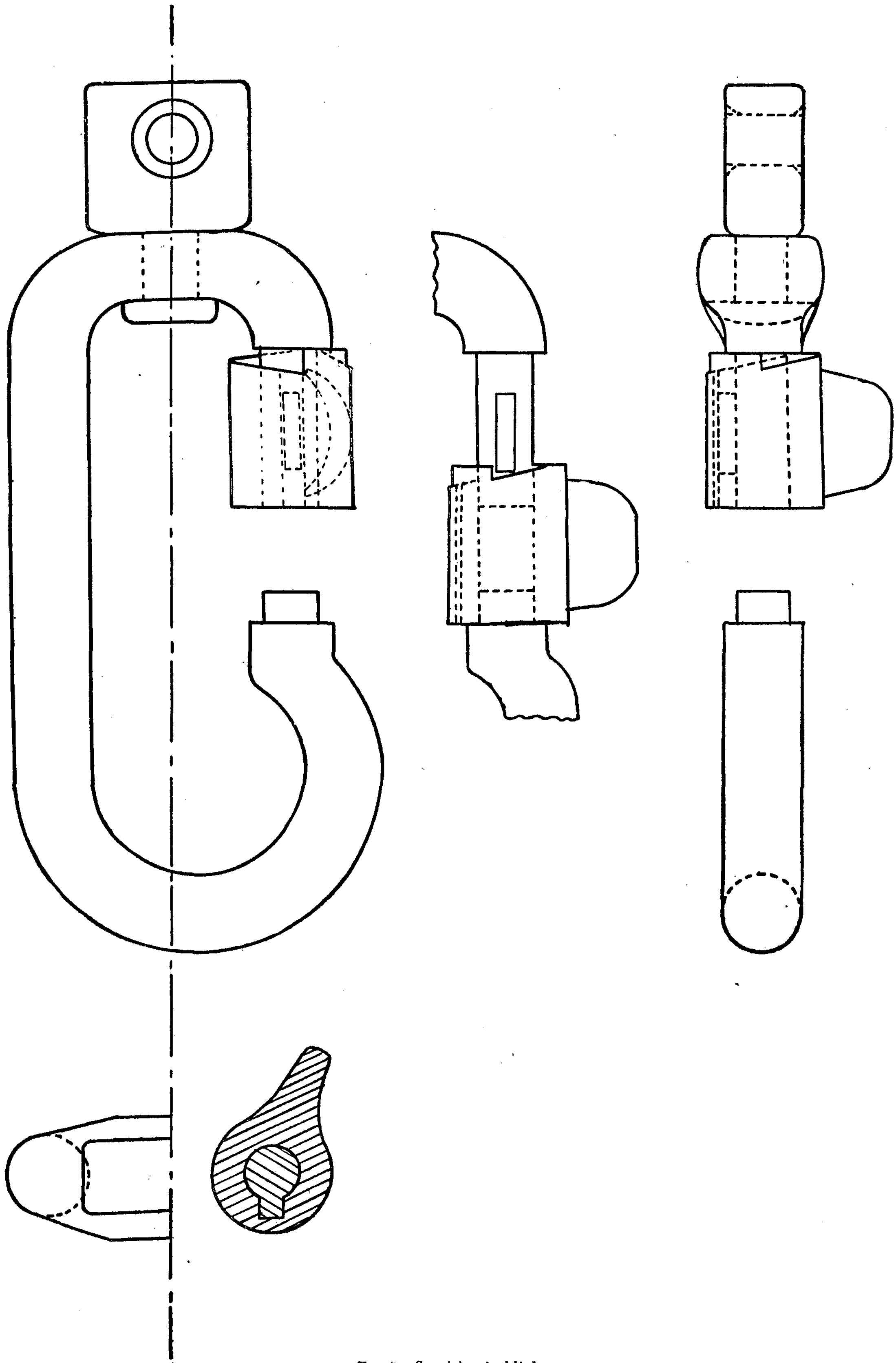


FIG. 8.—Special swivel link.

cleat so that part of the strain comes on the cleat, but the line must be long enough to allow the launch to swing until the towline is at right angles to the launch without putting any strain on it.

3. The line from the juncture with the metal towline, which has a thimble spliced in at a proper distance from the juncture (24 feet with launches thus far used). This thimble engages the hook of the spring balance. This line reeves through a block attached to a cleat or stanchion on the launch, a little forward of the spring balance, and thence to a hand windlass with cleats on the stern. The windlass (Fig. 6) is for the purpose of taking off the strain so that the scales can be attached or detached as desired. The line must be long enough to permit launch to swing.

4. A small line with a large snap hook in the end, which is attached to the towline at a point opposite the after part of the stern and thence to a cleat near the windlass, so that the line tender can tend it without moving. The function of this line is to keep the third line out of the propeller. It must be long enough to permit the launch to swing as described under second line.

5. The tripping line is attached to either part of the third line by means of small thimbles. It leads from the ring of the tripper to a thimble in the end to which an additional line may be hooked, so the tripping device can be operated with the launch in any position.

The end launch towline (Fig. 7) arrangement is similar, except that it reduces the tension of the spring balance to one-half and substitutes a double purchase for the windlass. It is necessary to remember to keep the blocks hauled together when towing, so as to keep the towline base correct.

Ropes described under 1, 2, and 3 should be well-stretched manila rope 2 inches in diameter; other ropes should be 6-thread manila.

The spring balances read to 500 pounds with 10-pound graduation. They should be of a cylindrical type, as any other type will damage the sides of the launch. It is desirable to insert a chain from the hook to the ring of the spring balances to keep them from being constantly stretched to their maximum when fluctuating. Care should be taken with a powerful launch to avoid pulling constantly against the chain, thus getting greater pull than desired.

The metal towline arrangement consists of a standing part and two sides of a triangle, the third side being the upright as described. The standing part and the upper and lower cables are made of five-sixteenths-inch galvanized wire rope with a swivel at the end of each part. The length of these parts is the same, 100 feet, if the greater portion of the area to be examined is 30 feet or more in depth. For less depths, especially in rocky bottom, 80 feet is a better length for the upper and lower cables, as it is easier to keep them from catching on the bottom when the drag is not being towed. The lower cable and upright are shackled to the upper end of the rod on the large sinker, and the lower and upper cables are attached to the standing part in the same way. The end of the upper cable is shackled to a ring in the strapping on the front of the large buoy, just below the water line. The connection of the three cables is held up by a pair of cedar floats (Fig. 4 (c)), and in shoal rocky areas a float is attached at the middle of the lower cable (Fig. 4 (d)).

A three-eighths-inch ring, 4 inches in diameter, is shackled to the end of the standing part nearest the launch, and the tripping device is attached to this. A small thimble is inserted about 4 feet from the ring and a buoy is attached by means of a swivel snaphook and several feet of rope. This buoy carries the end of the towline when it is detached from the launch, and it should have a large ring in the top, so that it can be readily picked up from a moving launch.

The tripping device (Fig. 4 (f)) is made necessary by the difficulty in instantly stopping the headway of a large launch if the drag takes bottom when running with a strong fair tide. It is also necessary to prevent the launch from being held broadside to the current if the launch is brought to a stop before tripping.

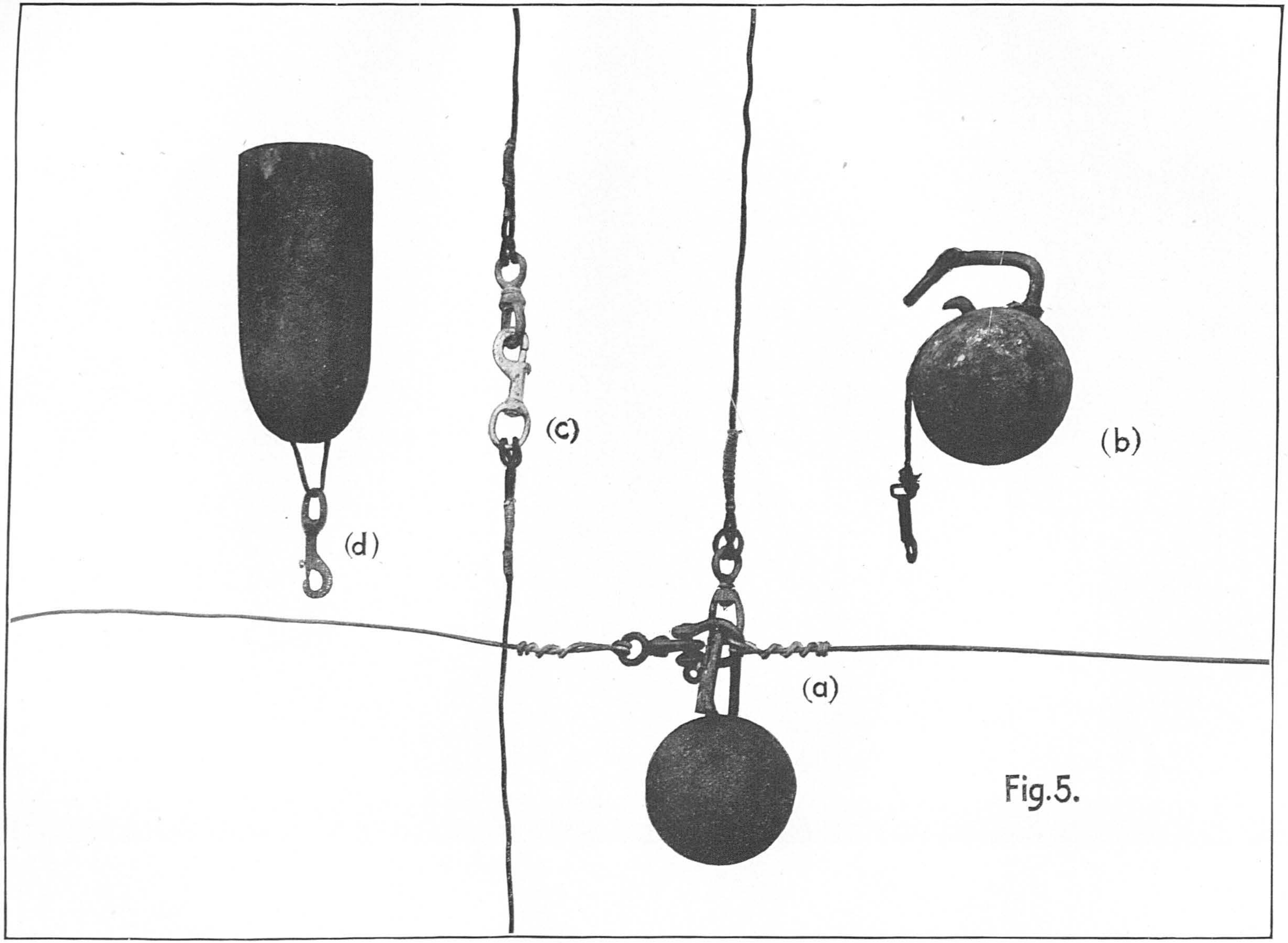


FIG. 5.—DETAILS OF INTERMEDIATE UPRIGHT.

AN ILLUSTRATION OF TRIPPING DEVICE.

To trip, sufficient tension is placed upon the tripping line to pull the link B over the beveled projection at the extremity of the releasing arm C. The tension in the spring of C throws the device open and the towline ring slips off.

The large sinker (Fig. 4 (a)) is of cast iron 11 inches in diameter and 165 pounds in weight. For convenience in lifting, a rod of wrought iron 1 inch in diameter and 7 inches long with a one-half-inch hole near the end is used to attach the uprights and towline. Diametrically opposite there is a three-fourths-inch staple of wrought iron 3 inches high to which the ground wire is attached by a shackle. It is desirable to shackle an extra large swivel to the top of rod in order to carry the excessive strain at this point.

