ture, and fineness of grain; but they are all composed of distinct particles of siliceous sand, often very fine, cemented by more or less abundant lime and magnesia carbonates. Sometimes small quartz pebbles occur in them. The fine-grained varieties of the rock are often exceedingly compact, hard, and tough, usually grayish or greenish in color. They are often bored by annelids, sponges, etc., and are usually weathered brown, due to the presence of iron (probably in part as carbonate, sometimes as pyrite). The sand consists mainly of rounded grains of quartz, with some felspar, mica, garnet, and magnetite. It is like the loose sand dredged from the bottom in the same region. The calcareous cementing material seems to have been derived mainly from the shells of Foraminifera, abundantly disseminated through the sand just as we find the recent Foraminifera in the same region. In some cases, distinct casts of Foraminifera are visible in the rock. In some pieces of the rock, distinct fossil shells were found, apparently of recent species (Astarte, etc.). The larger masses appear to have been originally concretions in a softer deposit, which has been more or less worn away, leaving the hard nodules so exposed that the trawl could pick them up. The age of these rocks may be as great as the pleistocene, or even the pliocene, so far as the evidence goes. No rocks of this kind are found on the dry land of this coast. It is probable, however, that they belong to a part of the same formation as the masses of fossiliferous sandy limestone and calcareous sandstone, often brought up by the Gloucester fishermen from deep water on all the fishing-banks, from George's to the Grand Bank.

The chemical composition of these limestone nodules is of much interest geologically. Analyses made by Prof. O. D. Allen prove that they contain a considerable amount of magnesia. They are, therefore, to be regarded as magnesian limestones, or dolomites, of recent submarine origin. They also contain a notable quantity of calcium phosphate. The presence of the latter is not surprising when we consider the immense number of carnivorous fishes, cephalopods, etc., which inhabit these waters, and feed largely upon the smaller fishes, whose comminuted bones must, in part at least, be discharged in their excrements. In fact, it is probable that the greater part of all the mud and sand that cover these bottoms has passed more than once through the intestinal canals of living animals. The Echini, holothurians, and many of the star-fishes and worms, continually swallow large quantities of mud and sand for the sake of the minute organisms contained in it, and from which they derive their sustenance.

The following partial analysis by Prof. O. D. Allen gives the percentage of the most important constituents. The sample analyzed was a hard, compact, and very fine-grained magnesian limestone. Its color was yellowish green, with a darker green surface, weathered rusty brown in some places. It contained some minute specks of iron pyrite. Its specific gravity was 2.73.

Composition of a deep-water limestone.

	Per cent.
Lime	24.95
Magnesia	14.41
Iron (estimated as protoxide)	2.00
Phosphoric acid (not weighed).	
Insoluble residue (sand)	16.97

WATER-BOTTLES AND THERMOMETERS FOR DEEP-SEA RESEARCH AT THE INTERNATIONAL FISHERIES EXHIBITION.

IT would naturally be expected that at an exhibition of this kind in England, where so much has been done in the past for deep-sea investigations, there would be found a good collection of the apparatus used in deep-sea work. Great Britain has, in fact, shown almost nothing of the kind; indeed, one may say, nothing whatever that especially relates to deep-sea investigation. After spending the not inconsiderable sum of money required to fit out the Challenger, the British government seems to have lost all interest in deep-sea exploration; and other nations are carrying on the work with greatly improved apparatus, while Great Britain rests content with the laurels already won.

The United States exhibit is the most complete of all, as regards apparatus of this kind. Denmark and Sweden have some apparatus for collecting specimens of water and observations of temperature, which, with the later forms used by the U.S. fish-commission and by the coast-survey, will form the main subject of this article.

