III.—DESCRIPTION OF SOME OF THE APPARATUS USED BY THE UNITED STATES COMMISSION OF FISH AND FISHERIES IN DREDGING OFF THE NEW ENGLAND COAST.

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[Prepared by request of Professor S. F. Baird, Commissioner of Fish and Fisheries.]

Since the organization of the United States Fish Commission, in 1871, dredging has been carried on extensively by it every summer, except that of 1876, in connection with the investigation of the marine fisheries. In addition to the ordinary form of the naturalists's dredge, which has, with minor modifications, been in constant use, several other forms of apparatus, some of them novel, have been used. The "beam-trawl" and "otter-trawl" have proved very efficient in this work, wherever the character of the bottom would admit of their use. By their use fishes in large numbers are always secured, and also very large quantities of crustacea, echinoderms, sponges, &c. For use on rough and stony bottoms, an improved form of "tangles," to be used without the dredge, was devised by the writer as early as 1871, and has done good service. In order to secure those creatures which burrow so deeply beneath the mud or sand as to be beyond the reach of the common dredge, which usually merely scrapes over the surface of the mud, or penetrates it but slightly, a "rake dredge" was constructed in 1871. This has proved very useful indeed for securing certain bivalve-shells, rare holothurians, and many annelids, &c., that might not have been obtained by the ordinary dredges. Owing to the enormous quantity of material brought up, especially by the trawls and rake-dredges, it became necessary to devise new forms of sieves, by means of which large quantities of mud or sand could be washed out rapidly, and the specimens properly cared for at once, without incumbering the deck. This necessity led to the invention of the "cradle sieve" in 1872, and subsequently, in 1878, of the large "table-sieve." The latter has proved to be one of the greatest improvements yet devised, giving great satisfaction to the officers and crew of the steamer, as well as to the naturalists, for it keeps a large proportion of the mud off the deck, and wonderfully facilitates the work of assorting and preserving a large haul of specimens.

Some other pieces of apparatus will also be mentioned below.

THE DREDGE.

Figure 1.

The common dredges used by the Fish Commission are mostly of two sizes. The larger size is the one ordinarily used on the steamer; the

smaller one is intended for use with a sail-boat, especially if it has to be hauled in by hand. They differ only in size. An intermediate size has also been used to some extent. The rectangular frame has the side-pieces considerably flaring and moderately sharp. The net is of the stoutest twine procurable, with ¼ inch meshes, except toward the end, where the meshes are smaller. In many cases we have used the cylindrical form of net, the open lower end to be tied up when used. We have found the latter form most convenient for the large dredge. The net is protected by a bag of stout canvas, open at bottom, surrounding the net and extending somewhat beyond it. Whenever it has been found necessary to use any means to prevent the net from turning or twisting, a stout wooden stick lashed across the end of the net and canvas bag has proved sufficient. For weights, both for dredges and trawls, we have recently used a set made in 1877, of cast iron, each weighing about 40 pounds. They have the form of a cylinder flattened on one side and at each end, and with a hole in each end for lashings. The number needed will depend upon the strength of tide, drift of vessel, depth, &c., to be ascertained only by practice.

The following are the dimensions of the dredges now in use:

	Larger size.	Smaller size.
	Inches.	*Inches.*
Length of frame, outside	24	18.5
Breadth of frame, across front	8.75	8
Breadth of frame, across back	7.50	7
Length of arms	18	15
Diameter of arms	0.75	0.50
Diameter of end pieces of frame	0.75	0.60
Thickness of side pieces, at back	0.50	0.50
Width of side pieces	2.50	2
Size of holes for fastening net	0.36	0.36
Depth of net	36	27

The dredges and other iron instruments are painted with asphalt black, or, still better, coated ("galvanized") with zinc, to prevent rusting. One arm of the dredge is attached to the drag-rope (*d*) by a smaller rope (*e*), to diminish the danger of losing the dredge on rocky bottoms.

THE BEAM-TRAWL.

Figure 2.

The beam-trawls used by the Fish Commission have varied in size and somewhat in construction. Some have been made with a wooden beam, others have had a piece of large iron gas-pipe for a beam. The sizes most used have the beam 11, 15, and 18 feet in length, respectively. The wooden beam appears to be preferable to iron, and may be of ash or any other strong wood. The principal improvements made upon the original English pattern by us consist in making the runners considerably wider and higher, so as to admit larger specimens under the beam, and and in making the "pockets" by putting in a separate piece of netting, instead of fastening the upper and lower sides together directly.

