UNITED STATES

COAST AND GEODETIC SURVEY

J. E. HILGARD

SUPERINTENDENT

DEEP-SEA SOUNDING AND DREDGING

SUPPLEMENT

TO

A DESCRIPTION AND DISCUSSION

OF THE

METHODS AND APPLIANCES USED ON BOARD

THE COAST AND GEODETIC SURVEY

STEAMER, "BLAKE"

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THE SIGSBEE MACHINE FOR SOUNDING WITH WIRE; PATTERN OF 1881.

During the year 1881 a Sigsbee Sounding-Machine was made for each of the following-named organizations: U. S. Navy, U. S. Coast and Geodetic Survey, and Imperial German Navy. Another is now being made for the U. S. Commission of Fish and Fisheries. The leading object in this supplement is to point out such improvements in these machines as are not embraced in the machine shown on Plate 8, &c., of the original volume to which the supplement pertains.

The references herein relate to the original volume. In the views shown on the two accompanying Plates the scale of dimensions is the same throughout the set.

In the construction of the new machines metal only has been employed, a cast-steel bed, in two parts, replacing the wooden bed formerly used. The new style of bed allows the machine to be more compactly folded than before.[1] The strain-pulley has been abandoned and its former place on the bed is now occupied by the steam-engine and a special form of tightening-pulley.[2] An auxiliary brake has been placed beneath the reel; a single spur buffer only is used at the foot of the guide-pipes, and the outriggers to which the side stays are set up, and the casting which supports the fairleader and swivel pulley, are now hinged or pivoted.[3] The intention is to adapt the machine for folding with the removal of so few parts that, in inexperienced hands, there need be no doubt as to the position which each part should occupy when the machine is set up for use. Steel castings are used wherever they can be utilized.

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[1] Comp. Plate 12. [2] Page 62, ¶ 4, and p. 72, ¶ 1. [3] Page 64, ¶¶ 7 and 8.

Plate 42 shows the right side of the machine. In Fig. 1 the machine is rigged for reeling in by steam, the reel being connected with the engine by means of a belt of round leather on one part of which rests the tightening-pulley.[1] The swivel-pulley is down in the position it would have when reeling in while the ship has headway.[2] Fig. 2 shows the machine in temporary disuse, as in port, for instance. The reel, being unshipped, is supposed to be in the tank containing preservative.[3] The register is thrown back out of the way.[4] The fairleader arrangement is thrown back on its pivot and the swivel-pulley is carried still farther to the rear on another pivot; neither are unshipped. The side stays are slacked and their outriggers are thrown up on pivots into a snug position.[5] The two parts of the back brace or stay are disconnected, and the upper section of the guide-pipes is thrown back where it remains supported, all parts of the machine thus being accessible for cleaning.

Plate 43 shows the left side of the machine. In Fig. 1 it is rigged for paying out.[6] The belt is disconnected and the friction-line is applied. The swivel-pulley is laid aside, resting on the left outrigger. The clamp is in use in the fairleader as if the reel had been stopped temporarily to repair a defect in the wire.[7] Fig. 2 shows the machine folded for transportation or stowage, the reel being in the tank. The cross-head pulley has been removed, but the cross-head itself remains in place.[8] In folding the machine the reel and this pulley are the only parts that do not remain hinged or otherwise attached to their proper places; such bolts or screws as are necessarily removed are again replaced, after the machine has been folded, to secure them against loss or error in future adjustments. The front part of the bed has been thrown upward, carrying with it the guide-pipes. The guide-pipes are folded in a reverse way from that shown in Fig. 2, Plate 42, while the outriggers, fairleader arrangement, and swivel-pulley are folded as shown in that figure. For inclosing the machine when folded, a box is placed over it and screwed to the wooden piece shown by the figures of Plates 42 and 43. This wooden piece forms the