The Swedish apparatus was devised by Prof. F. L. Ekman, principally for the use of the Swedish expedition of 1877, which carried out very thorough and systematic hydrographic investigations in the waters extending from the North Sea, through the Baltic, to the extreme end of the Gulf of Bothnia. Although the apparatus worked with entire satisfaction, it would scarcely be used at the present time, for it is unnecessarily heavy and large, Two forms of apparatus for collecting samples of water from different depths are shown, both constructed on the same principle. The larger, having an ingenious means of closing, is chosen for description here. It consists of a brass cylinder open at both ends, about ten inches in length by four and a half in diameter, sliding freely through a space somewhat greater than its length, between three vertical brass rods or guides, which also constitute the frame of the apparatus. When the cylinder slides down, it encloses a vertical rod having a horizontal plate at the top, which forms a tight cover for the cylinder, similar to the end of a piston. The bottom of the cylinder falls into an annular groove in which a sheet-rubber ring is fitted, thus making a tight joint below. A rubber ring is also employed to make the upper joint tight. In the smaller instrument the lower groove is filled with a mixture of suet and wax; and the cylinder has an annular plate on top, the border of which extends inwards sufficiently to be bent downward so as to fit into a similar groove on the upper surface of the horizontal disk forming the top of the closed chamber. When the apparatus is sent down, the cylinder is suspended at the top. When it reaches the desired depth, the cylinder is released by a mechanism to be described, and falls, enclosing a sample of the water. In the smaller apparatus the cylinder is sustained during descent by the resistance offered by the annular plate above referred to, which is considerably larger than the diameter of the cylinder. On drawing up the apparatus, the plate also acts to force the cylinder well down into the grooves. In the larger instrument the cylinder is held up by a catch, actuated by a system of levers, which are connected with a turbine wheel enclosed in a brass case at the top. During descent the water passes through the case, entering and leaving it freely through strainers of brass gauze, and causes the turbine to revolve. The latter turns freely until the desired depth is reached. When ascending, the wheel makes a certain number of revolutions in the opposite direction, and soon acts upon the system of levers through a ratchet and ratchet-wheel, thus releasing the cylinder. This instrument has been successfully used in depths of three hundred metres. It is sufficiently good to enable the quantity of air contained in the water at different depths to be determined.

Arfwidson's water-bottle, exhibited by Denmark, is a simple cylinder of brass, shaped somewhat like a bell, closed by bottom and top plates with bevelled edges connected by a central stem. The bell falls, and the whole apparatus is drawn up by the central rod. The joints are made tight by grinding the plates and cylinder together. It is very simple, very light, and seems to be a good instrument. No information concerning its use is available at the present moment.

Another of Professor Ekman's instruments is used to collect samples of water, and also to enable the temperature to be correctly determined. Although quite different in construction from the others, it is the same in principle, except that it is made to protect the sample from any change of temperature while being drawn up, so that a thermometer may be introduced on deck to get the temperature of the stratum of water from which it was taken. The instrument has been found to give accurate results at depths of two hundred metres. It is not stated whether it has been used at greater depths.

In this instrument the cylinder is fixed between two galvanized iron rods, which, with four horizontal circular bands of the same material outside, constitute the frame, resembling a sort of cage. The top and bottom of the cylinder are formed by what may be described as two piston-heads connected together by a hollow rod, which slides up and down on another rod running vertically through the middle of the apparatus. The piston-heads are made of thick gutta-percha secured between brass plates. The connecting-rod is also covered with gutta-percha, and the cylinder itself is lined with it. Rubber is used to make the joints perfectly tight. The sample of water is thus protected by gutta-percha in every direction about two and a half centimetres in thickness. The upper piston-head carries a brass plate, which offers sufficient resistance to the water, while descending, to sustain it at the top of the apparatus. On hauling in, the water forces the piston down into the cylinder, enclosing the sample. The apparatus gives remarkably good results, if we may judge from some of the figures given in the case of a series of temperatures taken in the Baltic, where the alternations of cold and warm strata were quite remarkable. The temperatures were recorded to tenths of a degree of Celsius's scale, as, indeed, it was necessary that they should be, in order to make the results of unquestionable value; for the total variation in temperature between depths of 50 metres (when the temperature was 1°.8) and the bottom, 210 metres, was only 2°.1 C., yet there was a rise to 3°.9 at 100 metres, and a fall to 3°.1 at 210 metres.

No one would undertake to obtain such results with any deep-sea thermomèter in use at that time. The Miller-Cassella instrument would utterly fail to record the temperatures at the bottom; and, even if it did record them, its readings would not be regarded as within half a degree F. of the exact temperature. The Siemens electric apparatus, which has been used on the Blake with great success, cannot be depended upon for greater accuracy than a quarter of one degree.