The largest size used by the Commission has the runners about 27 inches high, made of flat iron, about 3½ inches broad and ¾ of an inch thick; the beam is of hard wood, 18 feet long and about 6 inches in diameter; the net about 45 feet long. The net should be of very strong twine, the meshes about 2½ inches in the upper part, but not more than 1 inch toward the end. It is open at the lower end, and must be tied up securely when used.

The rope for the "bridle" is about 4 inches in circumference. Those of smaller size have had the runners of relatively narrower and thinner iron, but it appears to be better to give increased weight to the runners, so that less weight will be required on the drag-rope. Moreover, the increased weight of the runners has a tendency to prevent the trawl from overturning in going down, an accident that occasionally happens where the currents are strong, or when the drag-rope is new and inclined to twist. The unusual breadth of the "shoe" of the runners is of advantage in preventing the runners from sinking too deeply into the mud. The leaded bottom line should recede in the middle 8 to 10 feet.

THE OTTER-TRAWL.

Figures 3, 4, 5.

The otter-trawls first used by the Fish Commission were imported from England, but those now in use were made in this country,* to order, after the English pattern.

The side pieces (*a*, *a*, Fig. 3) consist of pieces of thick hard-wood plank, bound all around with flat bar-iron, ½ inch thick. The rings (*d*, *e*, Fig. 4) to which the bridle-ropes are attached are of ¾-inch iron, and should be attached to the wooden side-pieces by strong ropes, arranged as shown in Fig. 4. The bridle-rope is 4 inches in circumference. The dimensions of the otter-trawl now in use are as follows:

Length of wooden side-pieces	35 inches.
Breadth of wooden side-pieces	24 "
Thickness of wooden side-pieces	2.5 "
Thickness of iron runners	0.5 "
Width of iron runners	2.5 "
Diameter of rings for bridle, inside	2.5 "
Length of ropes (*i*, *i*, Fig. 4)	12 "
Length of ropes (*o*, *o*, Fig. 4)	9 "
Length of ropes (*b*, *d*, Fig. 4)	24 "
Length of net	40 feet.
Breadth of net at mouth, when extended	30 "
Breadth of side-pieces of net	2½ "
Length of bridle-ropes, each half	84 "

The leaded rope (*d*, *d*, Fig. 3) should be longer than the upper rope (*c*, *c*), so as to recede considerably behind the latter when in use. The figure

* By the American Net and Twine Company, Boston, Mass.

is faulty in this respect. The rope (*c*, *c*) forming the upper side of the aperture of the net is provided with cork buoys, in order to keep the mouth of the net distended. The drag-rope is connected with the bridle by means of a stout swivel (*a*, Fig. 5) so as to allow the rope to twist without overturning the trawl.

THE RAKE-DREDGE.

Figure 6.

This instrument was devised in 1871 by the writer* for the special purpose of obtaining deep-burrowing species of bivalves, annelids, holothurians, crustacea, &c. It can be used only on muddy or sandy bottoms, and, of course, requires considerable force to draw it through compact mud or sand. In its original form, which is still in use, it consists of a strong A-shaped frame, made of flat bar-iron, and so bolted together that it can be folded up compactly when not in use, or for convenience in transportation. The rakes consist of two flat bars of iron, furnished with strong iron teeth (steel would, perhaps, be better) about a foot in length, with thin sharp edges and sharp point. The two rake-bars, when in use, are placed back to back and bolted to the ends of the side-pieces of the A-shaped frame. The cross-bar of the A projects beyond the side-pieces, and has a hole at each end, by which the arms of the dredge-frame are attached, so that the dredge follows the rake at a distance of about two feet. The net-frame for this instrument is made entirely of round iron, and as light as is consistent with the stiffness necessary to support the bagful of mud when being hoisted on deck. The length of the frame should be equal to or somewhat exceed that of the rake-bars. In the one now used by the Commission it was originally considerably larger, but owing to the too great weight of the load of mud it brought up it has been made smaller, so that it is now of about the same length as the rake-bars.

The net is similar to that of the common dredge, but deeper and with somewhat larger meshes, in order that a part of the mud may pass through more rapidly. The vast numbers of annelid tubes, often encountered in using the rake-dredge, frequently clog the net so as to prevent even the fine mud from passing through the meshes. As this form of dredge can only be used on smooth bottoms there is not so much need of a canvas protection as in the case of the common dredge, and we have often dispensed with it, but the net will doubtless last longer if protected with the canvas bag.

