No. 6. — (Letter No. 2) *To* C. P. Patterson, *Superintendent Coast Survey, Washington, D. C., from* Alexander Agassiz, *on the Dredging Operations of the United States Coast Survey Steamer "Blake," during parts of March and April,* 1878, *with the Preliminary Report on the Mollusca of the Expedition, by* Wm. H. Dall, *Assist. U. S. Coast Survey.*

Since my last letter our operations have been confined to dredgings along a line to the northward of the Tortugas, running, in a general way, parallel to the 100-fathom curve of the western edge of the great Florida Bank. This line was extended northward to about the latitude of Tampa Bay, a distance of some 200 miles. A second line was then run from that point directly for the mouth of the Mississippi, a distance somewhat less than 200 miles. At New Orleans Mr. Garman and myself left the ship. It must have been a great relief to the officers of the "Blake," more particularly to the executive officer, Lieutenant Ackley, to be able to put the "Blake" again in an orderly condition. The work of dredging is not conducive to cleanliness, and during the whole time I was on board no routine was ever allowed to interfere with our work, Lieutenant Ackley himself always being the first to see that everything was in readiness for our dredging operations at all times. That the interest shown in the work by the other officers of the "Blake," Messrs. Sharrer, Jacobi, Moore, Sigsbee, and Dr. Nourse, did not flag after my departure, is amply testified by the collections made off Havana, containing some of the most valuable specimens of the expedition, all of which were forwarded to the Museum in an excellent state of preservation. The "Blake" subsequently returned to Key West to continue her regular work of sounding between the Tortugas, the coast of Cuba, and the Yucatan Bank. On the way to Key West, a few casts were made by Captain Sigsbee, on the Florida Bank, in lat. 26° 31′, long. 89° 03′, in a depth of 119 fathoms, at a point where a good idea of the fauna of the Florida Bank could be obtained. Before setting ashore the dredging apparatus, Captain Sigsbee ran over to Havana, hoping to be able to dredge a few specimens of Pentacrinus in one of the localities where we had, on a former occasion, found innumerable fragments of stems. He was most successful in this at-

tempt, and a short distance from the Morro light (1½ miles), at a depth varying from 242 to 42 fathoms, he brought up no less than twenty perfect specimens of Pentacrinus * of all sizes, beside a number of fragments which will be most useful for anatomical examination. The specimens obtained represent the two species thus far recognized, but I am inclined, from a cursory examination, to consider the P. Mülleri, with its distant cirri and more slender stem, merely as a younger stage of the P. Asterias, though the latter has a stouter stem and shorter intervals between the cirri. I shall send a number to Sir Wyville Thomson, who will examine our stalked Crinoids, Holopus and Pentacrinus,† at the same time with those of the "Challenger," and who will thus have ample materials for comparison and description. While on the way from Key West to the Tortugas we stopped at the Marquesas Islands, which form a circular ring of islands. Their formation has undoubtedly been identical with that of the great Alacran Reef, briefly described in my first letter, and, from the fact that no corals are now found living on their weather side, these islands must have assumed their present shape at the time when their weather side made a part of the outer reef in connection with the islands of Key West and the other keys, previous to the formation of the present growing reef, or while the latter existed only in the shape of a submerged reef several fathoms below the surface. I shall, on another occasion, give maps of the Alacran Reef as well as of the Marquesas, with the sections explaining their mode of formation. The weather during the greater part of our trip from the Tortugas to New Orleans was atrocious, as is usually the case during March in the Gulf of Mexico. We managed to do but little beyond ascertaining, in the most general way, the faunal characteristics of the lines run between Key West and New Orleans. Our materials were, however, ample to show that the deep-water fauna on the western slope of the great Florida Bank corresponds with that of similar depths ‡ on the eastern slope of the Bank of Yucatan, and that this deep-water fauna extends over the bottom of the Gulf of Mexico, until the line running from the 100-fathom line in latitude of Tampa Bay towards New Orleans strikes the Mississippi River slope. Here, owing to the presence of dark, rich mud, the fauna materially changed its character, and we obtained, off the Passes of

* See note from Captain Sigsbee.