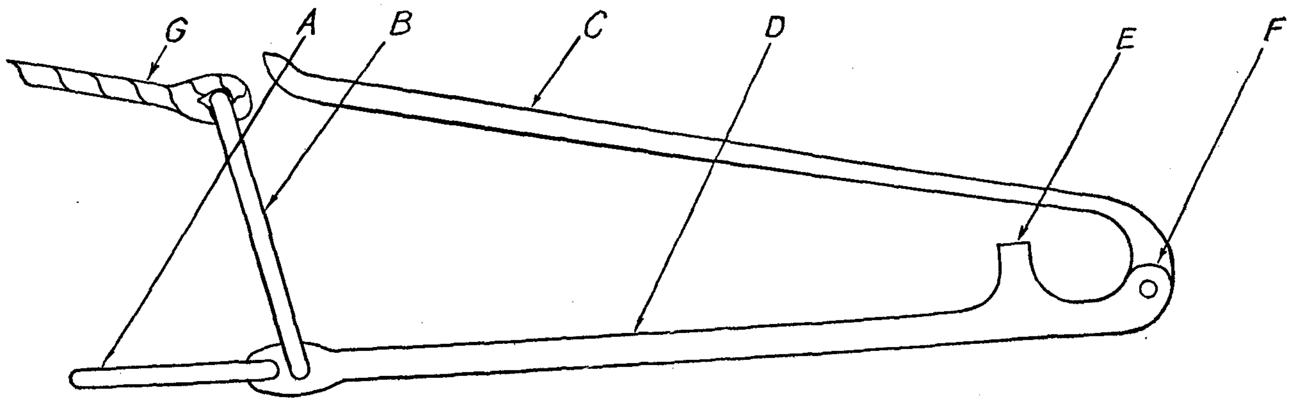


FIG. 4F.—Tripping device.

A=Link for making fast, towline; B=double link for closing device and making fast tripping line G; C=releasing arm made of spring steel and hinged to fixed arm at F; D=fixed arm about 1 foot long; E=lug for holding ring of towline in place and acting as fulcrum for arm C; F=hinge, joining fixed arm and releasing arm; G=tripping line.

INTERMEDIATE UPRIGHT.

The small buoy (Fig. 3 (6)) is so shaped and proportioned that when in use it is submerged to within 6 inches of the top. The buoy is made of No. 18 galvanized iron, riveted at all the joints and soldered to prevent leaking. The buoy is designed to have a minimum resistance at the speeds at which the drag is operated, and the lift of the bottom wire has thus been practically eliminated. The pipe passing through the buoy permits the upright to pass vertically to the drum of the depth-adjusting apparatus. The pipe is attached by a lock nut inside and out, at bottom of buoy and inside at top, and the joints are soldered. At the top of the pipe the depth-adjusting apparatus is attached by means of a lock nut. As a further prevention against possible leakage caused by movement of the upper end of the pipe a piece of leather, coated with shellac, is placed between the depth-adjusting apparatus and buoy. An oak leader is attached to the bottom of the pipe, which is threaded on the outside to prevent the cable from becoming stranded against the edge of the pipe. A brass nipple is placed in the upper end of the pipe for the same reason.

The depth-adjusting apparatus consists of a supporting frame which carries a shaft with drum and ratchet. The supporting frame is made of a single piece of iron shaped as shown in Fig. 3 (b). The shaft is squared at the end to receive the crank socket. The ratchet pawl is attached to the frame and it is held in place by a cotter pin which passes through a hole drilled in the frame and one of a number of holes bored in the drum to correspond to the different positions of the ratchet. A lanyard from the end of the shaft keeps the pin from being lost when not in place. The drum, which is made of oak, is keyed to the shaft. A special device to replace the cotter pin is shown in Fig. 9. This will probably replace the frames if continued use proves it satisfactory.

The sinker is of cast iron 5½ inches in diameter and weighs 20 pounds. It has either a wrought-iron staple three-eighths inch in diameter and 5 inches high or the special arrangement shown on plate (Figs. 5 (a) and (b)).

The intermediate upright is made of galvanized wire cable, extra flexible, three-sixteenths inch in diameter. Commencing at the lower end an allowance of one-half foot is made for the difference between the index point on the buoy (the upper end of the pipe) and the surface of the water.

The system of graduation is the same as for the large upright, except that the intermediate feet are marked by wrapping with sail twine, in the same manner as the footmarks on a lead line.

The bottom of the upright is attached to the sinker and bottom wire, either by a special link (Fig. 8), or by the method shown on plate (Fig. 5 (a)).

BOTTOM WIRE AND FLOATS.

The bottom wire (Figs. 4 (a), (e), 5 (a)) is made up in 100-foot lengths of two 50-foot units, connected by a swivel, each length having a shackle in one end and a swivel in the other. In attaching the fittings for wire of size No. 7 or smaller, two turns are made through the fitting before the wire is twisted around the standing part. For larger wire a single turn is sufficient. In practice it is found that the weakest part of the wire is the standing part about 1 inch from the end of the joint. This weakness can be partially avoided by having the wire made up only by the most expert members of the party, who have learned to make the turns without twisting the standing part.

The cedar floats (Fig. 4 (e)) are 20 inches long by 5 inches in diameter and rounded on the ends. These are usually placed every 100 feet, and when additional ones are required, as in short-drag work, the floats are cut in half (Fig. 5 (d)) and the small ones are placed on the 50-foot swivels. There should be just sufficient buoyancy to allow the floats to come to the surface when the wire is not under strain.[1] The waterproofing of these floats is one of the most difficult problems under the conditions usually encountered. When first received, unless the wood is thoroughly dried, the floats are allowed to dry in the sun or are dried in a kiln, the former giving the best results but requiring more time. They are then boiled in a mixture of linseed oil and Japan dryer or coated with shellac. After they have been in use for about two months they are dried and the process repeated. After this treatment they last about one month, and then they can be treated again, but it is usually not worth while, as they last only a short time. The two processes mentioned are of about equal value in waterproofing. Coating with shellac is the more expensive, but it requires no apparatus, as they are not heated. When the floats are placed in boiling oil the process is cheaper, but considerable time and care is necessary and suitable apparatus is required. The best methods of attaching these floats to the wire is by means of nickel-plated swivel snap hooks of the kind used on harness. These are attached to the floats by wire and staples, and the ends of the wire should be turned and driven into the floats, as when taking up the drag at high speeds there is danger of a float coming off and striking the man engaged in removing them.

[1] The theory of the action of the floats is that when the drag is being towed their small lifting power is negligible, but they act when the drag is at rest.

TABLE OF MATERIALS.

END UPRIGHT (WITH TOWING DEVICE AND DEPTH-ADJUSTING APPARATUS).

1 large buoy.
1 depth-adjusting device, with strapping and blocks.
1 crank.
40 feet of galvanized chain, one-eighth-inch link.
325 feet of five-sixteenths inch diameter galvanized wire cable.
350 feet of manilla rope, 2 inches in circumference.
90 feet of 15-thread line from scales to stern.
60 feet of 12-thread tripping line.
8 No. 6 swivels, galvanized.
5 shackles, three-eighths inch pin.
2 small thimbles (for attaching buoy).
2 cedar floats fitted with snap hooks.
1 buoy (equivalent to small buoy formerly used) for buoying towline.
1 tripping device.
1 4-inch ring.
2 thimbles.
2 Chatillon iron-clad scales reading to 500 pounds with 10-pound intervals, or their equivalent in shape and quality.
2 blocks.
1 large sinker, 165 pounds, with 7-inch rod (1 inch in diameter) and a staple 3 inches high, three-fourths inch diameter.

SMALL UPRIGHTS.

1 buoy (previously described).
1 depth-adjusting apparatus, with strapping blocks.
40 feet of extra flexible wire cable, one-eighth inch diameter.
1 20-pound sinker (previously described).
Extra cable of same kind, 10 to 20 feet if upright is used.
1 special swivel link (previously described).
1 20-pound sinker.

LAUNCHES.

The use of large launches (Figs. 6, 10, 11) has been one of the most marked developments in the wire-drag work. The need for dragging exposed areas involved the adoption of large launches, and it was found that the greater independence of weather conditions thus obtained made their use economical even in the more protected bays and harbors. It should be recognized that in wire-drag work sudden storms or squalls are much more likely to cause danger or loss than in other work, as the apparatus must be taken up before the boats are free to seek shelter. With large launches this source of danger is practically eliminated.

A rough description of two launches used in the work gives an idea of the requirements. One was a power sloop, 59 feet over all, 20-foot beam, 40-horsepower gasoline engine. Another was a 58-foot launch, 14-foot beam. The qualities required are those of a vessel used for laying cable under similar conditions, and the second named above has been so used. Motor boats built for pleasure cruising are usually not strong enough for this work. In seaworthiness the requirements are identical with those for fishing vessels. It is also desirable that the launches should be large enough to carry the equipment when the base of operations is changed.

The guiding launch carries the greater part of the drag, reserve equipment, reels, hoisting engine, anchor engine, suitable guides for setting out and taking up the wire, drafting tables, signal apparatus, and signal flags. In some cases it is desirable to have special davits for setting out and taking up the large buoys and sinkers. The small buoys are carried in racks and the sinkers are kept in boxes, which prevent their rolling about. In place of the usual boat hooks, gaffs are used. These are simply hooks with handles, the size being governed by the character of the work of the launch or boat.

The subordinate launch must not be less than 40 feet long by 10 feet beam. It carries the reel, hoisting engine, drafting table, signal flags, signalling device, and a portion of the drag. On launches where there is no well-defined point to indicate the end of the tow line base a special device (Fig. 7) for this is placed upon the top of the launch. This device is especially necessary when used in conjunction with the apparatus (to be described later) for eliminating the eccentricity of the observer upon the subordinate launch.

The iron reel and the two-speed gearing connecting it with the engine are shown in Fig. 10. The essential parts of the reel are a drum with handles, which is divided into two compartments for towline and wire; a shaft to which the drum is keyed, which carries at one end a brake wheel and at the other two sprocket wheels of the same size spaced like those on the jackshaft described below; a supporting frame, built of wrought angle iron with braces, which

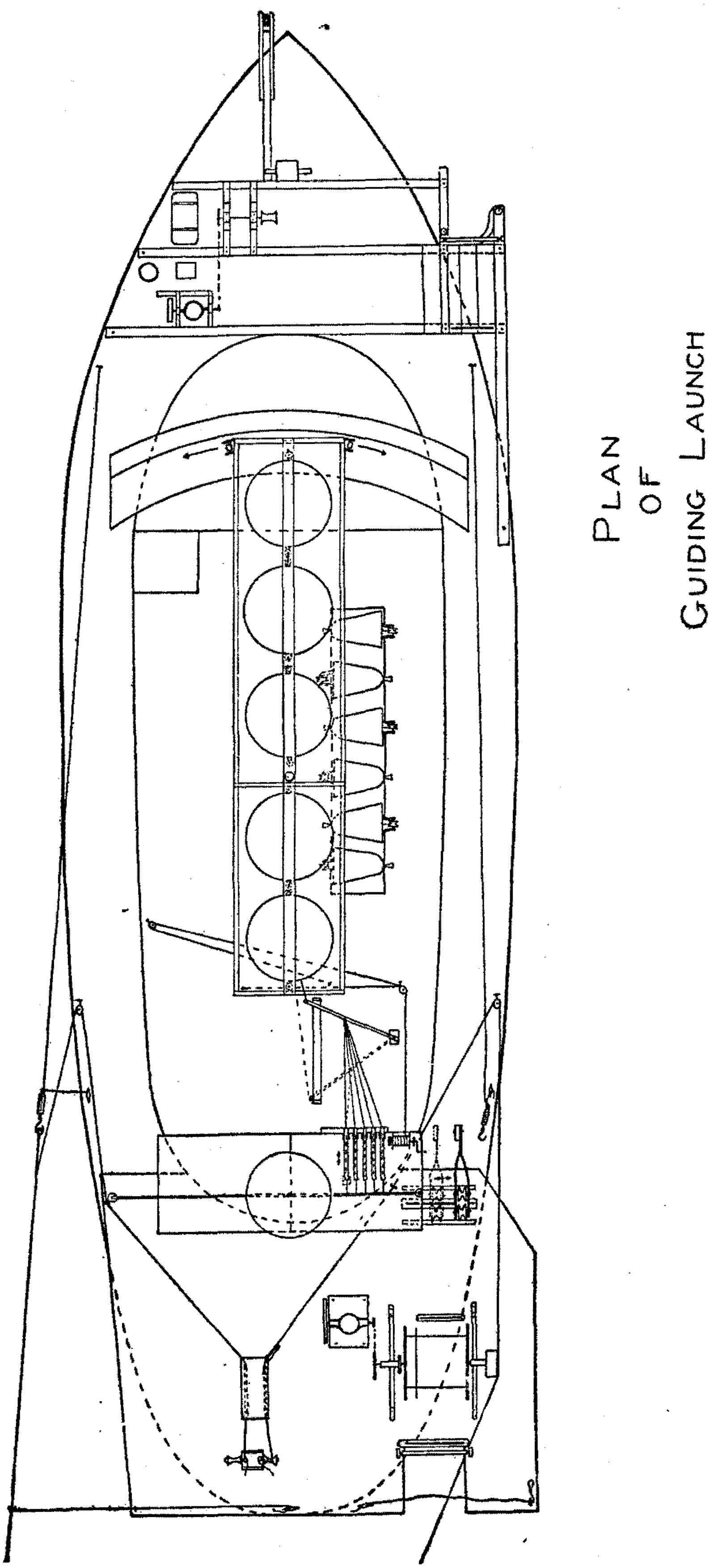


FIG. 6.—Plan of guiding launch.