Capt. G. Rung of the Danish meteorological institute exhibits some thermometers enclosed within thick layers of cork, only the scales being exposed to view. In this way it is possible to obtain deep-water temperatures; for the instruments can be hauled upon deck, and readings made, before any heat can pass through the cork. This method, however, seems rather primitive; and, even if practicable, it is quite too slow to receive much commendation.

Fig. 1.

There can be no doubt that the best deep-sea thermometer is the latest Negretti and Zambra form, represented in fig. 1. It is so well known that a full description is not necessary; but as a reminder it may be said, that, when the instrument is upright, the mercury extends up into the tube to a height corresponding to the temperature. If then inverted, the mercury breaks at a particular point in the bend A, and runs down to the other end, where the temperature is read off. The small quantity of mercury in the bore does not appreciably change its length for slight variations of temperature. For a long time this has been the favorite instrument for taking deep-sea temperatures singly, but until lately no means had been devised for taking serial temperatures with it at a single cast. At the fisheries exhibition are shown three new methods of inverting the instrument at a given depth. The first we shall mention is exhibited by Capt. G. Rung of Denmark. It is scarcely worth while to describe this apparatus in detail; for, although it is undoubtedly an excellent device, the two other methods to be described are much better, because they are lighter and smaller. Capt. Rung inverts the thermometer by sending down a messenger along the line. By causing the inversion of each instrument to free a messenger to invert the next instrument below it, he obtains serial temperatures in the same manner as is done with the new device of Mr. W. L. Bailie, to be soon described.

Capt. Rung also exhibits a water-bottle and thermometer combined. A brass cylinder, perforated at the bottom with three small orifices, has a piston working air-tight within it. Within the piston-rod, which is perforated here and there, is a Negretti and Zambra thermometer, the bulb being at the outer extremity of the rod.

To use the apparatus, the piston is shoved in, and the end of the sounding-rope tied to the projecting end of the piston-rod. The apparatus is then inverted; and the lower end of the cylinder, being now uppermost, is secured to a catch a short distance up on the line. In this position it is lowered to the required depth, when a messenger is sent down which releases the cylinder. It falls, turns over, and the weight is then transferred to the piston-rod. The thermometer, being now bulb up, registers the temperatnre; while the weight of the cylinder causes it to pull the piston-rod out to the fullest extent, and, as the piston rises, it draws the water into the cylinder through the small holes in the bottom.

In figs. 2 and 3 we have illustrations of the ingenious apparatus devised by Commander Magnaghi of the Royal Italian navy, and exhibited by Messrs. Negretti and Zambra. It will be seen that the propeller-wheel C screws up or down as it revolves. During descent the propeller does not move, as the pin F is against the stop G. On reversing the motion, the propeller screws upward until the screw E releases the case, which then turns over, as in fig. 3, and is held in position by the spring K.

A still later form of this instrument has just been made, in which the thermometer-case is suspended on trunions at the lower end, instead of near the middle.

Another method for accomplishing the same result has been devised by Mr. W. L. Bailie, U.S.N. In his arrangement the case of the thermometer is attached to the sounding-wire by a cam-catch at the bottom, and by two lateral spring jaws at the top, which encircle the wire.

A brass messenger is sent down the wire when the desired depth is reached, which opens the jaws, thus releasing the top of the case. The latter then falls over, turning on a swivel at the bottom. A hook at the bottom carries a second messenger, which is released as the case turns over, and falls down to invert the next instrument; and so on through the series. Instead of sending down a messenger on the wire, a propeller-wheel has also been arranged to open the jaws, so that either method may be employed.

The question arises, whether, with these excellent methods of using the instrument, the Negretti and Zambra thermometer cannot be made to record accurately to tenths of a degree. It would seem, that, by giving it a short range and a comparatively long tube,

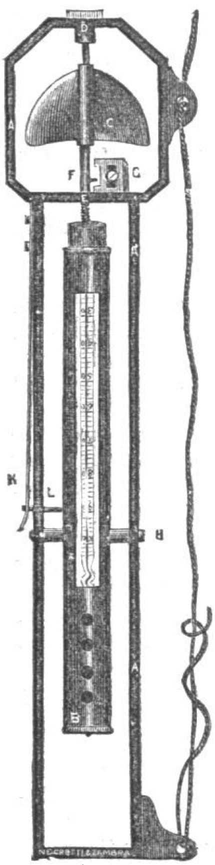

Fig. 2.