* Descriptions and figures (from drawings of Mr. J. H. Emerton, furnished by the Fish Commission) of the "rake-dredge," "wheel-tangles," "cradle-sieve," and other apparatus used by the Fish Commission were published in 1873, in the New York Tribune, by Mr. William C. Wyckoff. These were republished the same year in the Tribune Extra, No. 10, scientific series. They have also been described in several other articles. The writer also published a description of the rake-dredge, &c., in an article on "Deep-sea Dredging" in Johnson's Cyclopedia, Vol. I, 1875.

The dimensions of the rake-dredges of this pattern, used by the Fish Commission, are as follows:

	Inches.
Side-pieces of the A-shaped frame, length	30
Side-pieces of the A-shaped frame, width	2
Side-pieces of the A-shaped frame, thickness	$\frac{7}{8}$
Side-pieces of the A-shaped frame, hole for ring	$\frac{3}{4}$
Side-pieces of the A-shaped frame, hole for bolts	$\frac{5}{8}$
Cross-bar of the A-shaped frame, length	42
Cross-bar of the A-shaped frame, width	$2\frac{1}{2}$
Cross-bar of the A-shaped frame, thickness	$\frac{3}{8}$
Rake-bars (*d*), length	36
Rake-bars (*d*), width	$2\frac{1}{2}$
Rake-bars (*d*), thickness	$\frac{3}{8}$
Teeth of rake, length	8
Teeth of rake, width	$1\frac{1}{4}$
Teeth of rake, thickness	$\frac{3}{8}$
Ring for drag-rope, diameter	$3\frac{1}{2}$
Ring for drag-rope, size of iron	$\frac{5}{8}$
Dredge-frame (*a*), length	38
Dredge-frame, breadth	7
Dredge-frame, length of arms	20
Dredge-frame, size of iron (round)	$\frac{5}{8}$
Depth of net (*b*)	48

These dimensions might be improved by making the teeth 10 inches long and at least one-half of an inch thick, if of soft iron, and they should have a forward curvature. The head, passing through the bar, should be square and about three-quarters of an inch thick. They might be fewer and farther apart without detriment, say, five teeth on a bar 3 feet long, leaving the spaces about 6 inches each. The use of steel, of low temper, would be better still. The round iron for the dredge-frame should be at least five-eighths of an inch in diameter for the size of net given.

During the present season another form of rake-dredge has been devised by Capt. H. C. Chester, of our party, and used with excellent success. In this the teeth are attached directly to the two sides of a strong and heavy rectangular iron frame, much like the frame of an ordinary dredge of large size. The teeth are curved well forward and about 10 inches long. The rake-frame is followed by a lighter net-frame, of the same size as in the one previously described.

THE TANGLES.

Figure 7.

The original form of tangles, constructed by the writer for the United States Fish Commission, in 1871, consisted of a bar of iron to which several small iron chains were attached, each about 14 feet in length.

Along these chains, at intervals of about three feet, the bundles of unraveled hemp rope were attached, as shown in the figure. The bar of iron carrying the chains was attached to the cross-bar of the A-shaped frame forming part of the rake-dredge, the rake-bars being removed. In 1873 a farther improvement was made by the writer. This consisted in supporting each end of the chain-bar in the center of a stout iron hoop or wheel, by bolting it to a central cross-bar, firmly bolted to the inner side of the wheel. The wheels are not intended to revolve, but merely to serve as runners and supports for the iron bar, in order to keep it off the bottom and diminish the chances of its getting caught among the rocks, as well as to keep it from breaking and destroying the specimens before the tangles themselves can touch them. An oval or elliptical form for these runners would answer the same purpose, but the circular form was adopted as the simplest, and perhaps the least liable to become caught among the rocks.

In practice we have found the tangle-frame hitherto used too light for use on the larger vessel now employed, for when rocks are encountered the chain-bar often comes up badly bent. In constructing new ones, I should recommend a round or square bar of iron at least twice as heavy as the one we have hitherto used. Our present size was first devised for use on a steam-launch. It was also used on the Blue Light, a tug of 80 tons, with good success. The chains proved to be unnecessarily long, and are now shortened. We have used tangles of this form with profit on the roughest cod-fishing ledges off the coast of Maine and Massachusetts, where the dredge could not be used with safety.