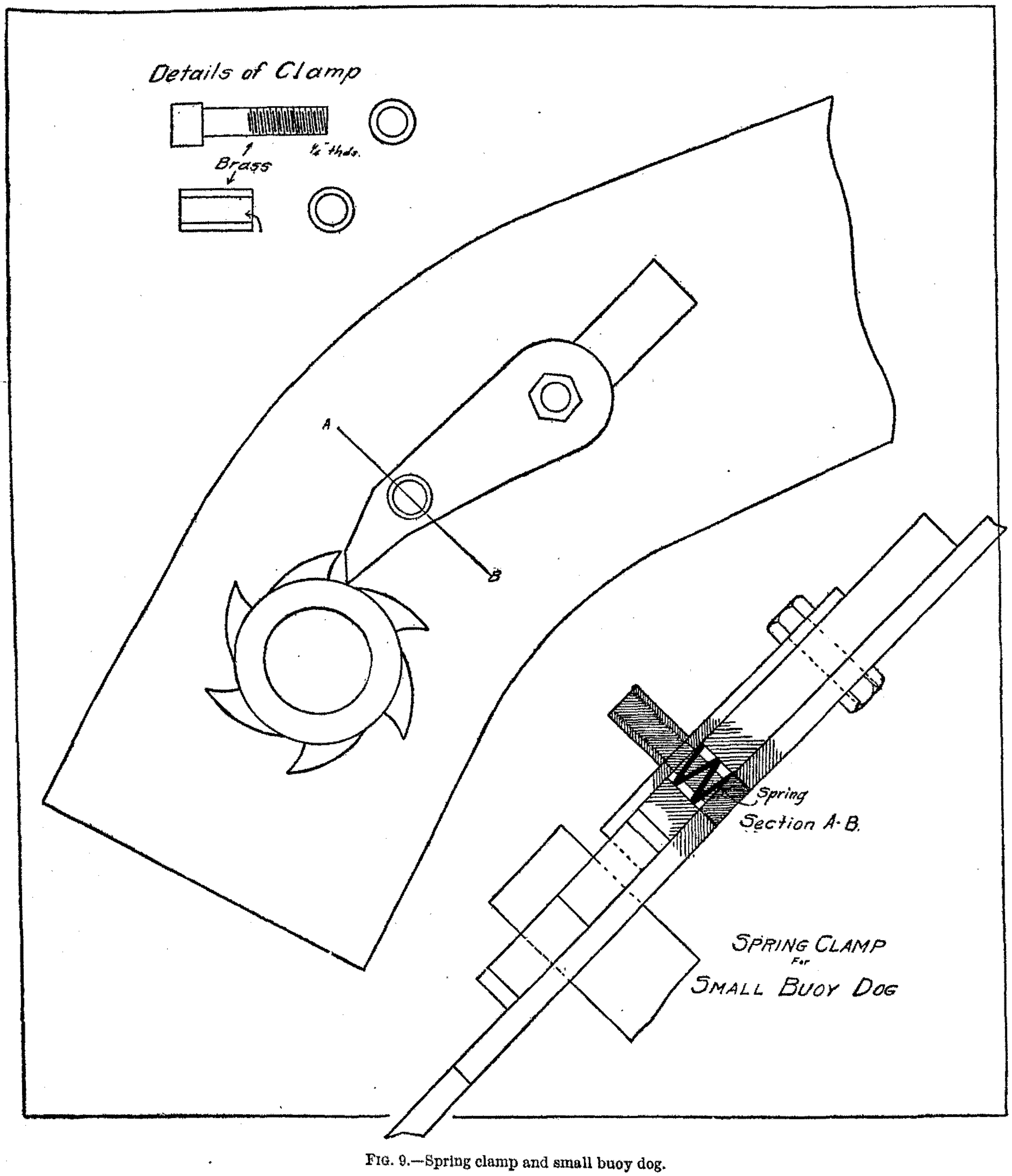


FIG. 9.—Spring clamp and small buoy dog.

carries bearings for the shaft; and the various levers which operate the reel. The intermediate or jackshaft is the essential part of the two-speed gear. The shaft is in two parts, connected by a one-way clutch, and it is supported by three adjustable bearings, known as drop hangers, attached to the deck. The one end of the shaft carries the large sprocket wheel driven from the engine and the cone of the one-way clutch. The other end carries the casing of the clutch and two sprocket wheels of different sizes between which there is a double-jaw clutch. The movable part of this clutch slides on a key on the jackshaft, and the other parts which it engages are cast with the sprocket wheels. This part of the shaft revolves without load until the one-way clutch and the double-jaw clutch are engaged, when the reel revolves at the desired speed. To stop the reel, the one-way clutch is disengaged and the brake is applied. To change the speed, the one-way clutch is disengaged and the lever of the double-jaw clutch is thrown to the opposite position. This lever also has a neutral position, so that the jackshaft will not turn when the drag is set out. A holder, consisting of a strip of iron with notches, is arranged by which this lever is held in one of the three positions, so that the rolling of the boat will not disengage it. The control levers and the brake lever are brought near together at the right-hand side back of the reel, so that they can be operated by one man without interference with each other. No. 52 sprocket chain is used. An essential requirement is to have the reel and engine bolted securely to the deck. The reel shaft is keyed to the disks of the reel, and to insure a greater bearing surface-deck flanges are bolted to each side of the disk, and the keyway extends through them both.

The system of leaders which guide the wire from the bow to the reel when the drag is being taken up is shown in Figs. 6, 10, 11.

The principal requirement is that the wire shall not come in contact with a metal surface with sharp bends. Oak vertical and horizontal rollers, and the first surface that the wire usually strikes, are curved pieces of very hard wood, such as the knees used in vessels. The distance between the vertical rollers shall be sufficient to allow the large sinker to pass between them. The frame carrying this part of the leader should be strongly built and firmly secured to the launch. About 4 feet back of the vertical leaders is an inverted "U" made of 1-inch pipe secured to plates on aft end of the frame. This keeps the wire from flying off the rollers when very slack. There is a similar shaped fender directly in front of the reel. The winder and tightener is shown in Figs. 6, 11. This is moved back and forth to wind the wire uniformly on the reel. The after roller has a counterweight attached. When the wire is slack the slight bend produces just sufficient tension to wind the wire properly, and as soon as the strain is heavy the counterweight lifts, the wire leads straight, and no bending of the wire occurs. Short bends under strain are always to be avoided, as they rapidly weaken the wire.

There is a leader (Fig. 10), shaped like those described, astern of the reel to guide the wire when setting out. It is obvious that the wire leads toward the stern from the top of the reel drum and toward the bow from the bottom.

The signal system (Figs. 6, 11) used when the bottom is very variable and constant signals to the subordinate boats are necessary is somewhat elaborate. That used in a season on the Florida Reefs is shown in the illustrations. The essential features are the five large colored balls, 3 feet in diameter, the arrangement for turning the canvas-covered frame which carries them so as to present the greatest possible surface to the other boats, and the arrangement for raising and lowering the balls simultaneously. The balls are made of wire covered by bunting, black, white, red, blue, and yellow, in order. The frame is made of wood. It is 17 feet long and swings on a tripod very firmly attached to the launch about a 3-inch pipe as a center. The lower end of the pipe is inserted in a block which is cut away at the bottom to allow the leading lines from the balls to pass to the levers. If the launch permits, a track should be built to carry the after end of the frame. The frame is readily swung by small blocks and tackles which lead from both sides of the forward end to the sides of the launch and thence to the operator's table. The lines from each ball lead upward to small pulleys at the top part of the frame and

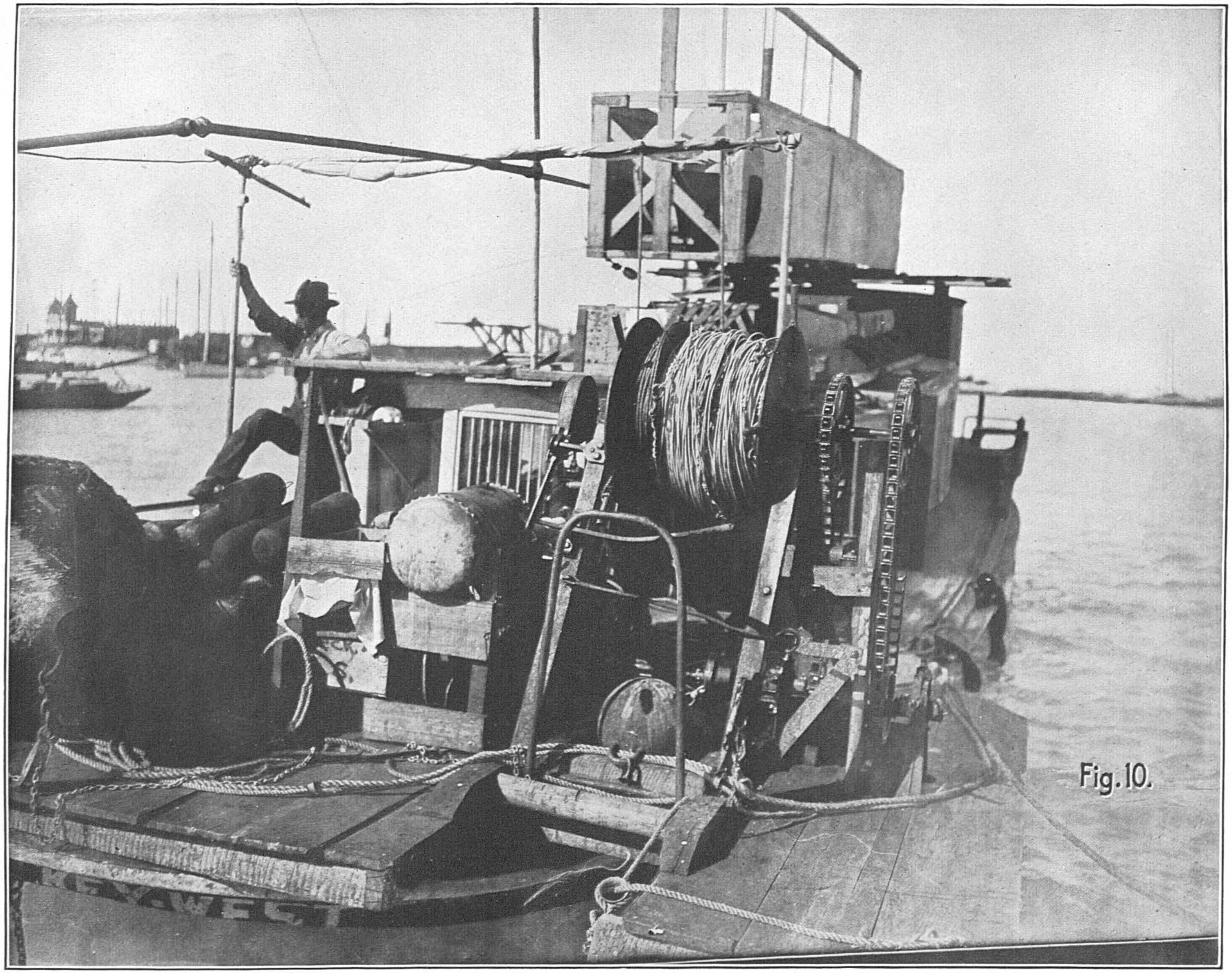


FIG. 10.—VIEW OF LAUNCH WITH REEL AND WIRE LEADERS.

along it to a block directly over the pipe, then down through it, through pulleys at the bottom to the ends of levers by means of which the distance necessary to lift the balls is reduced to half. From the center of the levers cables pass through blocks in the back of the operator's table to oak knobs with handles, which slide on horizontal polished brass rods. The knobs have a notch on the top which engages the wooden spring when pulled out to the proper position. The wooden springs, made of thin oak, are independent of each other and are attached to the inclined top of the back of the operating tables with bolts, which permit tightening them in case the wood should warp. The end of the horizontal brass rods should be firmly secured to the vertical back of the table, and the end should be connected with piping secured to the launch in such a way as not to interfere with the operation. The tripping device consists of a horizontal rod passing under the oak springs parallel to the back of the table. This is operated by a lever passing through the back of the table and connected by wire cable to a foot lever placed at a convenient location for the operator. Care should be used that the tripper has sufficient weight to make it drop away from the springs when released.