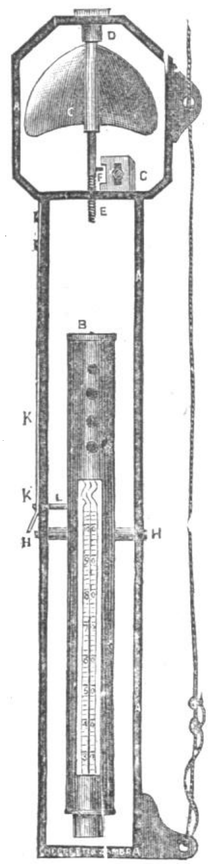

Fig. 3.

this might be done. If not, the most delicate observations for sub-surface temperatures will probably have to be made with some form of apparatus, which, like that used by Professor Ekman, brings the water to the surface in a case covered with a material through which heat cannot readily pass, or else by sending down a thermometer enclosed, like Capt. Rung's, in a thick case of non-conducting material. R. Hitchcock.

London, June 1, 1883.

REAL ROOTS OF CUBICS.

THEOREM I.

[In the equation $x^3 + Ax^2 + B = 0$, when the roots are real, A and B have opposite signs; and simultaneously changing the signs of A and B changes signs of roots of equation.]

Assume $x = a,\ x = b,\ x = -\frac{ab}{a+b}$.

$$x^3 - \frac{1}{a+b}(a^2+ab+b^2)x^2 + \frac{1}{a+b}(a^2b^2) = 0; \quad (1)$$

and, changing signs of roots,

$$x^3 + \frac{1}{a+b}(a^2+ab+b^2)x^2 - \frac{1}{a+b}(a^2b^2) = 0. \quad (2)$$

Since the factors $(a^2 + ab + b^2)$ and (a^2b^2) are positive when the roots are real, whatever the sign of $\frac{1}{a+b}$, A and B will have opposite signs, and, from (1) and (2), simultaneously changing signs of A and B changes signs of roots of equation.

THEOREM II.

$\left[\frac{A^3}{27}\right.$ is greater than $\frac{B}{4}$ in quantity.$\left.\right]$

$$\text{Assume} \quad \left(\frac{a^2+ab+b^2}{3(a+b)}\right)^3 > \frac{a^2b^2}{4(a+b)} \quad (3)$$

$$\text{or} \quad \left(\frac{a^2+ab+b^2}{3}\right)^3 > a^2b^2\left(\frac{a+b}{2}\right)^2;$$

$$\text{but} \quad \left(\frac{a+b}{2}\right)^2 \geqq ab \quad \text{(Algebra)}:$$

hence inequality (3) is true.

From (1), omitting the term $\frac{A}{3}$,

$$\frac{x}{\left(-\frac{B}{4}+\frac{A^3}{27}\right)^{\frac{1}{3}}} = \left(1+\frac{\sqrt{\frac{B}{4}}}{\sqrt{-\frac{B}{4}+\frac{A^3}{27}}}\sqrt{-1}\right)^{\frac{2}{3}} + \left(1-\frac{\sqrt{\frac{B}{4}}}{\sqrt{-\frac{B}{4}+\frac{A^3}{27}}}\sqrt{-1}\right)^{\frac{2}{3}}; \quad (4)$$

and, from (2),

$$\frac{x}{\left(\frac{B}{4}\right)^{\frac{1}{3}}} = \left(1+\frac{\sqrt{-\frac{B}{4}+\frac{A^3}{27}}}{\sqrt{\frac{B}{4}}}\sqrt{-1}\right)^{\frac{2}{3}} + \left(1-\frac{\sqrt{-\frac{B}{4}+\frac{A^3}{27}}}{\sqrt{\frac{B}{4}}}\sqrt{-1}\right)^{\frac{2}{3}}. \quad (5)$$