It is particularly useful in capturing star-fishes and sea-urchins, which frequent rocky bottoms. Several years ago the writer suggested the use of tangles of this or some similar form to capture star-fishes on oyster-beds, where they so often prove very destructive.

Dimensions of tangles.

	Present form.	Improved design.
Diameter of wheels outside	12 inches	14 inches.
Breadth of rim of wheels	2 inches	2½ inches.
Thickness of rim of wheels	½ inch	½ inch.
Width of cross-bar of wheels	2 inches	2½ inches.
Thickness of cross-bar of wheels	⅝ inch	¾ inch.
Length of chain-bar	48 inches	60 inches.
Width of chain-bar	2 inches	2½ inches.
Thickness of chain-bar	½ inch	1 inch.
Size of rings for drag-rope	3 inches	4 inches.
Size of iron of rings	⅝ inch	⅝ inch.
Size of iron of chains	½ inch	⅝ inch.
Length of iron chains	10 feet	10 feet.
Length of hemp tangles	2.5 feet	3 feet.

The drag rope for the tangles should be very strong, to resist the frequent and sudden strains, when using them on rough bottoms.

TOWING-NETS.

Figure 8.

The rings of the towing-nets generally used by the Fish Commission are made of ¼-inch brass wire, with three loops of brass wire securely soldered to the ring, at equal intervals. Other modes of attaching the lines are equally good, and often used by us. The nets are usually made of rather open and strong "embroidery canvas." Sometimes, for special purposes, coarse Swiss muslin is used, when they are to be drawn by a row-boat. "Crinoline" is also suitable for these nets. The nets should be made deep and rather "full." We have not found any special advantage in attaching a bottle with its neck in the bottom of the net, as recommended by some writers. We have used several sizes of rings, varying from 8 to 14 inches in diameter. The smallest sizes can alone be used when a steamer or vessel has much headway.

THE CHECK-STOP.

Figure 9.

This arrangement was devised by Capt. L. A. Beardslee, for use on the "Blue Light," in 1873. Its purpose is to put the strain of the drag-rope (B) upon a weaker rope (C), which may be broken so easily, in case the dredge or trawl catches upon rocks, as not to cause damage to the apparatus, and at the same time to give sufficient warning to allow the slack of the drag-rope to be paid out before the headway of the vessel can be stopped. It has proved to be a very useful and simple expedient for these purposes. The figure shows the arrangement so well that no further description is necessary.

THE CRADLE-SIEVE.

Figures 10, 11.

This form of sieve was devised by the writer in 1872. It was so constructed as to afford the means of rapidly washing out the large quantities of mud often brought up by the dredge and rake-dredge, and at the same time to keep the mud and water off the deck as much as possible. It consists of two wooden end-pieces, in shape forming rather more than half a circle, united by two narrow, wooden, side-pieces set into the end pieces so as to leave a flush surface. The outside covering consists of two thicknesses of wire netting; the inner one with meshes of $\frac{1}{12}$ inch or less, the outer one of stout galvanized-iron wire, with ½-inch meshes. The outer netting is only to afford support and protection to the inner one. The outer netting is nailed to the edges of the wooden end-pieces, and to the side-pieces, and is farther secured by a strip of hoop-iron nailed over the edges all around. The inner lining of fine wire netting is tacked to the wooden ends and side-pieces, on the inside, so that it can easily be renewed when worn out. A strip of wood

nailed across the bottom, from end to end, affords additional strength and protection from injury. Two stout iron straps fastened across each end-piece by strong screws, and terminating above the edge in rings, furnish the means of suspending this sieve against the side of the vessel, outside the rail. The mud is then placed in it, often filling it more than half full, and a gentle stream of water from the force-pump is turned upon it. In this way several bushels of mud may be washed out in a few minutes, with little trouble. Another sieve, with straight wooden sides about 6 or 8 inches high, just large enough to set partially into the frame of the cradle-sieve and rest upon wooden cleats provided for that purpose, has been sometimes used by us in connection with the cradle-sieve. Its bottom is made of strong, galvanized-wire netting, with meshes of ½ inch. It serves to separate the coarser specimens and stones from the smaller and more delicate species.

In our own work the table-sieve, described below, has, to a considerable extent, superseded the cradle-sieve. The latter is still used, however, when there is only a moderate quantity of mud, or when the table-sieve is already full of unassorted specimens.

Dimensions of cradle-sieve.