† Rhizocrinus has now been so carefully studied by Sars, by Pourtalés, and by Ludwig, that it will form an excellent standard of comparison for the other genera.

‡ Noticed in a general way in my first letter.

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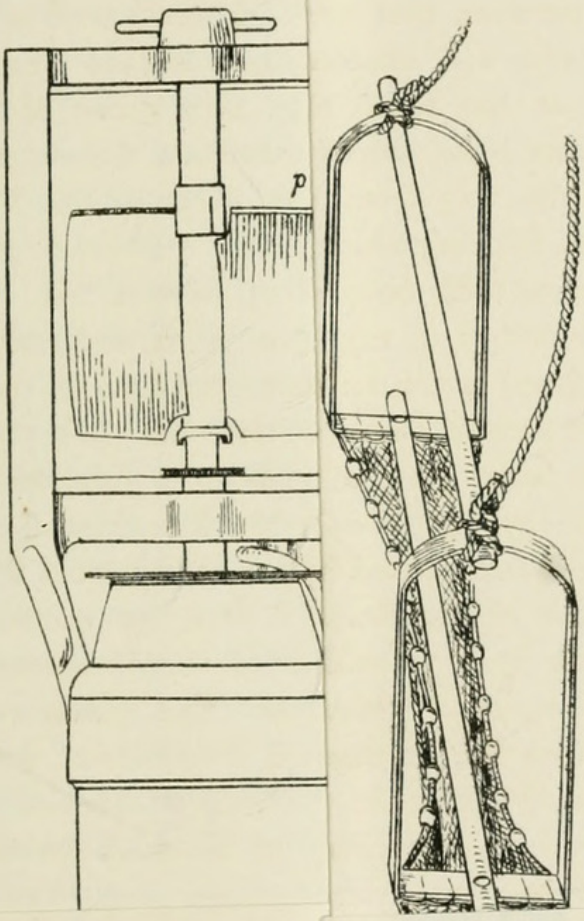
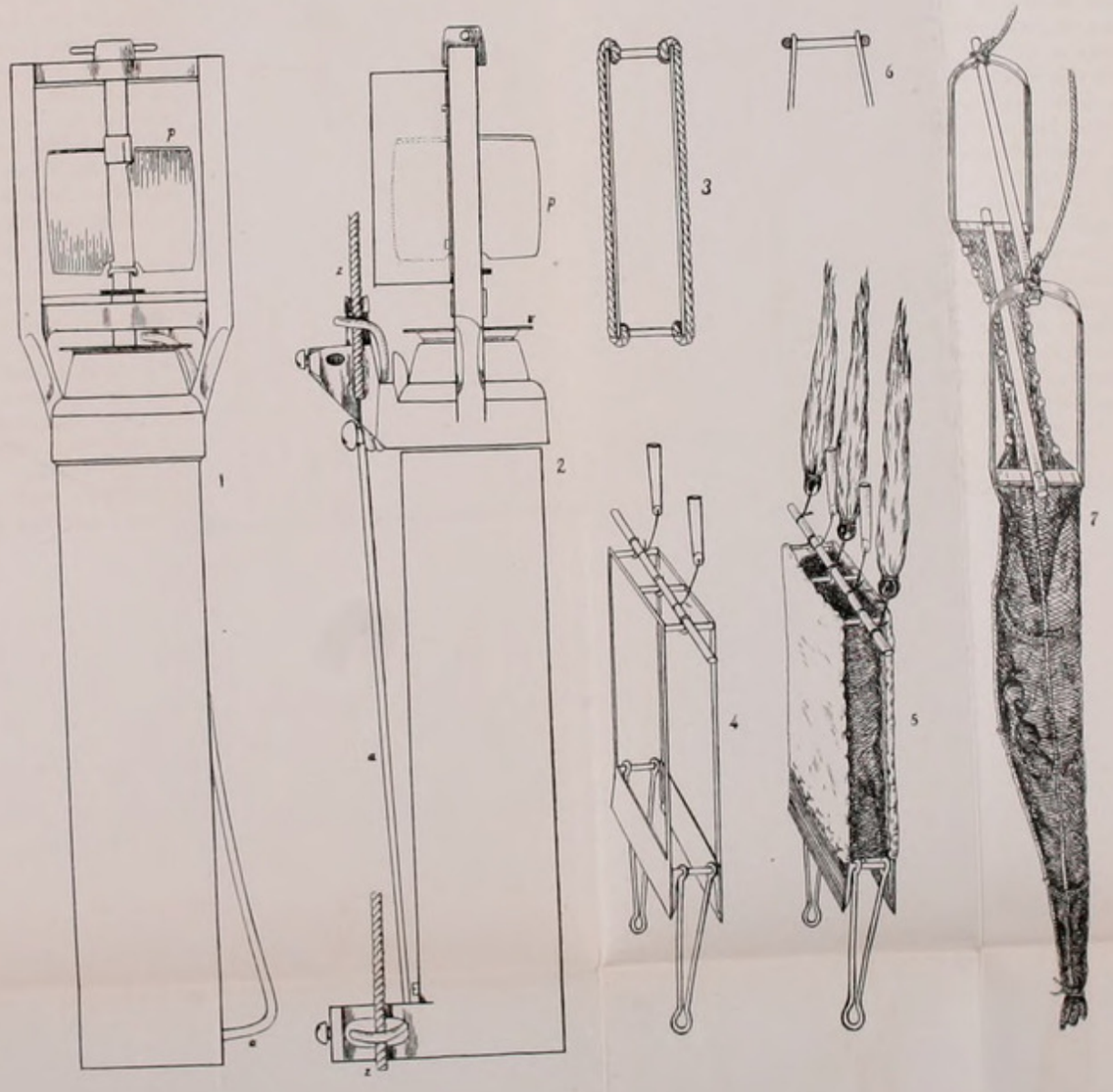
Plate I.