A time ball (Fig. 11), which is raised 5 minutes before each hour and dropped on the hour, keeps the time correct on the launches and tenders.

The equipment of signal flags includes a standard wigwag flag, red with white center, 4 feet square, with bamboo pole for signaling launch, a black or blue flag for signaling the large tender when sending words, and white with black center for sending numbers.

The anchor engine (Fig. 6) operates a drum by means of which the anchor is raised. It is necessary to use manila rope in anchoring in all drag work. The delay in using chain would interfere with the progress of the work. In such a region as the coast of Maine, where anchoring must be done in depths up to 50 fathoms, it is very desirable to have the drum operated by the main engine.

SUBORDINATE LAUNCH.

For the usual kind of work a launch 40 feet long by 10 feet beam, with 20 horsepower, is sufficient. The equipment consists of a small hoisting engine, 3½ horsepower, with a single speed for operating the reel, which is like that on the guiding launch; a guiding block which can be moved across the boat, so that the wire can be led to the reel. This block is known as trawl roller and it moves on a horizontal rod.

The signal flags include a regulation red with white center wigwag flag, and a black or blue flag used to call the tender in emergencies. When the signal system is used on the guiding launch, a ball arranged on a vertical rod, with the tripping system like that on the guiding launch, is used to indicate that the signals have been received. If the observer occupies an eccentric position in using the control system, a ball is placed on a horizontal thwartship rod directly above the point of attachment of the towline. This is moved across the boat as the point of attachment of the towline is changed. A correction table (Fig. 12) is mounted on a vertical pipe, which is set in a deck flange so that it may be detached when not in use. The use and theory of this is described later.

LARGE TENDER.

This should be an open launch of the ablest possible type, 28 to 30 feet in length, 7 to 8 feet in beam, with about 10 horsepower. Such a launch can replace one of the larger launches if the sea is not too rough. Its principal work is changing the length of the uprights, clearing the drag from the shoals, removing obstructions, such as lobster pots, and carrying messages or instructions too long for the wigwag. The special equipment includes a buoy holder, cranks for large and small buoys, a small hoisting engine for lifting lobster pots on the New England coast, a spare small buoy, a sinker, etc., to save time in replacing, buoys and weights for marking the shoals for sounding, and grapnel for lifting the bottom wire at any point when clearing. A 5-gallon can, with the line wrapped around it so that when the weight is thrown overboard the buoy will take care of itself, is a satisfactory arrangement for a marking

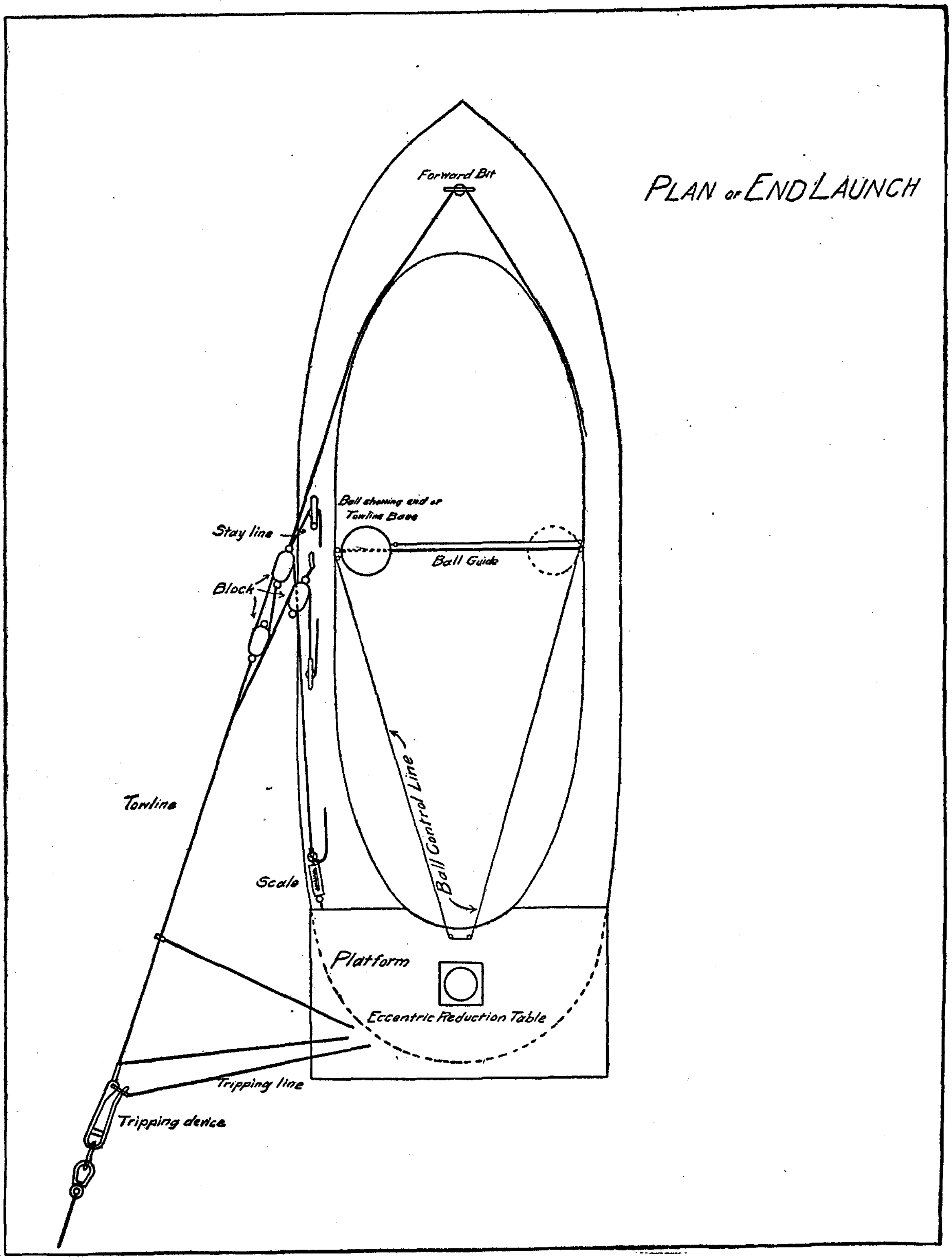


FIG. 7.—Plan of subordinate launch.

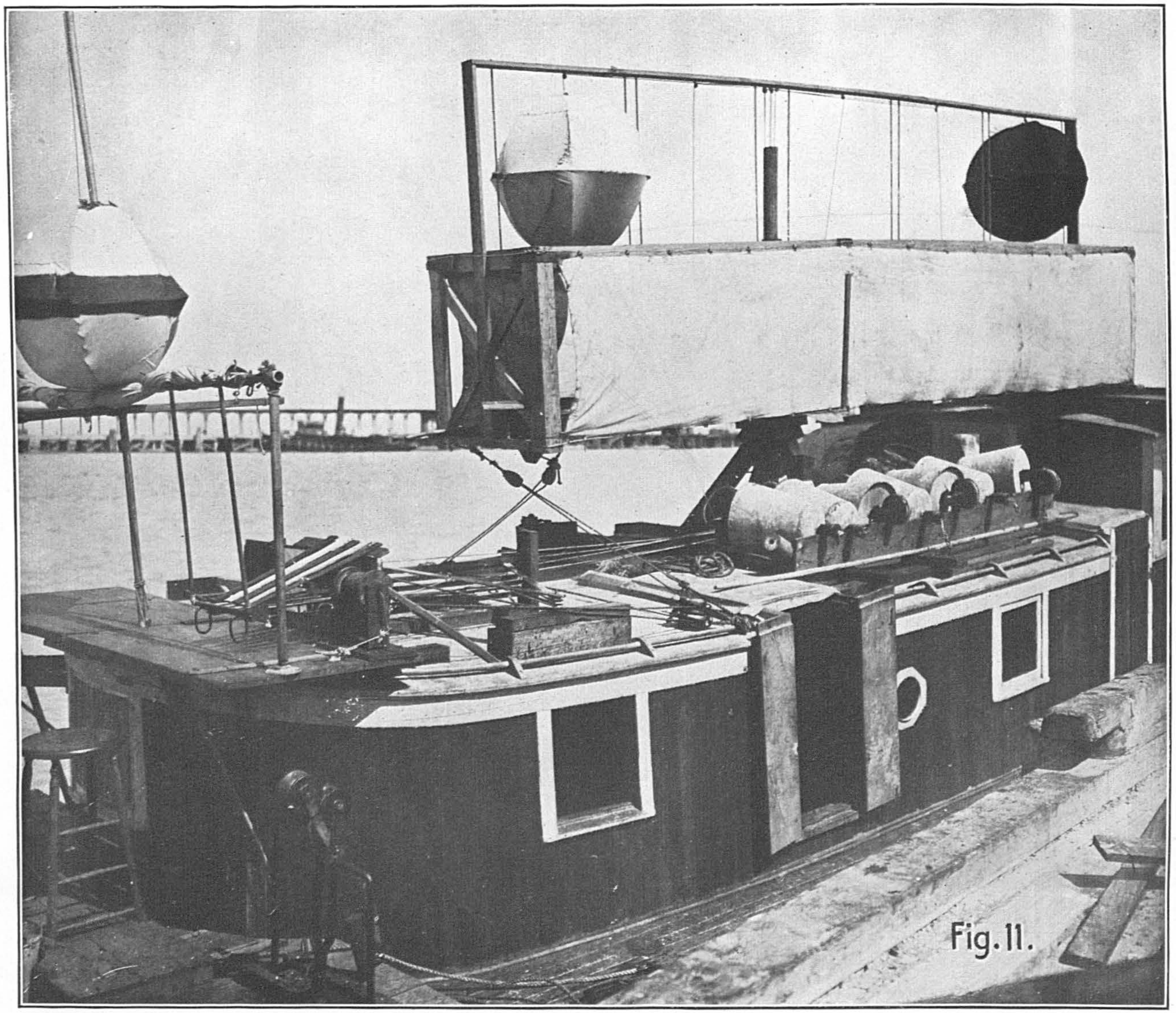


FIG. 11.—VIEW OF LAUNCH WITH SIGNALING SYSTEM AND TIME BALL.

buoy. It is desirable to have the main engine in the tender within reach of the coxswain or to have the clutch, throttle, and spark adjustment brought within his reach. A white with black center flag is used for signaling numbers. The tender also carries a wire cable 250 feet long, of the same size as the small upright cable, for measuring the length of the towline base, and a special device for measuring the drag depth. This latter consists of a brass pipe 3 feet long filled with melted lead and a small brass chain instead of lead line, as the former is less likely to change length. The chain is graduated with small pieces of bunting and leather attached to the links, with the same system used on lead lines. The wire cable has 60 and 70 meters marked by one and two pieces of leather, respectively, and the intermediate spaces are marked every 2 meters by the black, white, red, blue (2, 4, 6, 8) system, similar to that used on the uprights. The zero of this graduation is marked by a white cloth, and there is a free end about 8 feet in length to secure the cable to a stanchion on the boat, so as to bring the zero to the point used as end of the base. In measuring, the tender swings the line over the buoy several times, noting the distance and taking the mean value.

