introduced for determining position, and are based upon astronomical and geodetic observations. The survey of coast-lines is no longer made by the aid of the compass, but by accurate and really scientific methods. The meteorological element is introduced in the graphical representation of the seas, hydrographic signs guide the seaman, reliable soundings for every important point show the depth of water, the currents are indicated, and any peculiarities relating to local tides are marked with precision. The bathymetrical charts of Maury and Delesse, the wind and current charts of the Hydrographic Office, and the temperature charts of the Meteorological Office published previous to 1872, all show great progress in these branches of knowledge. The latest cartographic elements introduced are those relating to depth and the nature of the bottom, which were especially investigated by the Challenger Expedition. The study of deep-sea deposits has been brought about by the requirements of navigation and the more modern applications of electricity, and now constitutes an important branch of oceanography. Since the Challenger Expedition, charts show soundings and the nature of the bottom at all depths in nearly every region of the ocean, the reliefs of the ocean basins being indicated with much definiteness.

Deep-Sea Temperatures and Thermometers,—Cavendish, Irvine.

The first self-registering thermometer was made by Cavendish about 1757,[1] who suggested that it might be applied to ascertaining "the temper of the sea at great depths." It was applied for this purpose by Dr. Irvine, who accompanied Lord Mulgrave to the Arctic in 1773; during this expedition one of the first attempts was made at deep-sea sounding, the deepest cast being 683 fathoms. Irvine seems also to have sent down a water bottle of his own construction, the water brought up having a temperature of 40° F., the surface being 55° F. De Saussure in 1780, by using padded and protected slow-action thermometers, was able to ascertain correctly the temperature of the Mediterranean at 300 and 600 fathoms.[2] Six's[3] combined maximum and minimum thermometer was invented in 1782, and was used by Krusenstern in 1803 and by Sir John Ross in 1818. Du Petit Thouars in 1832, in the Atlantic and Pacific, and Martins and Bravais in 1839, off Spitzbergen, made use of forms of protected thermometers in attempting to measure the temperature of deep water. During Sir James Clark Ross's Antarctic expedition the temperature of the water was observed very frequently at all depths down to 2000 fathoms, and its density at the surface and at various depths was determined almost daily. These observations were very valuable at the time, as giving the first real clue to the distribution of temperature at the bottom of the sea, but in this expedition, and in those of Wilkes and D'Urville, the thermometers were not properly protected

De Saussure.

Ross.

[1] *Phil. Trans.*, vol. l. p. 308, 1757. Cavendish's maximum thermometer is constructed on the same principle as that known in France as Walferdin's *outflow* thermometer; his minimum thermometer is on the same principle, but has a U-formed stem instead of a straight one.

[2] H. B. de Saussure, Voyages dans les Alpes, Neuchatel, 1796. In the agenda (tome iv.) he gives a scheme for a complete study of the oceans; many lines of work there suggested have since been carried out.

[3] *Phil. Trans.*, vol. lxxii. p. 72, 1782.