Blake, del.

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the Mississippi, in depths of from 118 to 600 fathoms, a number of interesting forms of Fishes, of Annelids, of Mollusks, of Ophiurans, and Sea-Urchins. The hauls in deeper water, off the Mississippi, yielded no specimens of importance. Throughout this last cruise we obtained, below 500 fathoms, the forms characteristic of deep water in all the deeper basins of the ocean, the more special or faunal species occurring at a lesser depth.

The new dredges improvised in Key West by Captain Sigsbee and Mr. Jacobi worked very satisfactorily, and were a great improvement on the old model, obviating completely the defects referred to in my last letter. The double trawl also worked admirably, obviating all fouling, and doing away with the frequent delays so annoying when the ordinary single-beam trawl is used in deep water.

The steel-wire rope continued to give excellent satisfaction, and we experienced fewer mishaps from causes connected with our rope than any other deep-sea dredging expedition. The uniform success attending our use of this rope during the past season enables me to recommend it to any future deep-sea dredging expedition as an economy of space, time, and money, for our rope occupied about one ninth of the space required by a hemp rope, and was, at the end of the cruise, as good as when we first left Key West.

There still remain many minor improvements, suggested by the use of the steel-wire rope, which would facilitate the working of the dredge or trawl, but not greatly increase their efficiency. Much still remains to be done, for instance in the way of a perfect accumulator. The accumulator devised by Captain Sigsbee consisted of a series of spiral steel springs capable of withstanding a strain of 4,000 pounds, these springs moved upon an iron rod; the accumulator was lashed vertically to the foremast, the play of the accumulator, some six feet, being transmitted to a large iron sheave over which the wire rope played. This iron sheave was suspended from a boom fastened by a swivel to the foot of the foremast, and projecting over the starboard bow far enough for the dredge or trawl to clear the side of the vessel. The steamer was invariably backed while dredging, our operations being all carried on at the bow. Of course, in a small vessel like the "Blake," a moderate sea soon made it not only difficult to dredge, but also endangered greatly all our dredging gear from the rapid rolling or pitching to which the accumulator could not respond promptly enough. It seems very doubtful if the accumulators used thus far are a great safeguard against accidents. While dredging, what is going on at the bottom can readily be ascer-