This tender also carries a lobster-pot hoist, which consists of a drum on a shaft operated by means of sprockets and chain either from the main engine or a small auxiliary. In the former case both a one-way clutch and a grab clutch are required.

The small sounding tenders (fig. 13), dinghies about 15 feet long, have 1½-horsepower gasoline engines either of the detachable type or, preferably when the work is continuous, regularly installed engines. These engines should be cased in as far as practicable. The engine control should be carried to the stern, and tiller ropes should extend forward, so that either the officer or the engineer alone can control engine and steering, so as to leave the other free. The tender carries a small buoy for marking shoals, grapnel, lead line, buoy crank, and red and white signal flags.

All the tenders carry copies of the signal code, list of signals to be used instead of a boat sheet, sextant, and record. It is advisable for the officer to examine the boat sheet frequently, so that he will use the proper combinations of objects.

The party consists of the following: In the guiding launch, three officers, one, usually the chief of party, directing the depth changes and movements of the launch and tenders, one observing, plotting, and directing course of guiding launch, and one taking one position angle, distance angle, receiving distance angle, and computing distances. The hands include coxswain, engineer, recorder, drag tender, and line tender. In the end launch are one or two officers, according to whether drag is under or over 4000 feet in length. The hands are coxswain, engineer, and line tender. In the large tender are hands, coxswain, and engineer. Coxswain takes angles on shoals if required and engineer changes length of upright, and both clear the drag when caught on rocks. In the small tenders are one officer, who sounds on pinnacles and takes positions; one hand, engineer, takes care of engine and rows boat while sounding.

ASSEMBLING AND OPERATING.

For assembling, a wharf or covered building where there is sufficient room to stretch out the parts is selected. On a suitable platform or other level space of sufficient length every foot up to 100 is marked, and special marks are made for the end of each part to prevent error in making new parts. In cutting wire, wire cable, and rope a proper allowance must be made for each splice. The wire is connected as soon as the fittings are inserted, and placed on a wooden reel which is used for this purpose. It is led from this reel directly to the launches when required, and the hoisting engines are used to turn the reels.

In setting out the drag the guiding launch anchors at the proper position. If the drag is long, the tender tows out the wire until all of that on the guiding launch is out, then the other launch connects to the end and is towed out by the tender. If the drag is short, the launch takes the end and sets out, on signal, whenever the strain is too great at the guiding launch. The guiding launch gives the length of upright, of section, and amount of drag to be set out. It requires about 35 minutes to set out 8000 feet.

The operation of setting out comprises connecting the ends of the ground wire, running it off the reel, and attaching uprights and floats at the proper interval. An officer attends the reel to see that the wire comes off properly and stops the reel with the brake or with the clutch or by stopping the towing tender by signal if necessary. In using the clutch it is necessary to throw in both the one-way and the double-jaw clutch. It is advisable to throw in the latter first and then the one-way at the point of stopping. The reel can not then turn without turning the engine. It should be noted that when setting out the double-jaw clutch is kept in the neutral position.

The wire cable is set to the desired depth before the uprights are attached to the wire. The upright is connected to the bottom wire and the sinker either by a special line or by device attached to the sinker. In putting over the small or large buoys care should be taken to pay out the wire cable until a strain comes on it. The buoys should not pass under the bottom wire after leaving the launch. In case there is not sufficient strain to carry out the bottom wire care should be taken to avoid putting it out too fast, as kinking, the most common cause of parting, is likely to result.

When the end of the drag is reached, the bottom wire is unshackled from the reel and shackled to the bottom staple of the big sinker, the free end of any wire that may remain on the reel being fastened to the reel. The cable section of the large upright is then unwound until the point of attachment is reached, when it is connected to a swivel and shackle in the top of the large sinker. The sinker is then lowered, using the brake to check its speed. In putting over the large buoy from a large launch a rope is permanently fastened around the top of the buoy, and this is also used by the tender to hold the buoy when making a change in the length of upright. When the upper end of the cable section is reached, it is attached to the chain part of the upright. As soon as the upper part of the towing bridle is reached it is connected to a staple in the front of the buoy. Two cedar floats are attached at the junction of the triangle, and a small buoy is attached about 6 feet from the end of the standing part. The connection between the standing part and rope towline is made by the tripping device. The drag is then ready to proceed after hoisting the anchor.

In open water, using a long drag, large areas can be covered rapidly. It is now the practice in shoal water with many projections above the average bottom to use a drag about 3000 feet in length and to set the different parts to clear the portion of the bottom which they will meet. There is a slightly greater chance for error than with a drag of uniform depth, but a season's work in Florida indicates that the results are good. The use of a long drag makes the removal of lobster pots a more difficult problem, but the majority of the lobstermen now have power hoists, and as they know the areas to be dragged well in advance of the dragging they can thin them out, so that the final clearing of the area can be readily accomplished.

CONTROL.

A long drag, 4000 feet and over, is controlled from each end. By a prearranged plan definite lines are followed and communication is not necessary unless some unforeseen contingency arises. The only observations necessary are those for the position angles and the direction of the nearest large buoy, the known length of the towline giving its distance.

Short drags, under 4000 feet, are controlled from the guiding launch, the officer in charge of the end launch taking but one angle. He signals this to the guiding launch by means of the wigwag and records it for future comparison. The method employed for locating the far end of the drag from the guiding launch involves the use of a towline base (the distance from the far large buoy to the middle of the end launch) and the measurement of two angles in the triangle having this for a base and the middle of the guiding launch for a vertex. One angle is measured from each launch, and by means of signals simultaneous observations are obtained in each boat. A special form of circular slide rule is used to compute the distances of the large buoy, the operation requiring only a few seconds. In addition to the position angles and the angles

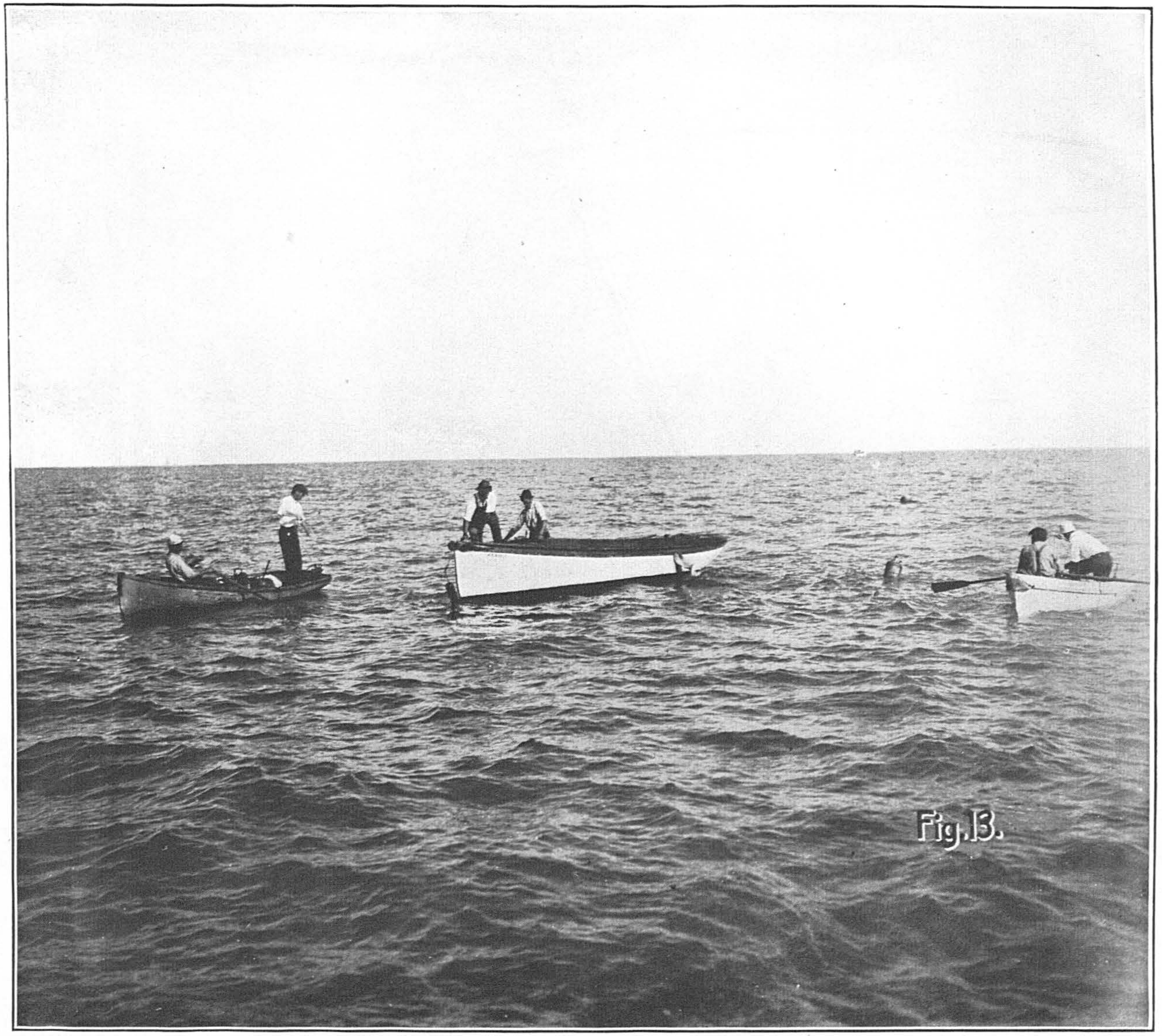


FIG. 13.—CLEARING DRAG AND SOUNDING.

above referred to, two buoy angles are taken, all in quick succession, by the two officers on the guiding launch. A special form of protractor and suitable scales, when necessary, are used to plot the positions of the ends of the drag. The whole operation seldom requires more than a minute. For the angles and the distances involved in the foregoing system of control, see Fig. 1.

Proper care must be taken to avoid taking the distance angles when the conditions are very unfavorable, as, for example, at the beginning of a line or with the end launch heading directly toward or away from the guiding launch. A short delay or the omission of the distance for one position will permit this without introducing error. A margin of safety is secured by using a length of base one-half to 1 meter shorter than its actual length as obtained by measurement, and with this precaution a position well within the required limits of error is obtained. Furthermore all doubt is removed by making the overlaps ample.

LENGTH OF TOWLINE BASE.

The towline base is the horizontal distance from the spring balance hook at the launch to the vertex of the far buoy. It is dependent on the length of rope towline from thimble to which the spring balance is attached to the juncture with metal towline, the length of the metal towline parts, and the length of upright.

With rope towline 24 feet, standing part 100 feet, triangle sides 80 feet, towline base is 61 meters for length of upright over 30 feet, 62 meters for 30 feet and under. For other combinations a graphical sketch will give the length of base, but this should be tested by actual measurements, with a proper margin of safety.

LIFT TABLE.

For length of upright 20 feet and under subtract one-half foot to get drag depth. Over 20 feet, subtract 1 foot. If estimated extreme swell is 3 feet from crest to trough, subtract an additional one-half foot. In this case do not drag in depths less than 20 feet. (This table is shown on p. 2 of each wire drag record.)

ECCENTRIC REDUCTION APPARATUS FOR SUBORDINATE LAUNCH.

In some subordinate launches it is very desirable that the officer in charge should remain at the stern all of the time, where he can send his signaled angle more readily and where he can assist in handling the towlines when it becomes necessary. When the signaled angle is observed from the stern it is necessary to apply a correction to reduce it to the launch end of the towline base. The reduction apparatus consists of two tables, about 2 feet square, the upper of which carries a sheet of drawing paper, and a wooden pointer mounted on a pipe. The pipe is mounted in a deck flange which permits its removal when not in use at a point directly forward of the reel. The upper end of the pipe is threaded, and the lower table, which is mounted on a threaded deck flange, is rigidly secured by a lock nut; the upper table also mounted on a deck flange is free to turn so that it can be set by means of a pin passing through both tables, with the zero line of the reduction sheet pointing toward the ball that marks the end of the towline base when in either position. Every time the towline is changed from one side of the launch to the other the ball must be shifted and a corresponding change made in the table. The top of the pipe has a wooden plug and a wooden pointer is attached. When the pointer is directed toward the large buoy, near the launch, the correction is read directly from the table.