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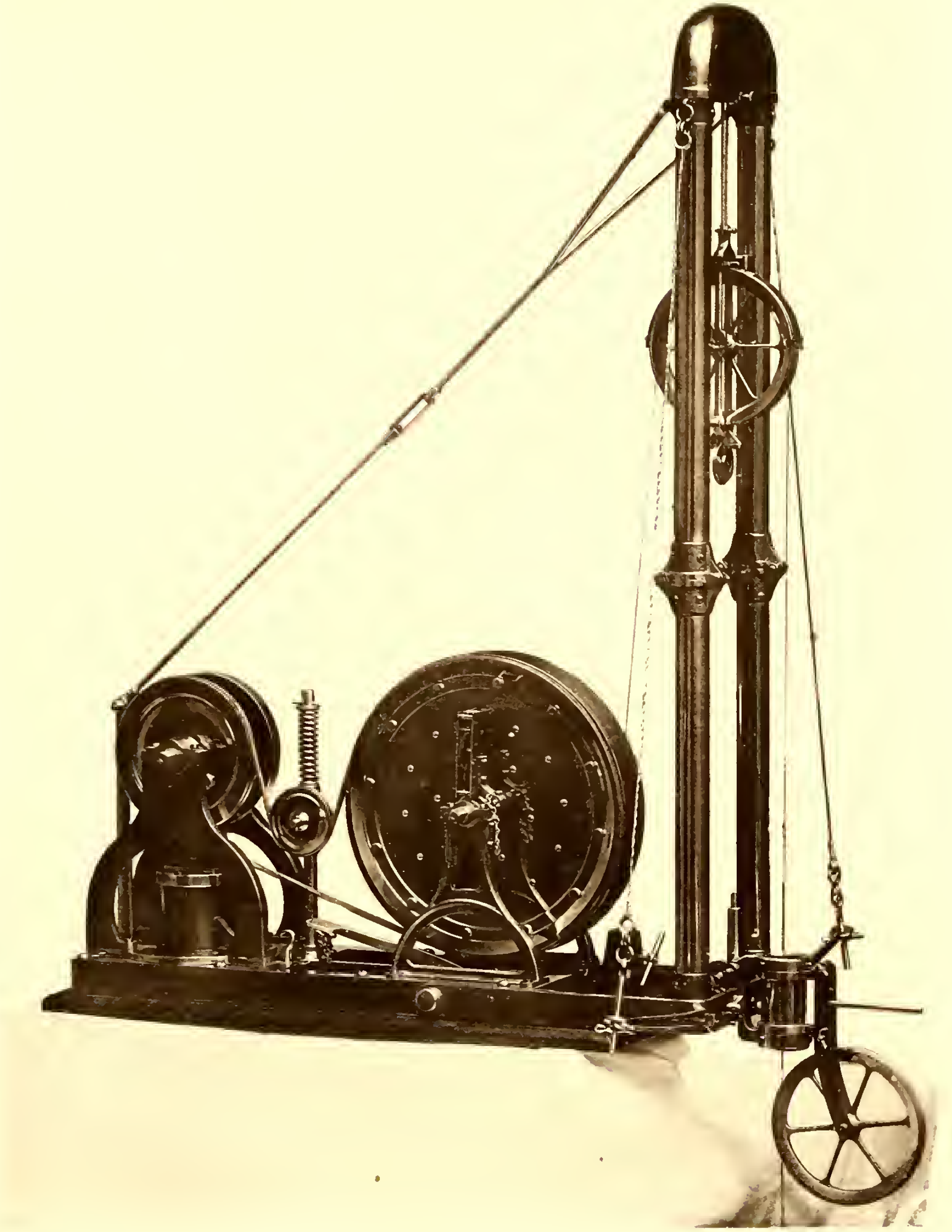
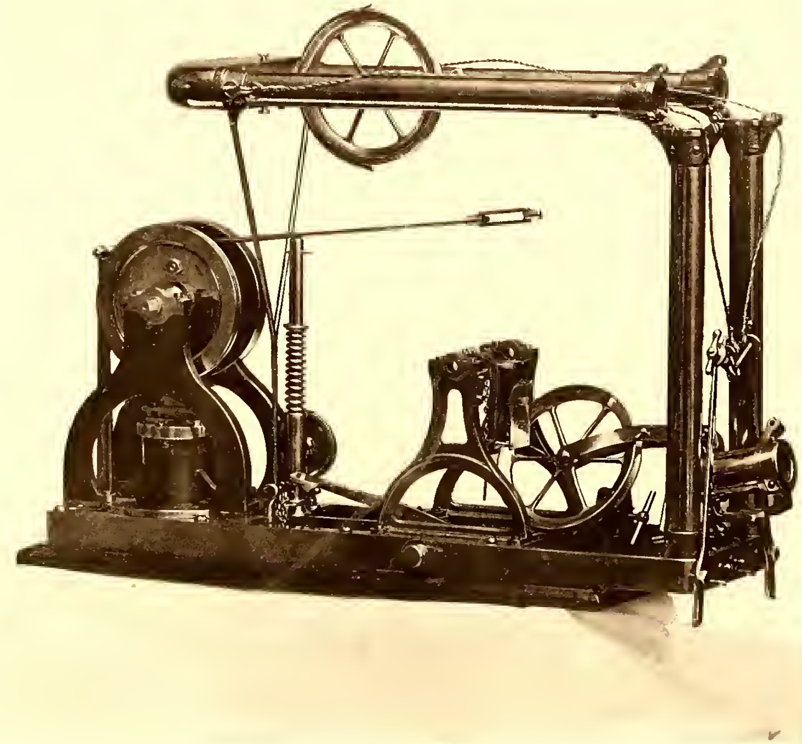
[1] Comp. Plates 7 and 13. [2] Page 81, ¶ 2. [3] Page 34, ¶ 5. [4] Page 62, ¶ 3.
[5] Comp. Plate 12. [6] Page 67, ¶ 5. [7] Page 77, ¶ 2. [8] Page 63, ¶ 2.