	Inches.
Length	36
Breadth	18
Depth	12
Width of side pieces	4
Thickness of side pieces and ends	1

During the past season a much larger cradle-sieve has been constructed, with an intermediate frame, covered with wire netting with ¼-inch meshes. The upper sieve has flaring sides, 1 foot wide, but the ends are upright.

THE TABLE-SIEVE.

Figures 12, 13.

This piece of apparatus is the result of several successive improvements. In fundamental principle, it is like the cradle-sieve, much enlarged and raised on legs; but the form is entirely different. The sieve foundation consists of a large, rectangular, wooden frame (C, Fig. 12), with wide side-pieces (made of inch boards) supported on stout legs, at a convenient height. The bottom of this frame consists of stout, galvanized-wire netting, with ½ or ¾ inch meshes. Below this is a funnel-shaped, stout, canvas bag (S), which terminates in a large canvas tube (*t*). This serves to conduct the waste water to the scuppers. A light frame of wood (B) is made to fit loosely inside of the main frame, and its under surface is covered with fine wire netting of ¼-inch meshes. This constitutes the real bottom of the sieve, the coarse netting below serving only as a support for it. It is fastened to a movable frame, so that it

can be taken out and its contents emptied upon the assorting table. This also allows the wire netting to be more easily renewed when it becomes worn. The upper or coarse sieve (A) is made with wide, flaring or hopper-shaped, wooden sides, upon which, at about the middle, there are cleats (*c*, *c*) that rest upon the edges of the main frame. The bottom of the "hopper" is formed of strong galvanized-wire netting, of ¾-inch meshes (Fig. 13, *b*, *b*).

Dimensions of table-sieve.

	Inches.
Main frame, height to upper edge	30
Main frame, length	66
Main frame, breadth	38
Main frame, width of side pieces	11
Main frame, thickness of side pieces	1
Hopper frame, width of side-pieces	13
Hopper frame, length at bottom	56
Hopper frame, length at top	66
Hopper frame, breadth at bottom	27
Hopper frame, breadth at top	37

This form of sieve, in its primary form, was invented by Capt. H. C. Chester and the writer, in 1877, but it was soon afterwards much improved by the addition of the canvas bag and pipe beneath it, which were devised by Mr. J. A. Smith, the executive officer of the Speedwell.

The original use of this sieve was to receive the contents of the trawl, instead of emptying it on deck, as had been done previously, but its advantages were soon found to be so great that it has also been used for washing the contents of the dredges whenever the quantity of mud was considerable. The legs are made of unequal lengths to correspond with the curvature of the deck.

EXPLANATION OF THE FIGURES.

[All the figures are from drawings by Mr. J. H. Emerton.]

FIG. 1.—The common dredge: *a*, *a*, the iron frame; *b*, *b*, outline of the net; *c*, *c*, the canvas bag; *d*, the drag-rope; *e*, light rope for the attachment of one arm.

FIG. 2.—The beam-trawl: *a*, *a*, the beam to which the upper edge of the net is attached; *b*, *b*, the runners supporting the ends of the beam; *c*, *c*, the leaded line attached to lower edge of net; *d*, the net; *e*, *e*, "pockets" in the net to prevent the escape of fish.

FIG. 3.—The otter-trawl, showing the mouth of net and side pieces arranged for use: *a*, *a*, the wooden side-pieces attached to bridle-ropes *b*, *b*, by means of four-short ropes *i*, *i* and *o*, *o*, of which the pair marked *o*, *o* are the shorter; *d*, *d*, the leaded bottom line; *c*, *c*, the top line of the dredge-mouth, with cork buoys (this should have been drawn shorter and less curved backward than the bottom line).

FIG. 4.—Wooden side-piece of the otter-trawl to show the arrangement of the ropes: *d*, *e*, rings for the attachment of the bridle; *c*, ring for the attachment of

the cork-line of the net; *b*, ring for the attachment of the leaded line; *a*, *a*, lower edge of the side-piece.

FIG. 5.—End of drag-rope (*d*) attached to bridle (*b*) of the otter-trawl by means of the swivel (*a*).

FIG. 6.—The rake-dredge: *a*, *a*, the dredge-frame; *b*, *b*, outline of net; *c*, *c*, canvas-bag to protect the net; *d*, the rake-bars.

FIG. 7.—The wheel-tangles: *a*, the iron cross bar; *b*, *b*, the circular runners, or wheels, supporting the cross-bar; *c*, *c*, *c*, the chains to which the hempen tangles are attached.

