

### 3.—DESCRIPTION OF A CLOSING TOW-NET, FOR SUBMARINE USE AT ALL DEPTHS.

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Recent experiments with closing tow-nets in submarine explorations have yielded so much accurate information concerning the vertical range of pelagic life that the construction of the Tanner intermediate tow-net in 1891<sup>1</sup> may be said to have inaugurated a new era in the study of the pelagic fauna, characterized by exact knowledge of the depth of the forms collected.

The vertical distribution of the pelagic life gathered with the open tow-nets of the *Challenger* expedition has necessarily been conjectural, the nets employed having been dragged open at all depths. Since then European investigators have employed several devices for closing submarine tow-nets, but direct evidence as to their reliability, so far as the writer is aware, seems to be lacking.

Open tow-nets of different forms have long been employed by the United States Fish Commission, while a closing collector, although of very limited capacity (the Sigsbee gravitating trap), has done service on the Coast Survey steamer *Blake*; but it was not until 1891 that a closing tow-net of large size was brought into use. The Tanner tow-net, closing tightly at any depth desired, has proved its efficiency during recent explorations conducted by the Fish Commission and by Mr. Alexander Agassiz, but its large size and somewhat complicated construction have prevented its use except by steam power from large vessels.

While towing a light surface-net behind one of the small boats of the *Albatross* in an Alaskan harbor in the summer of 1894, the idea of a very simple closing-net presented itself, which was at once experimented upon and gave satisfactory results. I at first used it in moderate depths only, but subsequently, having made one of heavier form than at first employed, the principle was found applicable to deep-sea work as well as near the surface.

<sup>1</sup>Tanner, Rept. U. S. Fish Com. 1889-91, pp. 259-260. Bull. U. S. Fish Com. 1894, pp. 143-151.

This form of towing-net is, on account of its lightness and simplicity, convenient for use by hand from all kinds of small sailing craft and open boats. It can be rolled into a small package with all its attachments and carried readily in one hand. With a light tow-line passed through a pulley slung from one of the boat davits of the Fish Commission steamer *Albatross*, it has been hauled in from depths of 20 and 30 fathoms by one man with very little exertion, and has not failed to work in a single instance.

In the summer of 1895 this net, constructed in larger and heavier form, with a net ring 3 feet in diameter, was used successfully on board the *Albatross* during fishery investigations in Bering Sea, at depths varying from 20 to 200 fathoms.

Following is a description of a closing-net of medium size constructed for use on the Fish Commission schooner *Grampus* (pl. 9, figs. 1 and 2): It consists of a tow-net with a folding-ring suspended by rope slings from a tripping-arm attached to the tow-line, and is operated at will by a messenger. The ring to which the net is attached is hinged to fold, for the purpose of closing the net, and is supported by two sets of slings of nearly equal length, one set attached near the hinges, supporting the net in an open position, the other attached at right angles to the hinges, supporting it in a closed position.

Closing is effected by means of a tripping-arm, from which the slings are suspended, and which, being tripped by a messenger, shifts the weight from the opening to the closing slings with the result of closing the net. The tow-line is attached to the lower end of the tripping-arm, the upper end of which is hooked to a ring on the tow-line. The opening slings are secured near the upper end of the arm, the closing slings to the lower end. A light messenger (pl. 9, fig. 3) sliding down the tow-line detaches the messenger-ring from the upper hook of the tripping-arm, shifting the weight from the opening to the closing slings. A spring catch in the upper hook of the tripping-arm keeps the messenger-ring from slipping out of place until struck by the messenger, while a heavy ring-shaped weight, released by the tripping of the arm, slips from the lower hook of the arm down the closing slings and keeps the jaws from opening after they have been closed by the messenger. The accompanying figures, showing the net in both open and closed positions, illustrate its workings clearly.