tained by keeping hold of the wire rope on deck, where the movements of the dredge are repeated by the vibrations of the steel rope so promptly that the moment it fouls or passes over rough bottom the speed of the vessel can at once be checked, or its direction altered, before the tension is great enough to affect the accumulators. It is only while hoisting the dredge that the accumulator is useful, and long before it works to its full power, the changes of form of the catenary of the wire rope, from an easy winding in of the dredge to the fouling of the same, will produce a greater or less strain, entirely unnoticed, on the accumulator, while winding up, if (as in our case) the strain is less than 2,000 pounds. The steel rope was hoisted by a small double-cylinder winding engine, with a surging drum of two feet in diameter, round which from six to ten turns were taken, according to the depth, and the rope then passed to the reel, where it was coiled as closely as practicable, the reel being turned by four men at the crank. A great improvement could be made in driving the reel from the winding engine at a greater speed than the drum of the engine.

In dredging, the dredge or trawl was invariably lowered independently of the winding engine from a reel built especially for our work. This reel, built of iron, consisted of a hollow axle two feet in diameter, four feet long, flanked by flanges extending eighteen inches above it, capable of winding 3,000 fathoms of $1\frac{1}{8}''$ steel-wire rope. The axle upon which the reel ran was supported upon bearings carried upon a strong iron frame securely bolted to the deck; the reel was checked by a band friction break, by which one man could readily control the velocity of the steel rope as it was unwound and accurately regulate the speed. The break was of sufficient strength to stop the dredge even at a depth of nearly 2,000 fathoms, and while dredging or trawling the break was securely held in place and the dredging carried on from it. To wind up, the wire rope was stopped and sufficient slack taken from the reel to make the necessary turns round the surging drum of the hoisting-engine. When this was done the reel was made taught, the stops unfastened, and the wire rope wound up by the winding engine until the dredge came in sight.

During the whole time the dredge or trawl was lowered or hoisted an accurate record was taken of the time spent in paying out or reeling in the rope, so that at any moment we knew the precise position of the dredge and the quantity of rope still out. The recorders were either Dr. Nourse or the Captain's clerk, Mr. Sigsbee.

The uniform success which attended all our hauls was undoubtedly

due not only to the improvements suggested in the apparatus by Captain Sigsbee, by Lieutenants Ackley and Sharrer, and by Messrs. Jacobi and Moore, but also to the great care taken by the officer of the deck in handling the "Blake" during the progress of a haul. With a vessel of the size of the "Blake," excellent judgment was necessary while working in a seaway, and that we incurred so few accidents is entirely due to the interest taken in the expedition by the officers, and the devices constantly suggested by them for overcoming the difficulties we encountered in this novel work.

The accompanying figures (Pl. I.) will explain the modifications introduced in the dredge and trawl.

A small map of the Gulf of Mexico, with the 100, 500, 1,000, 1,500, 1,800, and 2,000 fathom curve, has been prepared at the Coast Survey Office in order to give a general sketch of the Hydrography of the Gulf of Mexico. Only a small number of the soundings of the "Blake" are here introduced; they are selected from an immense number plotted during the last four years. The map speaks for itself, and I need only call attention in a general way to the principal features of the bottom. The most striking characteristics of the Gulf are the two great banks extending the one to the west of Florida peninsula and northward of the Florida Reef, the other northward of the peninsula of Yucatan, the 100-fathom line in both cases running in a general way parallel to the shore line and forming the edge of the steep slopes of the deeper parts of the central portion of the Gulf of Mexico. The rapidity with which the depth increases is very strikingly shown to the north of the Tortugas, and to the northward and westward of Alacran Reef, by the proximity of the 100 and 1,800 fathom curves, the eastern and southern edges of the central basin of the Gulf of Mexico having thus very steep sides, while the western and northern slopes are far more gradual. The north slope off Cuba is also quite abrupt, while the southern slope of the Florida Reef into the trough of the Gulf Stream is comparatively gentle. The soundings taken in 1878 have developed a remarkable extension of the southeast end of the Yucatan Bank within the 1000-fathom curve, in the direction of the Tortugas, with a depth of 500 to 700 fathoms for over one hundred miles. This will be shown in a more detailed map hereafter.

