

temperature, instead of sending a thermometer to the required depth, was that followed by all navigators up to the beginning of this century, and many valuable observations were made by its means, more especially in the colder waters of the Arctic seas. Various forms of special apparatus were designed and made for the purpose of securing the sample of water, and bringing it to the surface with as little change of temperature as possible, but they all consisted essentially of a vessel, as large as could conveniently be made, furnished at top and bottom with valves opening upwards. While descending these valves were kept open by the rush of water through the apparatus, and while ascending, they were kept shut by the resistance of the water. In many cases where no special apparatus was at hand, one was improvised out of a cask, and its use for this purpose demonstrated to many of these experimenters the enormous effect of the pressure of the water, especially on structured substances like wood. There being very little difference in the temperature of the water at different depths in the Arctic Seas, the results thus obtained were very accurate and valuable.

Whether the water is brought from the required depth and then tested according to the original method of Ellis and Hales, or the thermometer suitably protected is sent down to the water, then brought up and observed according to the method of Saussure, the accuracy of the results depends largely on the skill of the observers and on the approach to uniformity of temperature in the columns of water traversed. In the case of Saussure's observations on the temperatures of lakes in Switzerland and of Fischer and Brunner's on the Lake of Thun, there can be no doubt as to the trustworthiness of the results, as the experiments were made with very great care and attention to every particular; but the method besides occupying much time could not be recommended to any but skilled and careful observers. The same applies, but in a much less degree, to the use of the "sea gauge."

A method of determining the temperature at the bottom, analogous to the use of the sea gauge, consists in bringing up in a dredge or other apparatus as large a sample of the bottom as possible and plunging a thermometer into it. As a mass of mud conducts heat very slowly and is not affected by convection currents, the temperature of its interior is but very slowly affected by variations in that of the surrounding medium.

*Self-Registering Thermometers.*—By far the greatest number of observations has been made with self-registering thermometers of one form or another.

The first self-registering thermometer was made by Cavendish.<sup>1</sup> He constructed both a maximum and a minimum thermometer, and they were of the kind called by the French *à déversement, out-flow* thermometers. In fact, his maximum thermometer is in every particular identical with that known in France as Walferdin's; his minimum is on the same principle, but has a U-formed stem instead of a straight one. There are two

<sup>1</sup> *Phil. Trans.*, vol. 1. p. 300, 1758.