The tripping arm is merely a piece of half-inch brass, ordinarily about 2 feet in length and of the shape shown in the cut. The ring is 2 feet in diameter, made of  $\frac{3}{4}$  by  $\frac{1}{4}$  inch brass, and is essentially the same as that employed by Agassiz for use with his modified Chun-Petersen machine.<sup>1</sup> The messenger is a 2-pound bronze casting, in two parts, to lash around the towline. A small lead sinker is lashed to the bottom of the net, of sufficient weight to carry it down clear of the ring, as it is, of course, lowered vertically and the vessel from which it is operated

<sup>1</sup>Agassiz, Bull. Mus. Comp. Zool. 1892-93, vol. xxiii, p. 45, etc.

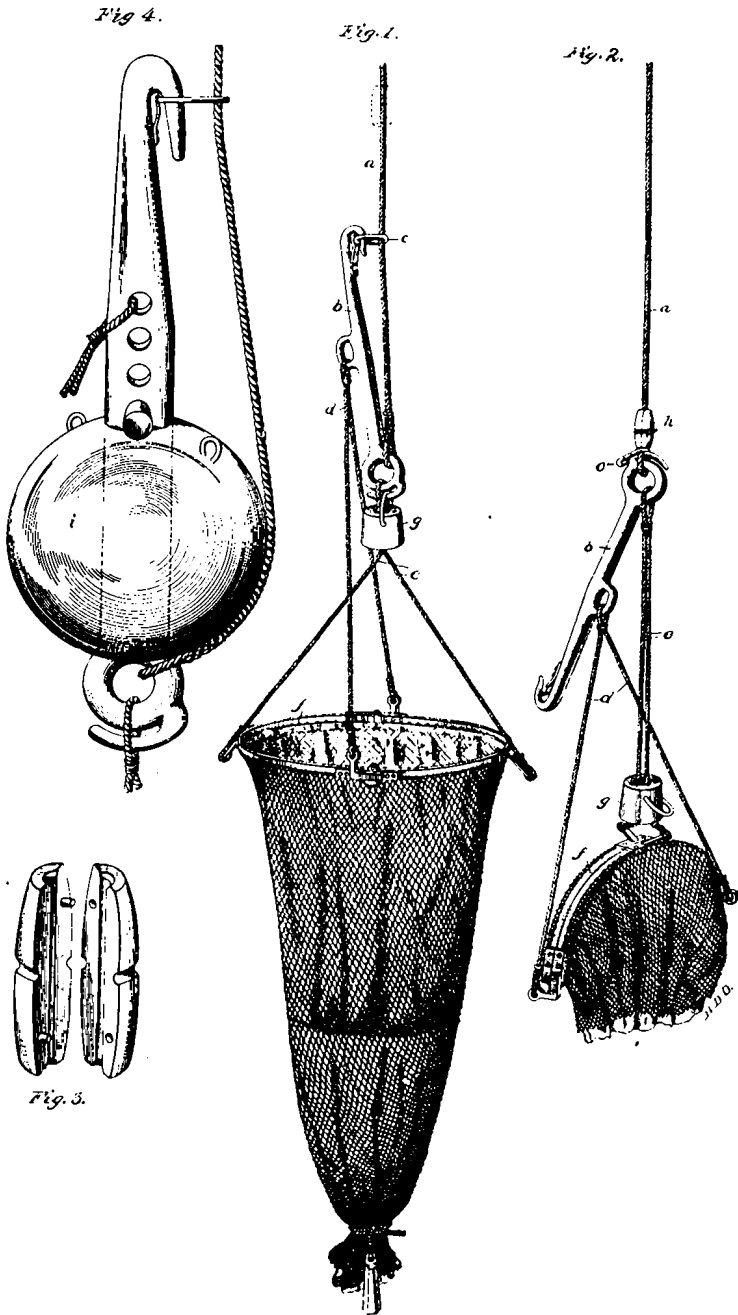


FIG. 1. Showing net in position for lowering and towing.  
*a.* Tow line.  
*b.* Tripping arm.  
*c.* Tripping ring.  
*d.* Opening slings.  
*e.* Closing slings.  
*f.* Folding net ring.  
*g.* Closing weight.  
*h.* Closing messenger. (See also Fig. 3.)