The greatest depth of the Yucatan Channel is somewhat more than 1,100 fathoms, so that the temperature of all the water which finds its way into the Gulf of Mexico is necessarily at its deepest point (2,119 fathoms) only the temperature of the bottom of the Straits of Yucatan

(1,127 fathoms), namely, 39½° Fahrenheit. The depth of the channel through which the water of the Gulf finds its outlet is very much less, — not more than 350 fathoms, — and the Straits of Bemini are not half the width of the Straits of Yucatan, while the temperature of the water at the bottom is much higher, with a far greater velocity at the surface than that of the current flowing into the Gulf of Mexico through the Straits of Yucatan.

Extract from Letter of Lieutenant Commander C. D. Sigsbee to A. Agassiz.

"On the first of April we put to sea again [from Havana]; we steamed about one and a half miles from the Morro (East), and at the third haul in 177 fathoms, from disintegrated coral rock bottom, up came six beautiful "sea lilies." Some of them came up on the tangles, some on the dredge. They were as brittle as glass. The heads soon curled over and showed a decided disposition to drop off. At a haul made soon after we got more, and being afraid to put so many of them in the tank together, I tried to delude the animals into the idea that they were in their native temperatures by putting them into ice-water. This worked well, although some of them became exasperated and shed some of their arms. They lived in the ice-water for two hours, until I transferred them to the tank. They moved their arms one at a time. Some of the lilies were white, some purple, some yellow; the latter was the color of the smaller and more delicate ones. All the sea lilies were obtained from the same place.

"At a point on the coast about one and a half miles to the eastward of Morro, there are the ruins of two detached houses one hundred yards apart and near the shore. Bring either of these houses to bear S. S. E. in 175 fathoms of water and dredge; sea lilies are bound to come."

In addition to the Pentacrini, Captain Sigsbee obtained from the same ground a most interesting addition to the species collected previously, especially among the Echini, Ophiurans, and Corals.

The following report of the Mollusca by Mr. W. H. Dall of the United States Coast Survey gives the results of a preliminary examination of the mollusks obtained during the cruise of the United States Coast Survey steamer "Blake" in the Gulf of Mexico and vicinity, with some others from the same region obtained formerly by Count Pourtalés and Dr. Stimpson in the United States Coast Survey steamer "Bibb": —

"The collection embraces material from three bathymetrical regions, which are more or less mixed throughout.

"I. The Pteropods and Heteropods from the surface of the sea, which are found mixed with most of the others from whencesoever derived.

"II. The shore fauna of the Gulf and Caribbean region, which in most re-

spects is well known, and extends from the margin of the sea and land to various depths according to the local temperature, but rarely in a living condition below 250 fathoms. Dead specimens belonging to this region, disgorged by birds or fishes, or washed by currents, are found mixed with the true deep-water fauna, and require the exercise of caution in assigning to the latter its true members. Thus, for instance, I find a specimen of *Pupa*, a land-shell, in dredgings from over 800 fathoms. The specimens from great depths off Morro Light, Havana, Cuba, are particularly mixed with littoral material.

"III. Lastly, we have the true deep-sea species, ranging from 1,920 fathoms to 200 fathoms, according to temperature, many of them coming much nearer the surface, when the temperature is cool enough, than has commonly been taken for granted.