The principle on which the operation is based is a graphic solution of the eccentric reduction. The solution is used in the form given in Merriman's Precise Surveying and Geodesy. (See diagram, bottom of p. 22.)

In this case d = distance from center of ball to center of reduction table, m = average drag length, n = average towline base, θ = angle at stern, ball to center of guiding launch, and $\theta+\alpha$ = angle from ball to large buoy.

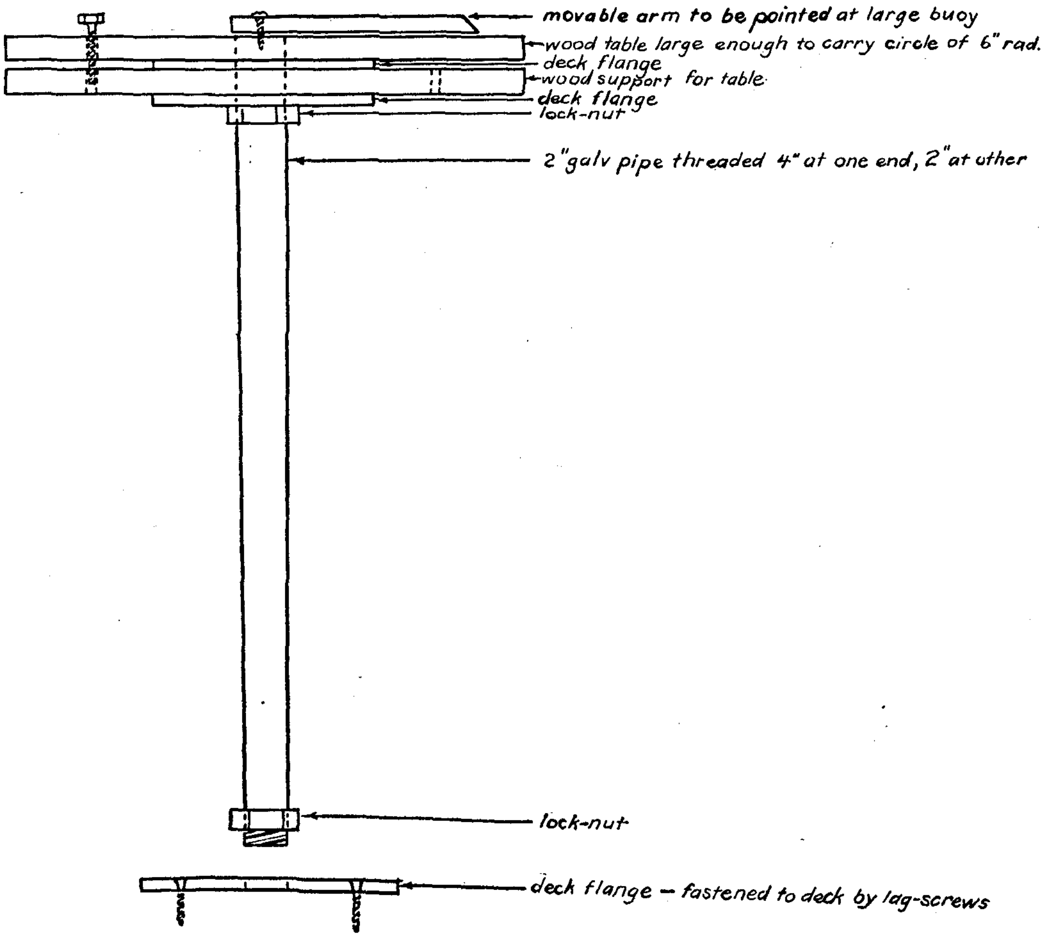
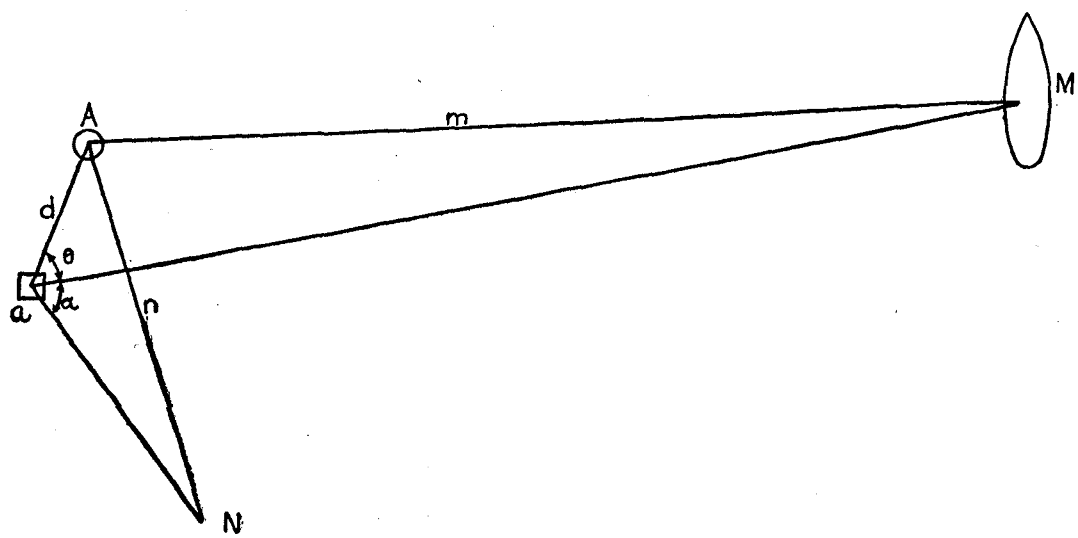


FIG. 12.—Reduction table for eccentricity.



$A = a - M + N$; $M = 57.3° \, d/m \sin \theta$; $N = 57.3° \, d/n \sin \theta + \alpha$

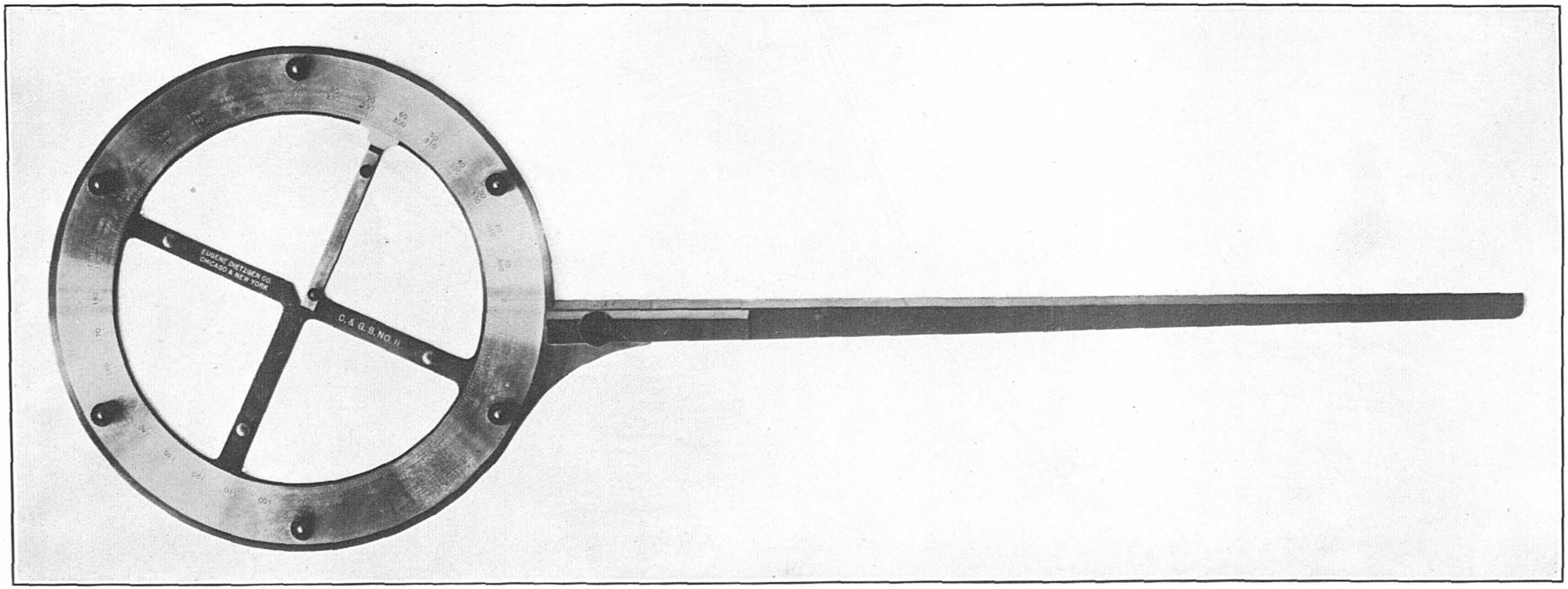


FIG. 15.—WIRE DRAG POSITION PROTRACTOR.

For $d=12$ feet, $m=2000$ feet and $\theta=90°$, the value of M is 0.3°. For $\theta=20°$ and 40° M=0.1° and 0.2°, respectively, and as nearly all the time θ is between 40° and 90°, and usually nearer 90°, the error involved in assuming a constant correction to all angles of 0.3° is within 0.1° of being correct, which corresponds to an error of 0.5 to 1.0 meter, according to conditions. If the drag length is 3000 feet, the maximum correction is 0.2°, and 0.1° should be added to all angles if the table is made for $m=2000$ feet.

N is computed for values of + at 5° intervals. In order to simplify the table the values of M+N are placed directly on the sheet by means of a protractor set to the corresponding values of + . The corrections are given to tenths of a degree. The correction M is always subtracted; N is added unless + is greater than 180°. Accordingly, whenever the launches are in such a position that the method gives accurate results, M+N is positive.

The movements of all the boats are controlled from the guiding launch by means of a signal code, either wigwag or the special code, the apparatus for which has been described. The former system has the advantage that no apparatus is required except the flags, but it has the disadvantage that a signal missed must be repeated, the flags are often difficult to see and distinguish, and they must be moved to different parts of a large guiding launch so that they can be seen best.

The special signal frame has the advantage that the large spherical balls can be readily seen; they are distinguished both by color and position; a signal remains visible till answered. On the other hand, the apparatus is large and unwieldy, it takes up the space on the launch, and it is necessary to have the canvas sides made like curtains so that they can be taken in when there is a strong breeze.

TABLE 1.

Letter	Wigwag	Sphere	Meaning [1]	Letter.	Wigwag	Sphere	Meaning [1]
A	22	14	4	N	11	124	7
B	2112	1	1	O	21	12	2
C	121	45	27	P	1212	234	16
D	222	1234	12	Q	1211	235	19
E	12	134	9	R	211	34	23
F	2221	145	11	S	212	3	22
G	2211	15	5	T	2	2	14
H	122	2345	21	U	112	5	28
I	1	13	3	V	1222	135	10
J	1122	234	18	W	1121	125	8
K	2121	123	6	X	2122	1345	13
L	221	35	24	Y	111	23	15
M	1221	4	26	Z	2222	25	17

[1] See "Order," Table 2.

Number	Wigwag	Sphere	Number	Wigwag	Sphere
1	1	1	6	21	12
2	2	2	7	111	13
3	11	3	8	222	14
4	22	4	9	122	15
5	12	5	0	221	123

TABLE 2.

[Sphere code: 1=black; 2=white; 3=red; 4=blue; 5=yellow.]

Order	Sphere	Letter	Meaning	Order	Sphere	Letter	Meaning
1	1	B	Begin line; set out drag.	17	25	Z	Call end launch tender.
2	12	O	Out 10°.	18	234	J	Annul last message.
3	13	I	In 10°.	19	235	Q	Dead line, over finished area.
4	14	A	Anchor.				
5	15	G	Drag aground; stop.	20	245		Recall tender to launch.
6	123	K	Call end launch.	21	2345	H	Call guiding launch.
7	124	N	Near buoy, large.	22	3	S	Stop.
8	125	W	Wait; stop till further signal.	23	34	R	Reverse; change to opposite course.
9	134	E	Launches change ends of drag.	24	35	L	Change letters to numbers and vice versa.
10	135	V	Stopped by engine trouble.	25	345		Recall all tenders to launches.
11	145	F	Far large buoy near end launch.	26	4	M	Call large tender.
12	1234	D	Take up drag.	27	45	C	Repeat last word of message.
13	1345	X	Remove lobster pots.				
14	2	T	Take signaled angle guiding launch.	28	5	U	I understand message received.
15	23	Y	Call tender.	29	12345		Emergency; drop work and seek shelter.
16	24	P	Drag parted.				