HELIOTYPE PRINTING CO.

Fig. 1.



BOSTON.

Fig. 2.

SIGSBEE MACHINE FOR SOUNDING WITH WIRE: PATTERN OF 1881. FIG. 1.—RIGGED FOR REELING IN BY STEAM. FIG. 2.—IN TEMPORARY DISUSE.

bottom of the box, but, for convenience, it is permanently attached to the steel bed. The outside dimensions of the box, when it is made of heavy stuff, are as follows: length, 4 feet 5 inches; breadth, 1 foot 8 inches; height, 3 feet. In this space are stowed such conveniences as the steam-engine, tightening-pulley, accumulator, dynamometer, governor, swivel-pulley, auxiliary brake, etc.[1]

The bed is well shown in the several figures of Plates 42 and 43. It is composed of two skeleton frames of steel, hinged together by bolts. The steel bed does away with the warping sometimes experienced with the wooden bed when exposed to a hot sun. Warping of the bed throws the standards of the reel out of alignment, which makes the axle of the reel bind in its bearings.

The engine does not differ essentially from that shown on Plate 18, with the exception of being vertical instead of inclined.[2]

The tightening-pulley.[3] A collar, sliding on the vertical shaft shown in the plates, has a stud on one side which forms the axle for the pulley. The tension on the belt is maintained by the elastic pressure of a spiral spring. Along the shaft are bored holes at regular intervals, into any one of which the pin shown near the top of the shaft may be inserted according to the amount of pressure which it is desired the spring shall exert. When the tightening-pulley is not in use the shaft is turned on its axis, carrying the pulley to the left side of the machine, giving place for the standing part of the friction-line, or the spring scales—Fig. 2, Plate 42, and Figs. 1 and 2, Plate 43. A pin at the foot of the shaft keeps the latter from turning when it should remain immovable.

The outriggers are of cast-steel; each is fastened or hinged to the bed by a bolt going through a longitudinal slot in the outrigger.[4] In use the inner ends of the outriggers rest upon studs projecting from the bed.