"The material from regions I. and II. does not call for any especial remark at this time, but appears to contain some new forms, among them *Calliostoma Psyche*, a beautiful new species of Trochoid shell, recalling European rather than the West American forms of the genus, and remarkable as being the second species of the group known to inhabit the Gulf, which is peculiar for the paucity of *Trochi*. It does not seem to inhabit the shores, but is intermediate between the true deep-sea forms and those of the shore. I find among the members of the third bathymetrical zone several species known to be widely distributed in the deep-sea, such as *Pleuronectia lucida*, Jeffreys, and species of *Limopsis arca*, etc. figured, but not named, in Thomson's Atlantic Ocean volumes of the "Challenger" voyage. Besides these, the most interesting species are *Lyonsia bulla*, n. s., which may with further study prove to belong to the fossil genus *Gressleyia* of Agassiz; *Euciroa elegantissima*, n. g. et sp., a beautiful pearly bivalve of the exquisite *Verticordia* group, which are mostly fossils; *Pleurotoma (Candelabrum) cathedralis*, n. s., an exquisite gem collected by Pourtalés in the Gulf Stream expedition several years ago, but of which the original specimens were lost in the Chicago fire; and *Dentalium perlongum*, n. s., the finest and most delicate of this abundant genus. The genera obtained from depths below 500 fathoms are *Limopsis*, *Arca*, *Aximea*, *Gouldia*, *Pleuronectia*, *Leda*, *Nucula*, *Lyonsia*, *Pleurotoma*, *Calliostoma*, *Trochus*, *Minolia*, and *Dentalium*, besides dead shells, which may or may not prove to belong with these associates.

"Of these, those from a greater depth than 1,000 fathoms are *Lyonsia bulla*, *Limopsis*, *Arca*, *Leda*, *Gouldia*, *Dentalium*, and a form of *Trochus* allied to *Minolia*. The *Lyonsia* cited came from the greatest depth of any, 1,920 fathoms.

"The general aspect of these collections is free from any trace of West American peculiarities. This was unexpected, remembering the *Haliotis* dredged off Florida by Pourtalés in his earlier work; but that species was, according to my recollection, more allied to African than West-American forms of the same genus, and might indeed have proved identical with some West-African deep-water species, had its characters been put on record before it disappeared in the Chicago conflagration.

"I shall send preliminary diagnoses of the few forms specifically named

above, to secure priority for American work; but with regard to the species mentioned or indicated in the "Challenger" reports, but not described, I have left all such untouched, as belonging, by proper courtesy, to the English naturalists to make known."

A good part of the collections made in the "Blake" have already been sent to several naturalists for examination, and I hope to be able to publish, without too great delay, the preliminary Reports in addition to the one of Mr. Dall printed with this letter. The Fishes have been intrusted to Dr. F. Steindachner, Director of the Zoölogical Museum of Vienna; the Sponges, to Prof. Oscar Schmidt of Strasbourg; the Crustacea and Starfishes, to Prof. Alph. Milne-Edwards and to Prof. E. Perrier of the Jardin des Plantes of Paris; the Annelids, to Prof. Ernst Ehlers of Göttingen. The Crinoids, as I have stated, will be sent to Sir Wyville Thomson, the Ascidians to Prof. Lacaze Duthiers, the Foraminifera to Mr. H. B. Brady, and the Ostracoda to Mr. G. S. Brady, both of Newcastle. In this country the Corals and Holothurians will be worked up by Mr. Pourtalés, the Ophiurans by Mr. Lyman, the Hydroids by Mr. S. F. Clark of the John's Hopkins University, and I shall take the Sea-Urchins myself. No disposition has as yet been made of the Halcyonoids and Bryozoa. As the latter are not numerous, it is possible that the collection does not contain many novelties. They will be examined and compared with the collection formerly made by Mr. Pourtalés, and described by Professor Smitt, of Stockholm.

EXPLANATION OF PLATE I.

From sketches by Captain Sigsbee.

The annexed sketches of Captain Sigsbee's water-bottle, Pl. I, Figs. 1, 2, will interest those who have used the apparatus for obtaining water from great depth. The method of closing the valves is entirely different from that employed by other hydrographers. It seems far more accurate for deep water than the water-bottles used by the "Challenger," and by the Swedish or the German expeditions. The tests to which it has been submitted show that it closes in a depth of about ten to fifteen fathoms, that it then remains hermetically sealed, and that no amount of pitching or stopping can open the valves again, when once closed. For serial lines the water-bottles and thermometers were not sent down on the sounding line, but a stronger steel cord, three eighths of an inch in circumference, was used, to which the thermometers and bottles were attached. No attempt was made on our trip to make any chemical examination of the water from different depths. The small size of the vessel made a chemical laboratory out of the question, and it seems more natural for another expedition to establish a laboratory on shore at some point near deep water, and carry the bottles to the laboratory for analysis.