FIG. 8.—The towing-net, in use.

FIG. 9.—The check-stop: A, A, the davit; B, the drag-rope; C, the check-stop applied to the drag-rope; D, D, side of vessel.

FIG. 10.—The cradle-sieve, suspended outside the rail, as when in use.

FIG. 11.—The cradle-sieve, end view.

FIG. 12.—The table-sieve: A, the "hopper" removed; *c*, *c*, one of the cleats on which it rests; B, the inner frame carrying the fine sieve; C, the main frame; *s*, the canvas-bag, beneath; *t*, the canvas waste-pipe.

FIG. 13.—Section of table-sieve; *a*, *a*, the hopper in position; *b*, *b*, the coarse sieve at bottom of hopper; *c*, *c*, the sides of main frame; *d*, *d*, the fine sieve; *e*, *e*, coarse wire netting on main frame; *s*, *s*, canvas bag; *t*, *t*, waste-pipe; *l*, *l*, legs of sieve.

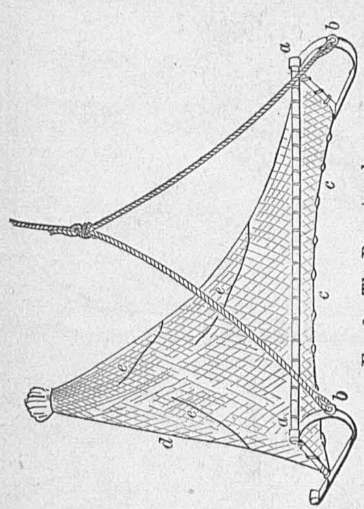

FIG. 2.—The Beam-trawl.

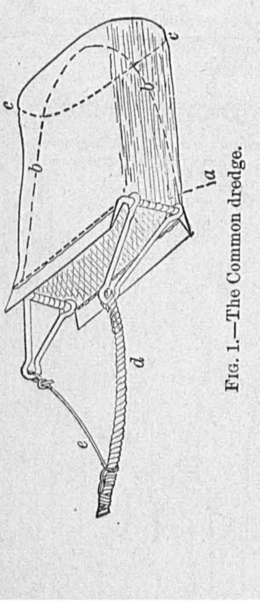

FIG. 1.—The Common dredge.

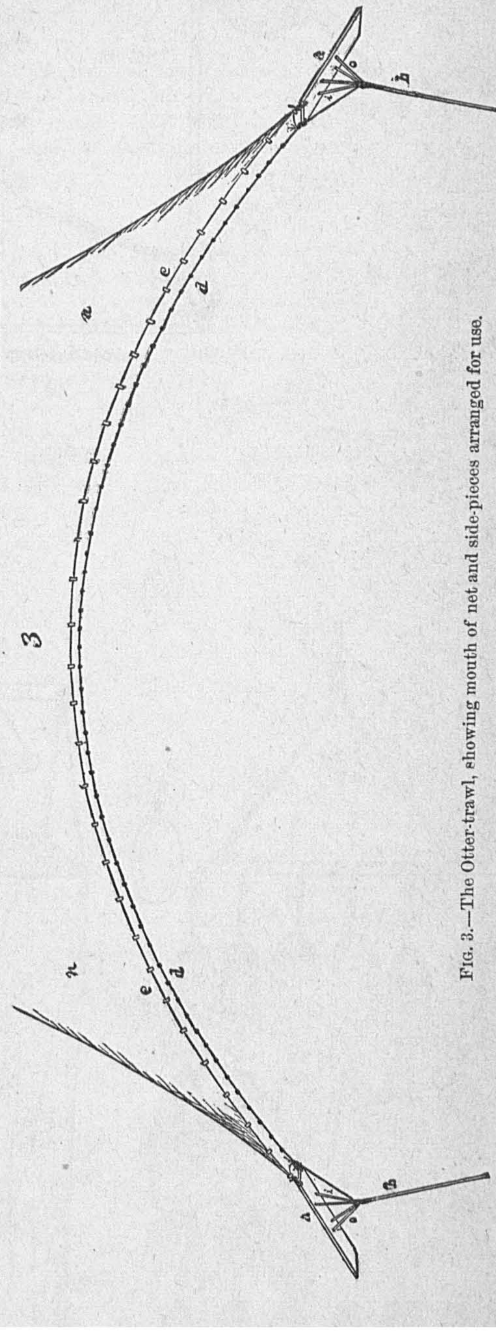

FIG. 3.—The Otter-trawl, showing mouth of net and side-pieces arranged for use.