FIG. 2. Showing net closed for heaving in.  
 FIG. 3. Closing messenger.  
 FIG. 4. Showing heavy tripping arm used on steamer Albatross, with 60-pound sounding shot attached as sinker for proper strain on wire tow line in deep-sea work.  
*i.* Common sounding shot - 60 pounds.

brought to a full stop. The net is light and of small mesh, preferably half inch. It is lined with bobbinet or mosquito netting, with a delicate inner lining of silk bolting-cloth, the last being the real collector, to which the outer nets act as supports.

In this combination of three nets all are of full width to the bottom, where they are closed by a lashing, the inner nets being secured rather slack, in order to avoid strain upon them in towing. As used on board the *Albatross*, by steam power at all depths, the net and its appliances have been constructed somewhat heavier and stronger. Additional weight is secured by passing the tripping-arm through a 60-pound shot, of the ordinary pattern used for sounding, the shot being secured by a bolt to prevent its slipping when the arm is capsized. (See pl. 9, fig. 4.)

A deep-sea tow-net, closed, with the folded jaws protecting its mouth, offers little resistance to the water, and can be heaved in rapidly without the danger of being torn away from an open and widespread net-ring, while the friction upon the contained organisms is reduced to the minimum.

The time gained in deep-sea work, with a folding-ring net which will permit of the steam winch reeling in at full speed, and the small stowage space required on shipboard for a net of this pattern, are matters of considerable importance. The readiness with which this net can be carried on deck by one man and attached to the wire dredge rope without complicated adjusting is perhaps the most important point of all in its favor, while its cost is less than that of any intermediate net hitherto employed.

This device has also been constructed in very light form, with a net ring 18 inches in diameter, for use in lakes or at very moderate depths, the heavier outside net being done away with, leaving merely the mosquito netting with its lining of silk bolting-cloth.

In this form it will be useful in gathering the minute life, crustacea, etc., of the Great Lakes, a knowledge of which is essential in its bearing upon the food of young whitefish and other important fishes now being propagated artificially.

The folding-ring tow-net is also available for use as an ordinary surface tow-net, without the employment of the messenger and the lead sinker.

The collections made by the *Albatross* during the past summer with the intermediate net were from depths of 20 to 200 fathoms, the net being lowered in one instance to 575 fathoms, when it accidentally touched bottom. The forms obtained consisted principally of minute crustacea, medusæ, annelids, and fishes, which have not yet been studied; but the ordinary surface tow-net having been used at the same stations as the intermediate net, the contents of the two nets were usually found to differ somewhat in character and quantity. As a rule, the surface net contained a slightly greater quantity of material than the intermediate net, but at some stations the reverse was the case, while the inter-

mediate net sometimes brought up forms not taken at all in the surface net. The towings, 18 in all, were made along the border of the submarine bank south of the Pribilof Islands during the month of August, from lat.  $54^{\circ}$  to  $56^{\circ}$  N. and long.  $167^{\circ}$  to  $172^{\circ}$  W. Soundings were from 75 fathoms, on the bank, to 1,901 fathoms beyond it. There can be no doubt that there is an abundance of pelagic life at 200 fathoms in this part of Bering Sea.

After some experience with the single tripping-arm described in the preceding pages, I designed a machine for *opening as well as closing* the jaws of the tow-net, which worked satisfactorily (plate 10). It is a combination of two tripping arms, for operating which two messengers are employed on the same tow-line, the second striking a separate detacher from the first. A rough experimental machine, constructed on board the *Albatross*, was used successfully in port, but did not have strength to withstand the strain of towing at sea. Experiments indicate, however, that a properly constructed machine of the same pattern would accomplish the desired result. Its use in place of the single tripping-arm permits of the folding-ring tow-net being lowered in a closed position, the closing-slings being attached to the right arm, the opening-slings to the left. The arms are bolted to a bar of brass about 2 feet long, suspended from the towline, and in position for use are hooked upright to detachers released by messengers. The first messenger tripping the right arm, the jaws of the net fall apart for towing. The second messenger, in turn, tripping the left arm, the weight is thrown back on the slings of the right arm, closing the jaws. A ring-shaped weight around the right slings, and suspended from a hook on the left arm, holds the jaws together for lowering. It is released upon the tripping of the left arm, and slips again to its position upon the right slings, holding the jaws together for heaving in.