Fig. 1 gives a view of Captain Sigsbee's water-bottle, seen facing the frame of the propeller (*p*), by which the valves are closed. As long as the bottle sinks, the valves remain open. These are connected by a rigid rod, extending through the centre of the bottle. The moment it is hauled up the propeller is forced down on the shaft, until it presses with all its force upon the upper valves, and when this takes place it also slips out from its connection with the upper end of the shaft, so that, should the bottle be lowered again, the propeller could not rise and the valves be opened.

Fig. 2 shows the same bottle, at right angles to Fig. 1, with the mode of attaching it to the steel rope (*z*) by means of a spring (*a*). This is done in an instant, and the bottles firmly held in place by the double spring holding the rope at two points. A similar mode of attachment for the deep-sea thermometers would be a great saving of time when making a serial line of temperatures.

Fig. 3 shows the mouth of an ordinary dredge, with the rope stopped round it to prevent its digging into the mud, as first applied by Captain Sigsbee.

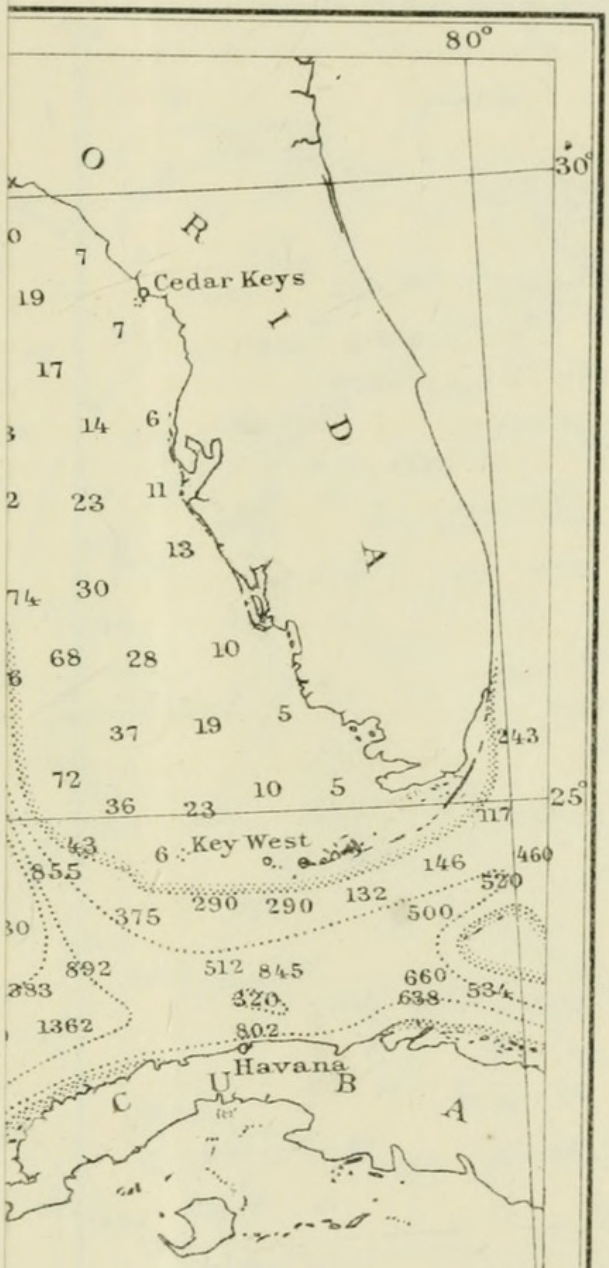
Fig. 4 gives a sketch of the iron frame of the flat dredge, with the mode of attaching the tangles, figured with its covering and appendages in Fig. 5.

Fig. 5. The dredge, as modified by Captain Sigsbee and Mr. Jacobi, in use on the "Blake." The end of the dredge-bag was, as in the trawl, securely tied and fastened to the frame, to prevent its reversing. A trap, as in an ordinary lobster pot, also prevented the washing out of many specimens when the dredge came to the surface. The opening of this dredge was 4 ft. by 12 inches.

Fig. 6. Section of Fig. 3.