Combinations.

Letter	Sphere	Meaning	Letter	Sphere	Meaning
U B	5–1	Connect drag by towing broken end nearest your launch to the other broken part.	U M	5–4	Measure towline base.
			U R	5–34	When drag is parted, reverse and tow your portion of drag toward broken end so that tenders can connect.
U C	5–45	Clear drag to continue line in same direction.			
U C R	5–45–34	Clear drag to go back in opposite direction.	U S	5–3	Send least water found on shoal.
U D	5–1234	Tender disconnect drag at place arranged.	U T	5–2	Test drag depth.
U H	5–345	Underhaul drag so as to indicate point where it is caught; clear as soon as this is located.			

Special.

L followed by numbers gives course measured from north in clockwise direction to end launch or tender towing out drag while setting out.

In giving directions to tenders to change length of upright, the signals are sent as follows: 45 N–3, 40 4–F, meaning near large and near three small buoys set 45; fourth small buoy to far large buoy set 40. The tenders should repeat this, using black flag for letters and white flag for numbers.

PULL-DEPTH ADJUSTMENT AND GUIDING-LAUNCH CONTROL.

With the present arrangement of the drag, the amount of the tension on the towline is negligible in affecting the drag depth. The pull is kept constant at an amount suited to the power of the launches, usually 450 to 500 pounds. It should agree in both launches or one will proceed faster than the other, making the maneuvering more difficult and reducing the effective width of the drag. All changes in depth are made from power tenders by means of the depth-adjusting apparatus on the buoys. When the drag is set out, the length of upright is obtained by adding to the predicted tide 1 foot for the difference between the length of upright and the drag depth (proved by tests never to exceed this amount) to the depth to be verified. If the depth is great enough, allow for several hours' work without changing the length of upright. When dragging close to bottom with a rapidly changing tide, it is necessary to change the length of upright frequently in order to keep the drag depth right, so that the drag will not take bottom in depths already charted nor on the other hand get too little depth.

Experience, based on a study of the conditions, is essential, as the speed of the drag the direction and strength of the tidal current, the rate at which the tender can make the changes are all more or less variable factors and are all important. The control of the movements of the guiding and subordinant launches is an important factor, as the paths made by the ends of the drag govern the division of the drag depths between the buoys. It is not unusual to have one launch proceeding at right angles to the course of the other and the resultant of their motion and the tidal current gives progress in the desired direction. Furthermore, when the subordinate launch approaches the guiding launch or goes away from it, the progress of the drag is faster or slower, as the component of the forces in the direction of progress becomes greater or smaller. Accordingly, the operation of a drag in variable bottom with depths to correspond is a complicated matter, and the greatest care is necessary in directing all of the launches. The tenders require about 25 minutes to change all the buoys on an 8000-foot drag and about 10 minutes for a 3000-foot drag, the length of section being a factor, as the number of buoys to be changed is of more importance than the actual distance to be run. The tender must be careful to approach the buoys in the direction that they are moving and keep headed in the same direction while they are being changed, as too great strain will lift the drag too much and possibly miss a shoal during the few seconds required for the operation.

In certain conditions, as in a following sea, skill is required in picking up the buoys at the first trial, which is necessary to avoid losing time, as the buoys have a very peculiar swing at right angles to their progress under these conditions, and the motion of a launch running on a sea has a similar motion, and it is necessary to make them agree.

The large upright is changed by turning the crank either up or down after taking out the pin and lifting the ratchet. The times of beginning and ending the changes in each part of the drag are recorded and later transferred to the guiding-launch record, so that the areas affected by each can be reduced and indicated on the sheet. In planning a system of work the general directions for towing the drag should be chosen to give the longest continuous lines and the best current conditions. Under special conditions, as in regions filled with lobster pots, it is necessary to lay out a scheme of work at the beginning of the season, post a chart of it in post offices and other conspicuous places, and rigidly adhere to it. This interferes with the rapid progress of the work, as sometimes the weather conditions are such that work could be done elsewhere than in the section arranged for, but it is necessary to keep to the agreement. The actual shifting of buoys also absorbs considerable time.

No area is considered to be completely dragged until every square foot outside of the limiting curves has been dragged to some depth. If this depth is insufficient, it is often necessary to cover certain portions of the area a second time.

For regions where there is a large range of tide, as 5 feet or more, tide predictions for the standard port of reference are furnished from the Office. These are made by the tide-predicting machines and require only a slight correction in time and range for the locality of the work. If these predictions can not be furnished or the range of tide is small, values can be obtained from the tide tables, using the table of hourly differences, plotting the curves on cross-section paper. In the final reductions tide observations made in the vicinity are used as in ordinary hydrography. As the wire-drag work is kept plotted on the smooth sheet as soon as done, it is desirable to have the tide gauge in the immediate vicinity of the base of operations, unless there is some reason based on tidal relations to the contrary. It is then possible to get the record from the observer whenever office work is done and keep the reductions up to date.

In addition to the boat sheet, which shows only the signals and the shore line, a celluloid sheet to the same scale as the boat sheet is prepared, which shows all the known depths, as obtained either from the charts or from bromide copies of the original sheets. If this has to be prepared from a chart of different scales, the easiest method of doing this in the field is to transfer by polar coordinates, using two of the buoy-plotting protractors with different scales. This celluloid sheet has the great advantage that erasures can be made and the new soundings and extent of areas dragged placed on the sheet as fast as plotted on the smooth sheet and thereby it becomes a record of progress and a graphical representation of the unfinished area, which is what is required.

The drag is taken up at the close of each day's work (the greater part of it) over the bow of the guiding vessel, the vessel proceeding under her power, as fast as the drag is being reeled in. She must not overrun the wire, as there is danger of its being caught in her propeller. The speed of the reel is varied according to conditions, the high speed being used whenever the strain on the wire is not too great. If the wire is caught very hard on the bottom, it is often necessary to hold it with the brake and break it out from the bottom in a manner somewhat similar to breaking out an anchor. Sometimes the vessel has to take a complete turn around the point where it is caught before the wire comes clear. The officer directing the operation from forward sees that the floats are stopped at the proper place and directs the coxswain and the man operating the reel levers. Another officer moves the leader to the reel so that the wire is properly wound; the other officer and one of the hands dispose of the small uprights as they arrive. Another hand is kept busy removing the cedar floats and small weights. The speed of the reel is from 40 to 150 revolutions per minute, and as its average diameter is 21 inches, the speed with which the wire comes in is considerable. The operation of taking up a 5,000-foot drag requires about 25 minutes, and other lengths in proportion.

REPAIRS.

When a drag parts, the ends are towed together, the particular method depending on the tidal current, the portion of the drag where the break occurred, and often on the character of the bottom. If practicable, it is desirable to get the entire drag back of the position where the break occurred so that no area will be missed, though if there is a strong fair tide this occasions too much delay. If the drag is aground, it is usually cleared as soon as connected and the drag proceeds from this point, leaving area to be covered later. When a break occurs, either a new fitting is spliced in the broken end or the entire section is thrown out. The wire now used lasts from one to one and a half months. When worn out, it is all removed and replaced by new wire. The fittings are used over and over again until worn out. As much of the wearing out of the drag is due to the strain in taking up as in the actual dragging and removal from shoals.

MANAGEMENT ON A SHOAL.

When a shoal is struck, it is indicated in two ways; The spring balance indicates that the pull is much greater than normal and the launches come to a stop. The drag then lines up toward the launches from the shoal and its position is indicated by the intersections of the two lines of buoys. If the shoal happens to come at a small weight, the buoy may lie over. The launch discovering that the drag is aground, should immediately report it to the other and both should stop. If they are proceeding with a fair tide, they should remain where they are until the tender has cleared the drag. If they have been proceeding against the tide, the launches should anchor, as the tendency of the current is to remove the drag from the shoal unless it is securely caught. If sufficient floats are used to bring the wire to the surface when at rest, the places where they do not rise indicate where the wire is caught. As soon as the signal is given that the drag is aground the large and small tenders proceed to the point indicated, and as soon as the latter find the edge of the shoal, they put out their can buoys in such a position that the drag wire will not catch them, and the large tender proceeds at once to clear the drag, which they do by lifting the wire with a grapnel, undermining it until the shoal is reached, either rapidly in case the shoal has been located or slowly if the tenders wish to know the exact spot. Frequently the drag comes clear in the process of undermining. If caught too hard for this, the wire is made fast to the bow of the large tender and she proceeds under power to break it out from the bottom. If this can not be done, the wire is disconnected at the nearest part, the free part being first buoyed. The tender then tries to free the end that is caught, as she has a better opportunity than when the strain comes from the other launch. If still unsuccessful, a portion of the wire is cut away and the tender connects the two free ends. If the shoal is very extensive, the small tenders can hold the wire up at different places, and sometimes it is advisable to shorten the length of the uprights adjoining the shoal and lower them again after the drag is cleared. A careful record should be kept of this, as the drag depth is affected. A drag can scarcely be caught so badly that the tenders can not clear it if sufficient judgment and patience is used, though sometimes it is quicker to take up the drag. The launches should not go ahead while the clearing is being done except under direction from the guiding launch. After clearing, the wire is usually held up until the strain that comes from both launches or ranges shows that the shoal has been passed. Sometimes the drag is towed ahead of the shoal by the tender and then the wire is dropped. In the latter case only a very small area is missed, immediately surrounding the shoal. In the former case the entire length of the drag is affected and a narrow strip between the two bights is indicated on the sheets as not covered and is examined further at another time.

After the drag proceeds, the tenders sound until reasonably sure that the least depth has been found. If the drag grounds again before the sounding is finished, one of the tenders is called to the new shoal. At times all three of the tenders may be sounding on different shoals. The least water is determined by carefully sounding over it, recording the least water and the general shape and extent of the shoal. Many shoal pinnacles are very small and are found with great difficulty when the drag indicates their exact position. It should be noted that a smooth small-grained material, such as mud, sand, or gravel, will not necessarily stop the drag even if of less depth than the drag depth, but that rock or any hard obstruction will stop it instantaneously. The drag can be used to find sand ridges, however, by placing the buoys fairly close together and reducing the number of cedar floats. Even then it is necessary to sound quickly and buoy or locate the shoal at once if there is any current.

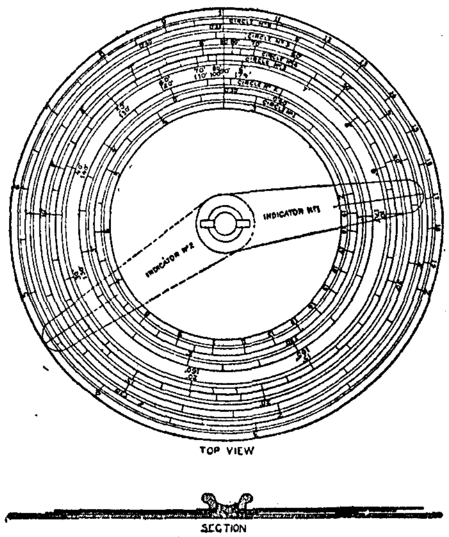


FIG. 14.—Wire drag position computer.

There is a great deal of work to be done when the weather prevents field work. The drag parts must be made in advance and the painting of uprights requires much time. The waterproofing of the floats requires several days each month. This and the miscellaneous machine and carpenter work, keeping signal systems and flags in working order, and care of the launches is sufficient to keep a party well employed.

WIRE-DRAG POSITION COMPUTER.

A circular slide rule (Fig. 14) for solving triangles was devised in 1909 by C. Y. Harger, aid, and this has since been made of more durable material then the celluloid originally used.