The auxiliary brake and its use.—The brake is a lever of the first order, pivoted on a block screwed to the board shown on the plates. The end of the lower arm, which is fitted with a wedge-shaped piece of wood, may be pressed into the V-groove of the reel by force applied to the other arm,

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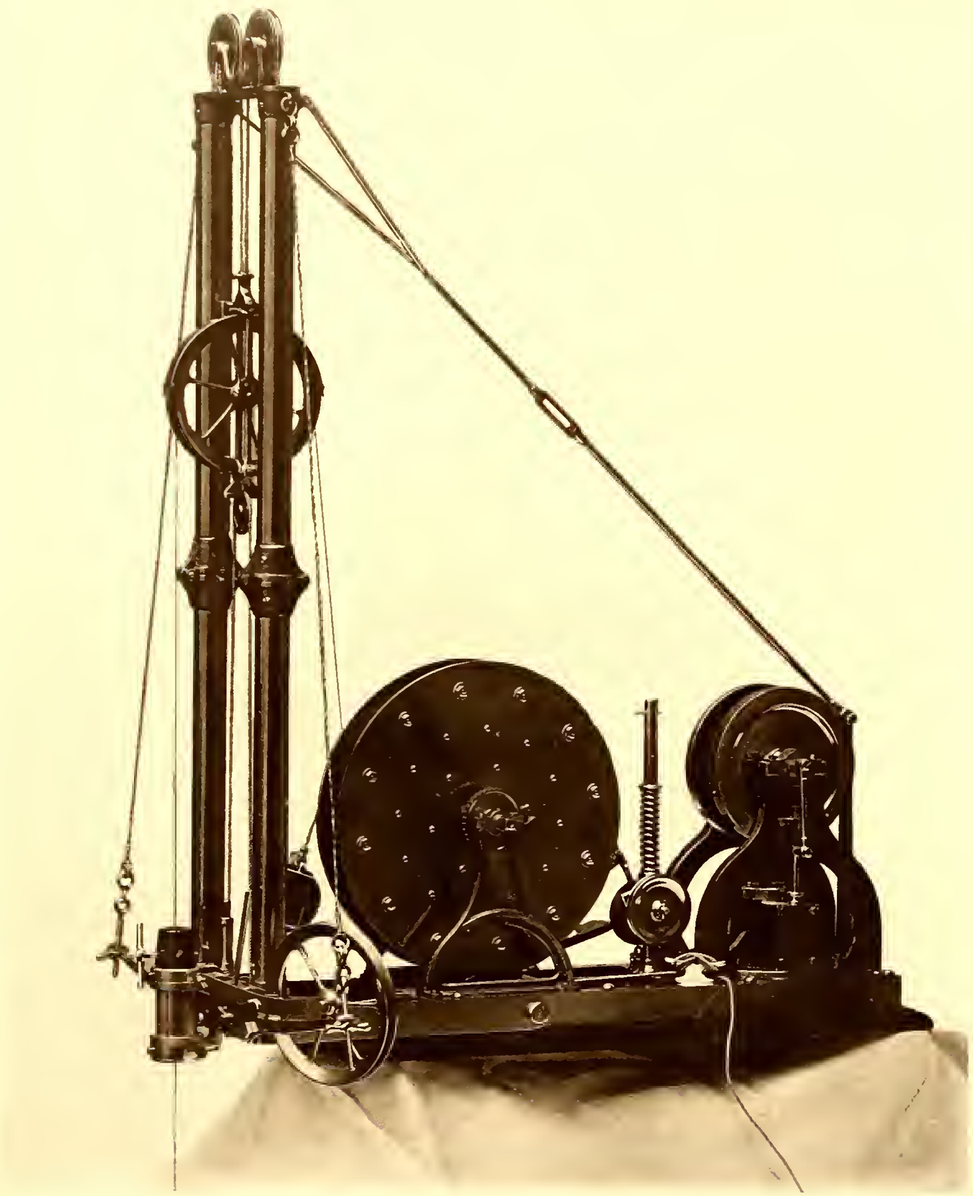
[1] Comp. p. 67, ¶¶ 2 and 3. [2] Page 87, ¶ 2. [3] Comp. p. 86, ¶ 3. [4] Comp. Plates 8 and 12.