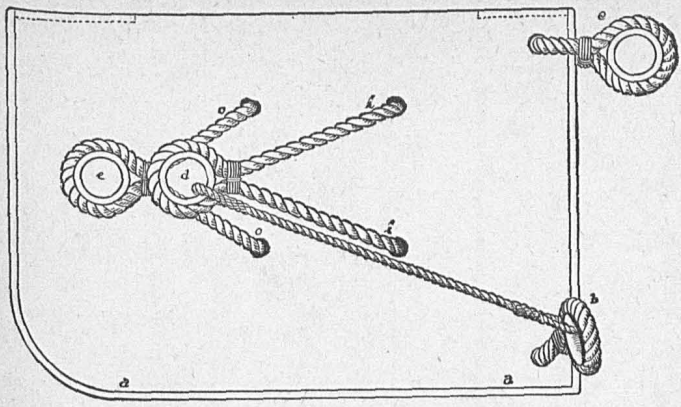

FIG. 4.—Wooden Side-piece of the otter-trawl.

FIG. 5.—End of drag-rope.

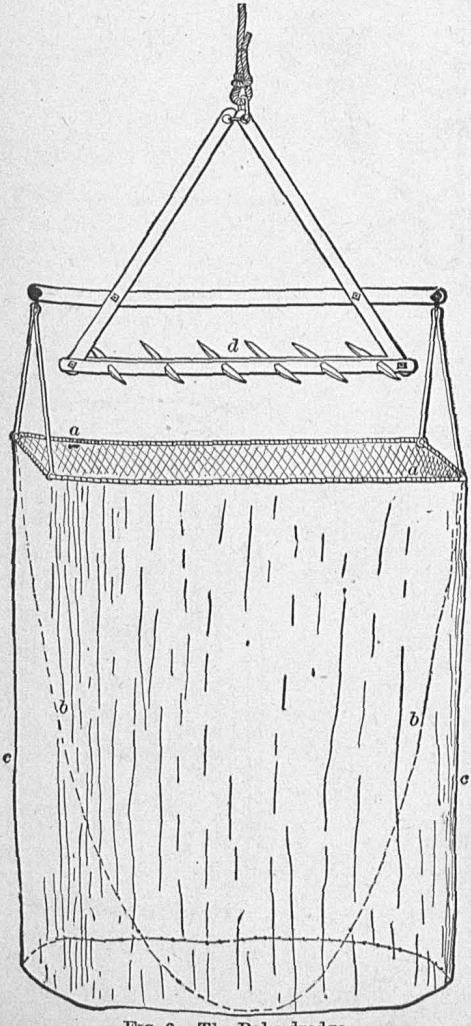

FIG. 6.—The Rake-dredge.

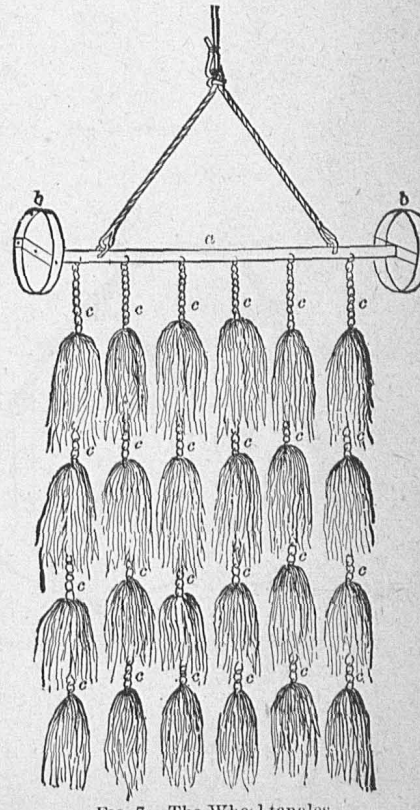

FIG. 7.—The Wheel-tangles.

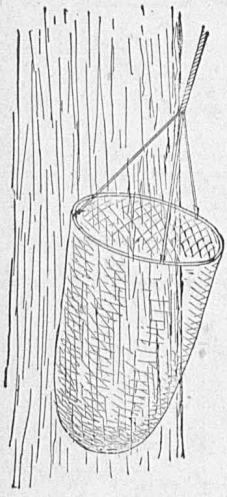

FIG. 8.—The Towing-net in use.