The slide rule consists of two circular disks, upon which are placed five concentric graduated arcs, with two indicators and a clamp nut in the center, which is so constructed that one indicator can be clamped to the upper disk, leaving the other indicator and the lower disk free to rotate around a common center. The disks are of hard rolled German silver and the center and washers of brass. All the linear measures are in meters.

Starting from a common index line the inner circle on the upper disk (circle 1) is a scale of cologarithms of numbers. As the numbers are set to increasing in a clockwise sense, the numbers representing their cologarithms must increase in the opposite direction.

The outer circle on the upper disk (circle 2) is an edge scale of logarithms of sines. The sines being set to increase clockwise, the numbers representing their logarithms increase in the same direction. Angles whose log sine has a characteristic less than 9 are omitted, as they are not required in practice. The scale of circle 2 is numbered also for the corresponding angles between 90° and 180° which have the same functions. The lower, larger disk carries three circles of graduations (circles 3, 4, 5, counting from the center outward), starting from a common index line. Circles 3 and 5 are scales of the cologarithms of sines, the two circles together forming a continuous scale from about 0° 25′ (angle whose log sine is 8.00000) to 90°, the zero end being on the outer scale to allow for more open spacing. The outer scale is divided into single minutes with every 10 minutes numbered.

Circle 4, placed between the foregoing, is graduated to correspond to the logarithms of numbers.

The method of operation is as follows: Set indicator 1 at the proper length of base on circle 1 and clamp it to the upper disk. Turn both together till the indicator is set on the distance angle given on circle 3 or 5. Press the upper and lower disks together with fingers and move lower indicator to signaled angle on circle 2. At lower index so set read distance sought.

WIRE-DRAG POSITION PROTRACTOR.

The special protractor (Fig. 15) is a form of one-armed protractor made of hard-rolled sheet brass, except the thin circle, carrying degree graduations and three linear scales of 1: 10 000, 1 : 15 000, 1 : 20 000 meters, which are of hard-rolled German silver.

The protractor consists of three concentric rings, one of which carries the bearing surface and a short arm to which an extension arm may be attached. A narrow ring turns in the one just described. This carries two cross arms at right angles to each other, which carry the center, the index arm, and the scale. The outer right is graduated to degrees, numbered to increase clockwise from 0° to 360° and counterclockwise 0° to 180°.

To plot the position of the buoy, the scale corresponding to the sheet is placed on the index arm. The index is then set to the angle to right or left of 0°, according to whether angle is + or −, and the distance marked off directly on the scale, which is set slightly back from the index line to allow for half the thickness of the pencil point.

The form of record book used is described in "Description of wire drag for 1910." No changes have been made in the record, but the method of keeping it has been improved. The use of rubber stamps for indicating changes in length of upright, etc., has added to the clearness and appearance of the records. The lettering of the stamp follows:

Time of start.	Start at buoy.	End at buoy.	Time of end.	Length of upright.
9.20	N	5	9.28	31
9.42	F	5	9.56	27

The pull is no longer recorded, as it is not a factor, improvement to the drag having eliminated its importance. The boat's head by compass is not recorded, as this is changed so frequently as to be of no value in indicating the direction of the line. A small change in one direction will, under some conditions, produce a much greater effect than a large change in the opposite direction. Under unfavorable conditions of wind and current, it may be necessary to swing back and forth through 120° to hold a line. (Each record book contains a towline base table and a lift table, on p. 2.)

In reducing the length of upright to effective depths the drag depth is obtained by applying the correction from the lift table and any additional correction for the day on account of sea or swell. This correction is entered at the beginning of the day affected, and attention is called to it on the first page of the record book.

Where there are several drag depths each is entered as it takes effect, and the several depths are entered in order from the guiding launch. Whenever one is eliminated, repeat those remaining. The same rule applies to effective depths. As a general rule entries are made at the top of each page and whenever changed.

For the guidance of the draftsmen in the field and for the final revision of the sheets, a diagram of effective depths is placed at the end of each day's work.

	N.	1.	2.	3.	4.	5.	6.	7.	8. ....F.
<1				32					
<5-7		23	——>		I.....			28	——>
<8-10				23	——>		I.....	31	

Thus the second line corresponds to a change N–3 and 4–F, the arrow indicating the direction in which the change is made. In plotting the work, the section between uprights of different lengths is considered to be of the adjacent less depth. Greater depths then extend between the extreme buoys named, less depths one section beyond, except in case of N and F.

When the drag is aground the launches are stopped at once and the distance of F can not be obtained. In its place the direction and approximate position of the point where the drag is aground are recorded, as G at 5–6, sand + 22° (aground between buoys 5 and 6). This makes it possible to draw the correct position of F, knowing the position of the shoal. It also affords a valuable check on the position of the shoal, which in some cases may be doubtful, as with distant signals it is much more difficult to observe angles from the tenders than from the launch because of the difference of elevation.

When the drag wire parts, care should be taken to reject a sufficient number of positions to eliminate uncertainty.

In order that proper credit and responsibility for entries and checking may be made, the following stamp (4) is placed at the end of each day and persons doing the work enter their initials.

STAMP.

	Entered	*Checked*
Reducers	....	....
Drag depth	....	....
Eff. depth	....	....
Distance	....	....
		Compared
Length of upright	.	....
Signaled angles	...	....

Plotted by........................

Examined by....................

While soundings may be taken from three tenders, and possibly from the launches, only one sounding record is kept for each sheet. The changes in length of upright and the soundings in order of time are copied and checked at the close of each day when en route to the harbor.

The tenders keep their records in books that are constantly getting wet, and furthermore the complications involved in keeping several records are very undesirable.

When a long drag (6000 feet or more) is operated, it is desirable to have one of the tenders take a position at the middle of the drag, whenever the drag curve overlaps previously dragged area, in order that there may be no doubt as to the overlapping.

The condition of the wire-drag work requires that the plotting of the work must be kept up to date, so that the celluloid sheet may give the information necessary for control of the drag work. The operation consists in plotting (preferably on a tracing cloth cover) the guiding-launch positions, then the N and F buoys, and these are connected both across and in the direction of the progress of the drag, using a hard pencil to make an impression on the sheet below. The outline is then penciled on the sheet, using the celluloid curve (Fig. 16) to plot the beginning and end of each strip, seeing that the drag curve passes through or back of the shoals found, which should be plotted, either immediately before or after the wire-drag work. After the drag has been cleared from a shoal, the curve should be drawn with its greatest ordinate toward the position of the shoal. As soon as the tide records become available, the effective depths are placed on the sheet, first in pencil, then examined by the chief of party, then inked.

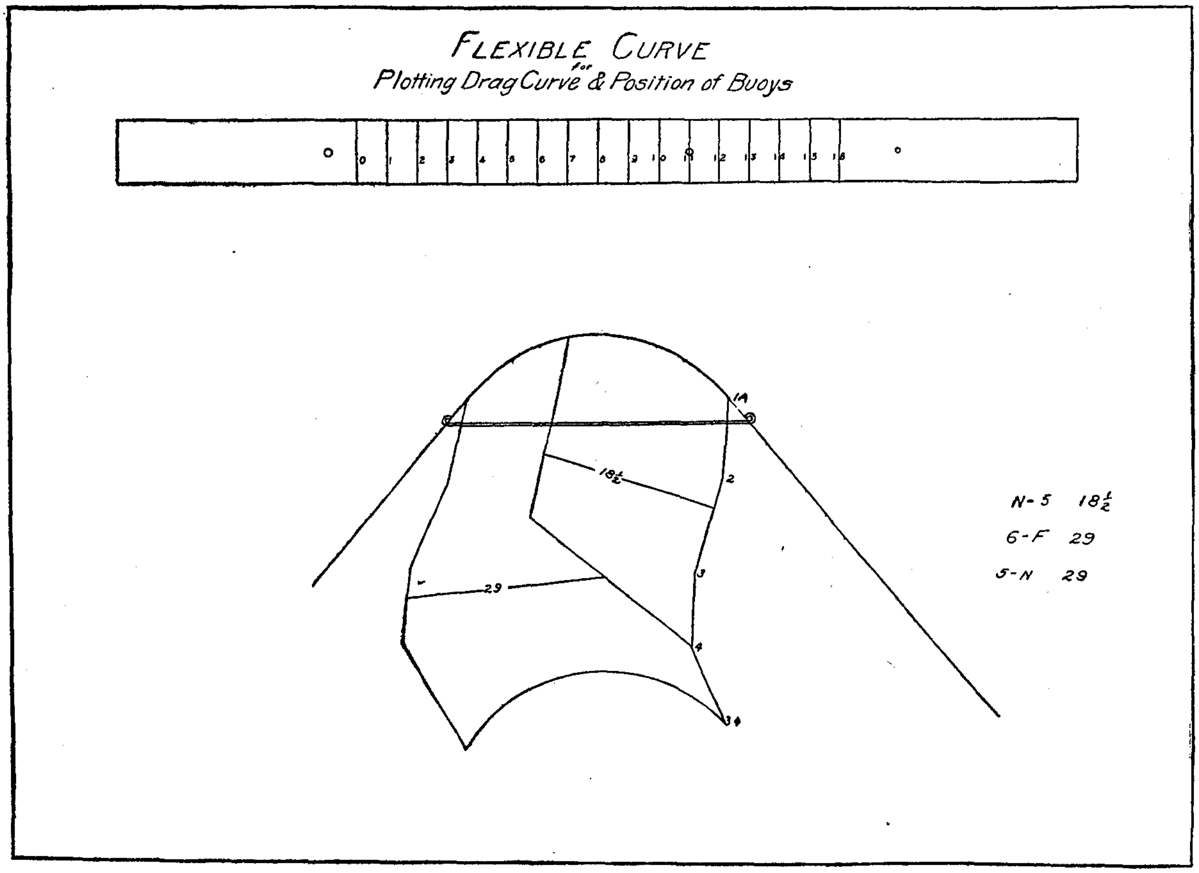


FIG. 16.—Flexible curve and method of plotting.

The method of division of the dragged strip between several depths is indicated in Fig. 16. The celluloid curve indicates the position of each buoy when the ends 0 and the number corresponding to the number of section are placed on corresponding position.

For changes due to tide the drag curve is drawn. For change in length of upright the position of the buoys of start and end are found by interpolating for the positions of N and F at the time given.

For changes affecting less than half the drag the points are connected by a straight line. If more than half of the drag is changed, it is desirable to indicate position of middle buoy and an intermediate buoy, assuming a uniform rate of change. Then connect these points by straight lines or smooth curves.

Changes accompanying complicated maneuvers of the drag may require modifications of these rules, but each individual case can be solved by careful study.

In inking the sheets the corresponding positions of N and F are indicated by short lines drawn from each toward the other. Numbers ending in digit 5 and 10 are indicated by longer lines, in a manner analogous to that used in decimal scales. The position of beginning and end of dragged strips are not so drawn, as the curves connecting them are sufficient. Each portion of area of the same depth is then surrounded by inked lines of the proper color, deeper areas being completely surrounded by the depth color and areas of less depth either by their own color or the color of the deeper area. Each area has one or more light lines extending across it, with a space for the insertion of the digit. The system of colors adopted for use on all sheets, except in revision of sheets with a different system, follows:

Orange, under 9½ feet.
Brown, 10 to 19½ feet.
Green, 20 to 29 feet.
Blue, 30 to 39 feet.
Red, 40 feet and over.

All lines and figures within an area should be of its color except number of positions of N and of soundings. These should both have the same color throughout, as "red" if one drag is used, and "blue" for the second drag; or in case of a long drag, with positions in each launch, each has a separate color.

The foregoing system of plotting is superior to and a closer approximation than any previous method. It involves the assumption that the maximum ordinate of the drag curve is at the middle, but in cross currents, or with marked differences between the courses of the launches, it may be only a quarter of the distance from one end of the drag to the other. The introduction of reserve buoyancy in the cedar floats and of the doubt as to the exact depth of the inclined section between different lengths of upright have had the effect of rendering the drag results a little more uncertain than when using a short drag of uniform depth and without reserve buoyancy. On the other hand, the possibility of covering a large area and of finding many more obstructions in a season warrant the change, but made it especially important to use care in plotting and in making an additional allowance for sea and swell whenever necessary.

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