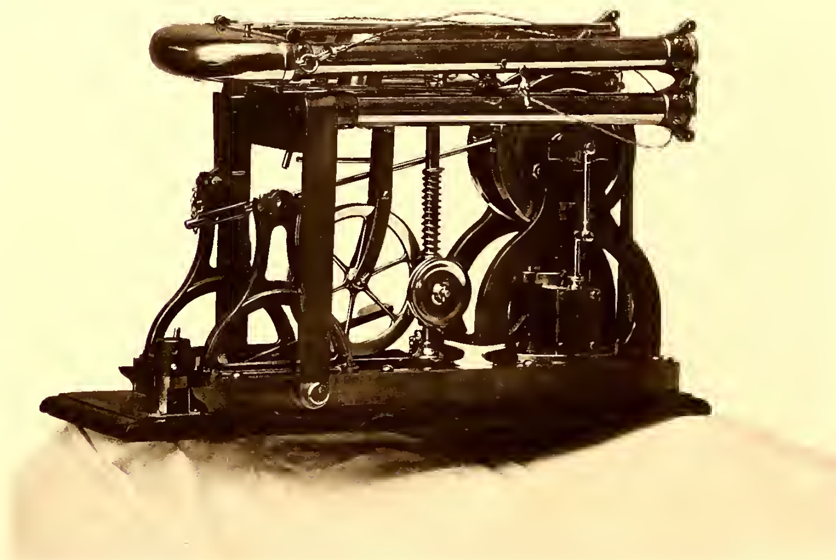
but, in the absence of such force it is held out of action by a spring. The auxiliary brake serves for immediate and temporary use in the event of the friction-line or the connecting-belt parting, and in unusually heavy seas and under adverse circumstances it may be used in lieu of the toggle tucked into the friction-line—described in the original volume. The office of the toggle—although it is rarely used—is to impose upon the reel a small amount of friction which will not be lessened by the action of the governor,[1] the object being to permit in heavy seas a rapid rate of paying out.[2] The occasional advantage which may be derived from this accessory is well illustrated by such an extreme case as would make the use of the auxiliary brake desirable, thus: sounding from the bow; sea heavy; ship pitching violently; a heavy reel in use, and containing a large coil of wire which adds much to its weight at the periphery.[3] Under these conditions, and when the reel is revolving with considerable speed, the vessel rises suddenly, increasing the tension upon the wire which is being payed out; the cross-head is borne down, easing the friction-line, we will assume, more than is desirable, and the heavy reel, thus deprived for a second of nearly all frictional control, is set revolving with great rapidity. At this instant the vessel gives a quick, deep plunge. The reaction of the accumulator acting as a governor is almost instantaneous, and the friction-line is set hard taut; but before the momentum of the heavy reel can be overcome the wire slacks and perhaps flies from the reel. If, in the case stated, the auxiliary brake, which is independent of the governor, had been bearing upon the reel with a constant pressure, maintaining a slight resistance, the undue slacking of the friction-line would not have been followed by such excessive revolution of the reel. To insure an even pressure of the auxiliary brake, the inboard end of the brake-lever—the long arm—might be connected with the bed of the sounding-machine by a spring of rubber or metal which could be set to any desired tension. It must not be inferred that the auxiliary brake is a necessity; it is intended as a convenience on extraordinary occasions, to obviate the necessity for unusual skill or judgment on the part of those

[1] Page 68, ¶ 6. [2] Page 70, ¶ 2. [3] Page 56, ¶ 1.



HELIOTYPE PRINTING CO.

Fig. 1.



BOSTON

Fig. 2

SIGSBEE MACHINE FOR SOUNDING WITH WIRE: PATTERN OF 1881. FIG. 1 —RIGGED FOR PAYING OUT; CLAMP IN USE. FIG. 2.—FOLDED FOR TRANSPORTATION OR STOWAGE.

operating the machine. It has been my purpose to add to the sounding-machine, when warranted by economy, every appliance which may save time or prevent accident. In many localities there is but a small proportion of weather during which astronomical observations can be had for determining the positions of soundings; it is therefore highly important in such localities to make the best use of favorable weather.