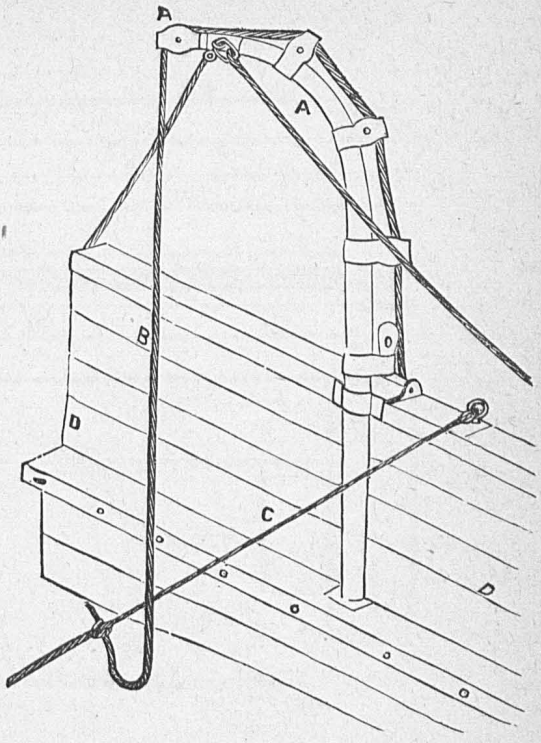

FIG. 9.—The Check-stop.

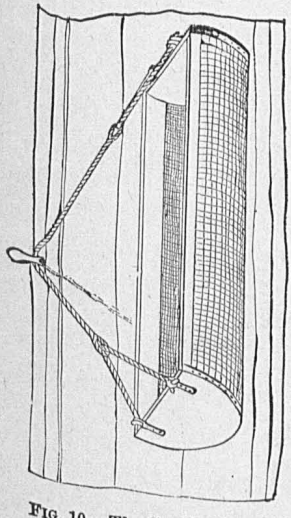

FIG. 10.—The Cradle-sieve.

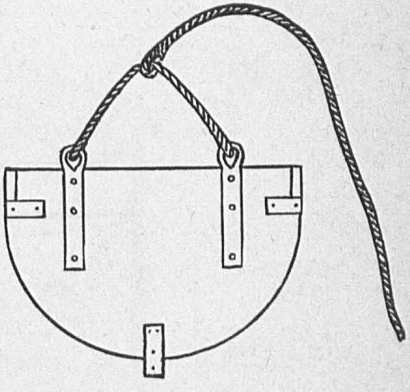

FIG. 11.—The Cradle-sieve, end view.

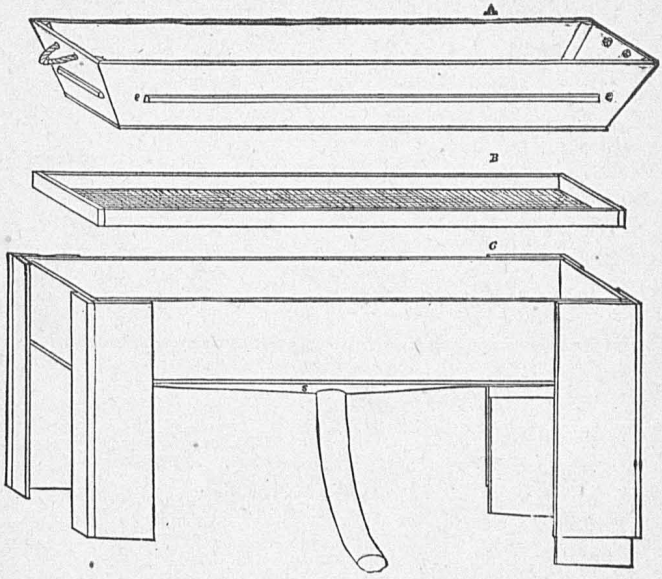

FIG. 12.—The Table-sieve with hopper removed.

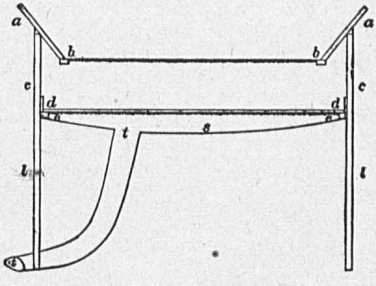

FIG. 13.—The Table-sieve, sectional view.