

more than $10\frac{1}{2}$ millions, the Dutch Meteorological Institute in De Bilt $3\frac{1}{2}$ millions, the Hydrographical Bureau in Washington $5\frac{1}{2}$ millions, and so on. Add to this the surface observations made by scientific and other expeditions, and it will be evident that in the course of the last sixty years a good deal of knowledge regarding the surface of the sea has been gained.

Making surface-temperature observations is very simple work. All that is necessary is to haul up a bucket of sea-water and measure the temperature by means of an ordinary thermometer. It is a far more difficult thing to record the actual temperature of the deeper layers. In 1749 Captain Ellis brought up water from 1190 metres and from 1645 metres to the south of the Canaries, and, on measuring the temperature of the water inside the water-bottle after it had been hauled up, found it to be 17.2° C. lower than the temperature at the surface. Some investigators coated their water-bottles with an insulating substance, so that the temperature might remain unaltered during the process of hauling up. This principle has recently been developed to a high degree of perfection in one of the water-bottles now most used, viz. the Pettersson-Nansen water-bottle, which will be described later.

Attempts were also made to insulate the thermometer itself by surrounding the bulb with a stout sheath of caoutchouc or wax. This insulated thermometer was lowered to the depth desired, where it was left for hours to assume the temperature of the water; it was then hauled up quickly and the temperature read off. In this manner de Saussure was able, in 1780, to determine correctly the temperature in the Mediterranean at 585 metres, finding it to be 13° C. Thermometers made on this principle have been much used until our own times, but they have one serious drawback, for the operation takes a very long time, and this makes them unsuitable for use in expeditions, where the work must be done as quickly as possible; they may, however, do good service in cases where the very greatest accuracy is not required, and where there is unlimited time at disposal, as on light-ships.

Nearly a hundred years ago some one thought of employing Six's maximum and minimum thermometer for temperature observations in the sea, various modifications being introduced, until finally in 1868 it became quite serviceable as made by Casella under the direction of Dr. Miller. The Miller-Casella thermometer (see Fig. 154) was the one principally used on board the "Challenger" and during other great expeditions. At the

Temperature observations at the surface of the sea.

Temperature observations beneath the surface.

Insulating water-bottles.

Insulating thermometers.

Maximum and minimum thermometers.

Miller-Casella.