GRAVITATING OR COLLECTING TRAP FOR OBTAINING ANIMAL SPECIMENS FROM INTERMEDIATE DEPTHS.

In the original volume, page 144, last paragraph, and page 145, foot-note, reference is made to the invention of an apparatus for collecting animal forms from intermediate depths. The apparatus has now been well tried and a full description of it by myself (accompanied by a drawing), and a statement of the results obtained, by Prof. Alexander Agassiz, is contained in the "Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. VI, Nos. 8 and 9, September, 1880."

I quote a part of my own description contained therein, as follows:

"The old practice of dragging for animal forms at intermedial depths by means of a tow-net, which, during the several operations of lowering, dragging, and hauling back remained open, was not regarded by Prof. Alexander Agassiz as affording acceptable evidence of the habitat of such specimens as were obtained, and he frequently referred to the subject during our association on board the "Blake" in 1878.

"In March, 1880, it having been arranged that Professor Agassiz should make another cruise on board the "Blake," Commander J. R. Bartlett, U. S. N., commanding, he asked my co-operation in devising an apparatus to meet the rigid demands of the work in question. This resulted in the apparatus described herein, which is presented in the precise form used with success by the "Blake," although, as may readily be seen, it is open to great improvement, especially in minor details.

"The 'Challenger' had examined intermediate depths by means of tow-nets trailing from the dredge-rope while hauling the dredge or trawl. In such a practice it must have been that the depths to which the nets were sunk depended in some degree on the amount of slack-rope payed out, and also on the strain upon the dredge-rope due to the resistance encountered by the dredge when dragging; it cannot, therefore, be said that strictly determinate depths were examined by that method, even assuming that the nets gathered nothing while being lowered and hauled back.

"It occurred to me that by using an apparatus in connection with a line and lead, payed out vertically as in sounding, and by dragging vertically, instead of horizontally as formerly, there would be at least as much certainty with regard to depths as in the old method, and that simple mechanical devices could be invented to satisfy the conditions of the work. The scheme has been stated in my volume on 'Deep-Sea Sounding and Dredging' (p. 145, foot-note), as follows:

"'Our plan is to trap the specimens by giving to a cylinder, covered with gauze at the upper end and having a flap-valve at the lower end, a rapid vertical descent between any two depths, as may be desired; the valve during such descent to keep open, but to remain closed during the processes of lowering and hauling back with the rope. An idea of what it is intended to effect may be stated briefly thus: Specimens are to be obtained between the intermediate depths *a* and *b*—the former being the uppermost. With the apparatus in position, there is at *a* the cylinder suspended from a friction *clamp* in such a way that the weight of the cylinder and its frame keeps the valve closed; at *b* there is a friction *buffer*. Everything being ready, a small weight or messenger is sent down, which on striking the clamp disengages the latter and also the cylinder, when messenger, clamp, and cylinder descend by their own weight to *b*, with the valve open during the passage. When the cylinder frame strikes the buffer at *b* the valve is thereupon closed, and it is kept closed thereafter by the weight of the messenger, clamp, and cylinder. The friction buffer, which is four inches long, may be regulated on board to give as many feet of cushioning as desired.'"

The trap was first tried in Narragansett Bay, and soon after was used for the second time at sea, several improvements having been made in the meantime by Professor Agassiz and Commander Bartlett. I quote from the Bulletin again, this time giving Professor Agassiz's words:

"On the 1st of July the Sigsbee cylinder was tried for the second time in Lat. 39° 59′ 16″ N., Long. 70° 18′ 30″ W., in 260 fathoms of water. The surface was carefully explored with the tow-net to see what pelagic animals and others might be found on the surface. There were found Calanus, Sagitta, Annelid larvæ, Hydroid Medusæ, Squillæ embryos, Salpæ, and a few Radiolarians. The cylinder, filled with water which had been carefully sifted through fine muslin, was then attached to the dredging-wire, and lowered, so as to collect the animals to be found between 5 and 50 fathoms. The time occupied by the cylinder in passing through that space was 28 seconds. The cylinder was then brought up, and the sieves and gauze trap carefully washed with water, which had also previously been strained through fine muslin. The water was carefully examined, and we found the very same things which had a short time before been collected at the surface with the tow-net and the scoop-net; nothing different was collected by the cylinder. The Radiolarians (two genera) were perhaps more numerous than at the surface. A slight breeze having sprung up after the surface collections had been examined, the cylinder was then sent down a second time at this same station, so adjusted as to collect any animal life to be found from a depth of 50 to 100 fathoms. Not only in this experiment, but in all the subsequent ones, the same precautions were taken in regard to straining the water which filled the cylinder at the start, as well as that used for washing out the sieve and the gauze trap. The messenger sent down to detach and open the machine occupied 21 seconds in reaching the (50 fathoms) point to which the cylinder was attached, and the cylinder then occupied 30 seconds in passing to the stop at 100 fathoms. On examining the sieves, it was found that the more common surface things, Calanus, Sagitta, Annelid larvæ, Hydroid Medusæ, and Squillæ embryos, were entirely wanting, and there were only two Radiolarians of the same species as those from the upper levels found after a careful scrutiny of the water. Nothing additional was brought up. The cylinder was then sent down a third time, lowered to a depth of 100 fathoms, the messenger sent down to open it (time occupied 45″), and the cylinder traveled from 100 to 150 fathoms (time 45″), so as to collect the animal life to be obtained between these limits. On drawing up the cylinder and washing out the sieve of the trap, not only did we find that the water contained nothing different from what had been brought up by the cylinder from the lesser depth, but it did not contain even a single Radiolarian.

"On the 15th of July, in Lat. 34° 28′ 25″ N., Long. 75° 22′ 50″ W., we tried the Sigsbee cylinder for a third time, in a depth of 1,632 fathoms. With the same precautions before and after using it, the cylinder was sent to collect first between 5 and 50 fathoms (time 30″). The surface was somewhat ruffled, and but little was found on the surface beyond a few Crustacean larvæ and Heteropods. The cylinder contained Hydroids, fragments of Siphonophores, pelagic Algæ, Crustacean larvæ, and Heteropod eggs; forms which differed from these scooped at the surface, but were identical with the species found on previous days at the surface under more favorable surface conditions of the sea. Next, the cylinder was arranged to collect between 50 and 100 fathoms (time of messenger 21″ from surface to 50 fathoms, time of cylinder 40″ to stopper from 50 to 100 fathoms). The water was found to contain only a couple of Squillæ larvæ, similar to those fished up at the surface. The third time the cylinder went down at this station it was lowered to collect from 100 to 150 fathoms (time of messenger from surface to 100 fathoms 45″, time of cylinder in passing from 100 to 150 fathoms 45″). The water when examined contained nothing. No Radiolarians were found at this station, either at the surface or at any depth to which the cylinder was sent (150 fathoms).

"The above experiments appear to prove conclusively that the surface fauna of the sea is really limited to a comparatively narrow belt in depth, and that there is no intermediate belt, so to speak, of animal life, between those living on the bottom, or close to it, and the surface pelagic fauna.

"The experiments of using the tow-net at great depths (of 500 and 1,000 fathoms), as was done by Mr. Murray on the 'Challenger,' were not conclusive, as I have already pointed out on a former occasion, while the so-called deep-sea Siphonophoræ, taken from the sounding-line by Dr. Studer, on the 'Gazelle,' may have come, as I have so often observed in the Caribbean, from any depth. I do not mean, of course, to deny that there are deep-sea Medusæ. The habit common to so many of our Acalephs (Tima, Æquorea, Ptychogena, etc.) of swimming near the bottom is well known; Dactylometra moves near the bottom, and Polyclonia remains during the day turned up, with the disk downward, on the mud bottom. I only wish to call attention to the uncertain methods adopted for ascertaining at what depth they live.