The net being closed tightly in going down, it is not necessary to stop the vessel and lower it vertically.

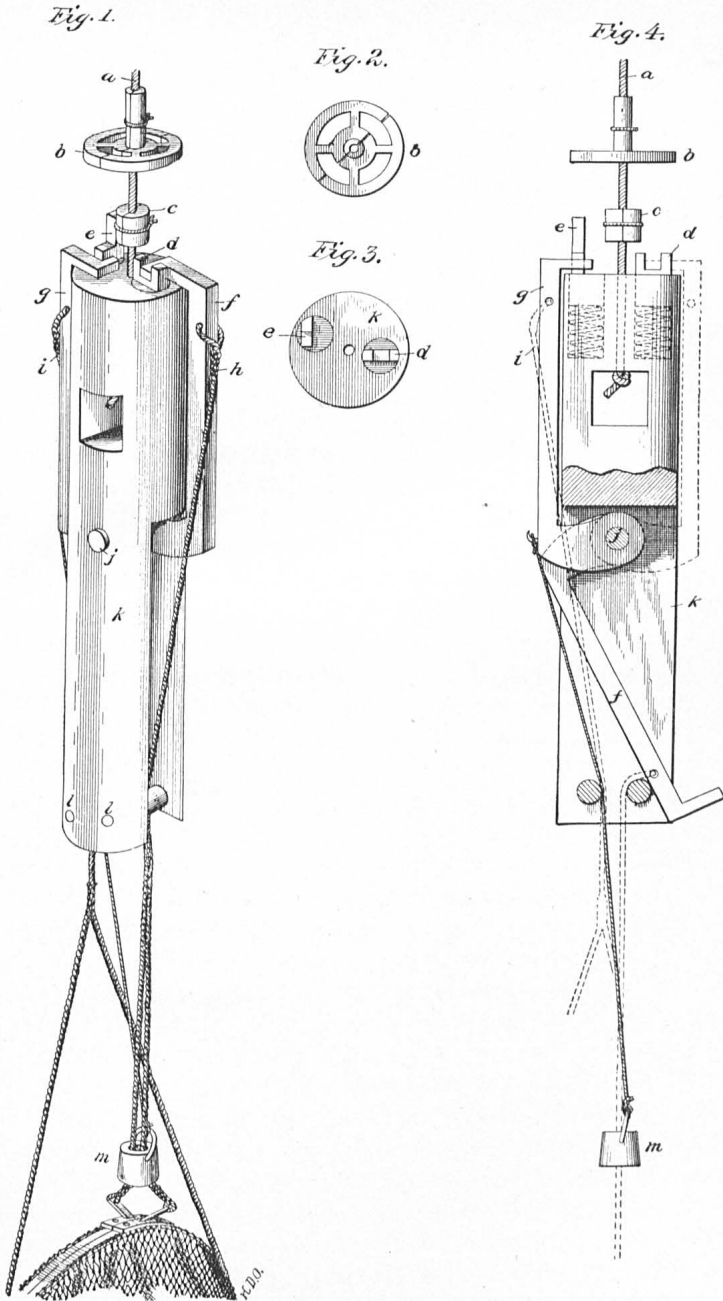


FIG. 1. Showing net in position for lowering.  
*a.* Wire tow line.  
*b.* Second messenger—to close.  
*c.* First messenger—to open.  
*d.* Plunger securing right arm.  
*e.* Plunger securing left arm.  
*f.* Right arm.  
*g.* Left arm.  
*h.* Closing slings.  
*i.* Opening slings.  
*j.* Bolt securing tripping arms.

FIG. 1. Showing net, etc.—Continued.  
*k.* Body of machine (2 feet 3 inches long).  
*l.* Bolts holding net lines on center of gravity.  
*m.* Closing weight.  
 FIG. 2. End view of second messenger  
 FIG. 3. End of machine, showing position of plungers.  
 FIG. 4. Showing right arm tripped, springs to plungers, and knot securing tow line.