Fig. 7. In a sketch of the double trawl (10 ft. beam) used on board the "Blake," the end of the trawl was securely tied so as to gain easy access to the specimens accumulated at the end of the trawl. A set of cork floats suspended in the middle of the trawl kept one side of the net well up from the bottom. The trawl had the usual trap. To the end of the trawl a common wooden detacher, similar to that of a deep-sea sounding machine, was fastened for detaching the shot with which it was usually weighted. At great depths weights were attached to the runners. The trawl was strengthened by ropes forming a large network to support it.

I hope, in my next letter, to be able to give detailed drawings of Captain Sigsbee's water-bottle and of his modifications of Sir William Thomson's sounding-machine.



OF MEXICO

Yucatan Bank from British
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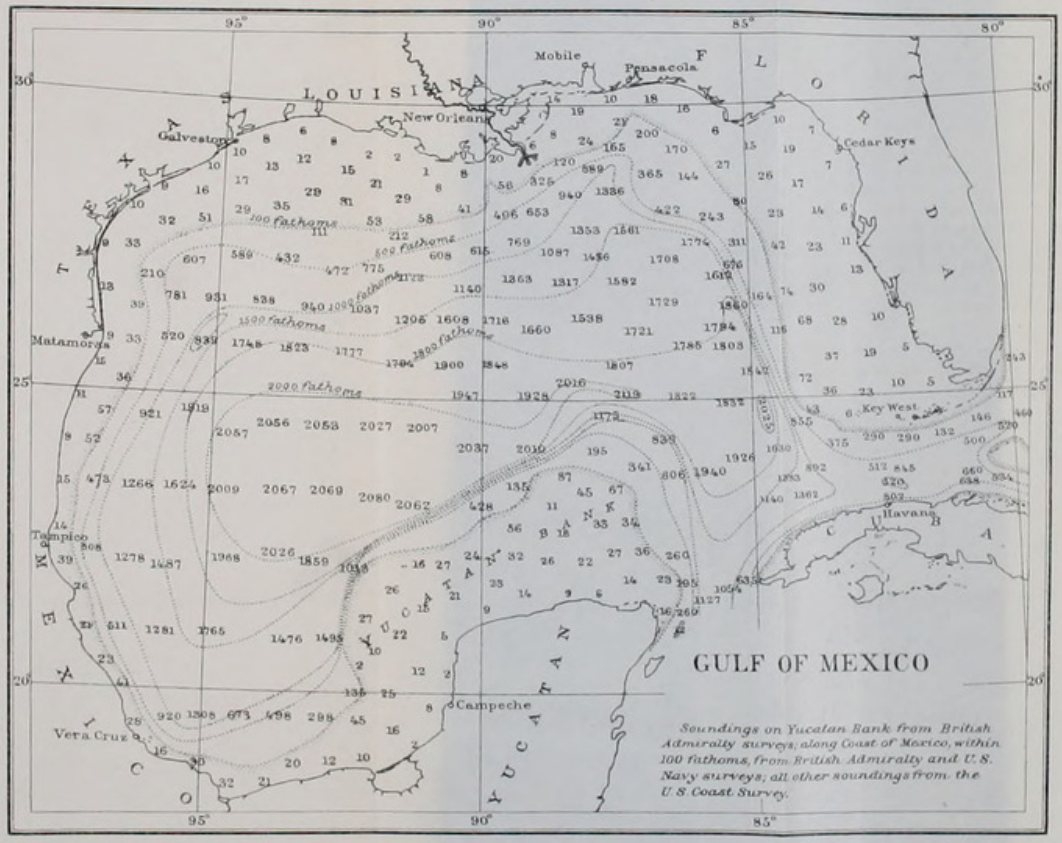
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Tampico
Vera Cruz
Campeche
YUCATAN
MEXICO
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500 fathoms
1000 fathoms
1500 fathoms
1800 fathoms
2000 fathoms
GULF OF MEXICO
Soundings on Yucatan Bank from British Admiralty surveys, along Coast of Mexico, within 100 fathoms, from British Admiralty and U. S. Navy surveys; all other soundings from the U. S. Coast Survey.