"As far as the pelagic fauna is concerned, those who have been in the habit of collecting surface animals know full well that the least ripple will send them below the reach of commotion; Müller and Baur were the first to adopt the use of a tow-net sunk below the surface to collect pelagic animals when the water was disturbed. It seems natural to presume, as we have found from our experiments with the Sigsbee cylinder, that this surface fauna only sinks out of reach of the disturbances of the top, and does not extend downward to any great depth. The dependence of all the pelagic forms upon food which is most abundant at the surface, or near it, would naturally keep them where they found it in greatest quantity.

"Of course, with the death and decomposition of the pelagic forms, they sink to the bottom fast enough to form an important part of the food supply of the deep-sea animals, as can easily be ascertained by examining the intestines of the deep-water Echinoderms. The variety and abundance of the pelagic fauna, and its importance as food for marine animals, are as yet hardly realized.

"One must have sailed through miles of Salpæ with the associated Crustacean, Annelid, and Mollusk larvæ, the Acalephs, especially the oceanic Siphonophores, the Pteropods and Heteropods, with the Radiolarians, Globigerinæ, and Algæ, to form some idea how rich a field still remains to be explored. The variety of the pelagic fauna in the course of the Gulf Stream is probably not surpassed by that of any other part of the ocean."

PRESSURE ERRORS OF MILLER-CASELLA THERMOMETERS.

The following report is taken from "*Nature*," issue of April 21, 1881, page 595. It treats of a matter contained in the original volume on Deep-Sea Sounding and Dredging, page 109:

"Royal Society, *April* 4.

"Professor Tait communicated the results of his experiments on the pressure errors of the *Challenger* thermometers, the correction for which, as originally furnished to the expedition, was 0°.5 F. per mile of depth. The mode of experimenting was to subject the thermometers to considerable pressure in a hydraulic press, which was essentially a strong steel cylinder that was warranted to stand a pressure of 25 tons weight on the square inch. It was supported in an upright position upon a strong tripod stand. Water was filled in from above; and into the upper end of the cylinder there was lowered a tight-fitting plug, which was fixed in position by a transverse steel bolt. The lower end of the cylinder was connected through a narrow copper tube to a hydraulic pump, which, by pumping in water to the cylinder, raised the pressure to the required amount. At three tons pressure an average effect of 1°.5 F. was produced upon the inclosed thermometers. Before drawing any conclusions as to the correction to be applied in deep-sea sounding, it was necessary to consider how far this effect could be explained as resulting from the peculiar conditions under which the experiments were made. From the known compressibility of glass it was calculated that the volume of the bore of a thermometer tube, closed at both ends, would be diminished by only one-thousandth part for an increase of pressure of one ton weight on the square inch; and from a direct experiment made with a metre-long tube this was proved to represent very approximately the real effect. Hence it was quite out of the question that this could have any appreciable effect on such comparatively short thermometers as those of the *Challenger*, which were besides subject to much graver errors, such as those arising from the shifting of the indices during the ascent from the depths, or even from the effect of parallax when taking the reading. The direct action of pressure may then be disregarded, and the effect produed upon the thermometers in the compression apparatus must be due to secondary effects of pressure, such as evolution of heat. The various sources of heat were four: 1. Heating of the water by compression. This depends greatly on the original temperature of the water, being *nil* at the point of maximum density (40° F.) and larger for higher temperatures. One-fourth of the total effect is due to this. 2. Heating of the water due to pumping in through the narrow tube. This accounts for three-twentieths of the effect. 3. Heating of the vulcanite frame by compression. This explains another fifth. 4. Heating due to the effect upon the protecting-bulb. This probably explains the remaining two-fifths of the effect. In this last case, however, there is not only compression but distortion; and of the thermal effects of such a strain no one yet knows anything. These four sources of error cannot be supposed to exist under the conditions in which deep-sea temperatures are taken; and the only other possible source, that, namely, due to the direct effect of pressure, gives rise to an error which requires a correction of only 0°.04 F. per mile of depth. In the course of the description of experiments Professor Tait had occasion to describe the various kinds of pressure gauges which he had found it necessary to devise, the ordinary forms of gauge being altogether useless for scientific work."