in the spirit in each limb above the mercury, which pushes one or other before it as the temperature is rising or falling, and leaves them at points denoting the highest and lowest tempera­tures passed through. The indexes are set by a magnet. The “Challenger” thermometers, which were not graduated on the stems, were secured side by side with porcelain temperature scales to vulcanite frames and placed in copper cases perforated to allow a circulation of water. Tait investigated the whole subject of pres­sure corrections after the return of the expedition, and found that the high result obtained by a previous experimenter was due mainly to heat developed by compression of the vulcanite, which affected the thermometer in the press, but would not do so at sea. The correction which had to be applied was rather less than 1/7 of a degree Fahr. per mile of depth.@@1 These thermometers require to be immersed from twenty minutes to half an hour before they acquire the temperature of the water, they can only be read to quarter degrees Fahr., and they simply indicate the extreme tem­peratures through which they have passed. Buchanan has greatly improved the instrument by reducing the bore of the tube on the minimum side, which is that most frequently used, thus giving long degrees. An arbitrary scale is engraved on the stem.@@2 His mercury piezometer is affected by temperature and by pressure, and enables the actual temperature at any known depth to be found.

Aimé in 1845@@3 invented a very ingenious arrangement of outflow thermometers, which were inverted by a weight slipping down the line, and registered as they were being drawn up. His instru­ments were accurate, but very delicate and troublesome to manage. Within the last few years Negretti and Zambra have patented several forms of modified out­flow thermometers. The first instrument of the kind was complicated and unmanageable, but that now before the public is both simple and convenient. It consists of a mercury thermometer with a cylindrical bulb and a stem AC (fig. 7) of wide bore terminating in a small pyriform aneurism. The stem is contracted and contorted just above the bulb, and when the in­strument is turned upside down the mercury column breaks at this point and flows down into the tube, which is graduated in the inverted position. To pro­tect it from pressure the thermometer is hermeti­cally sealed in a strong glass tube, the portion of which surrounding the bulb contains a quantity of mercury secured by a ring of india-rubber cement. When the thermometer is made to turn over at any depth in water of any temperature, the record remains nearly unaltered, and, until set for a new observa­tion, enables the actual temperature at the instant of reversal to be ascertained at any subsequent time and in any other place. The detached column stand­ing in the tube changes its length slightly by change of temperature. A series of experiments with twelve instruments has shown that for 60o F. change of tem­perature there is a difference of one degree in the reading of the inverted thermometer. Hence a cor­rection must be applied in all cases where the tem­perature at which the thermometer is read differs more than a few degrees from that at which it was inverted, contrary to the opinion of the German observers.@@4 If a thermometer is inverted in water and read while wet, the temperature by which it should be corrected is obviously that given by the wet-bιdb in air. In view of the great range of temperature experienced in deep-sea work in the tropics, the size of the little overflow cell B, which prevents mercury from the bulb from entering the tube must be considerably increased before the thermometer can be used with safety for such purposes. The Negretti and Zambra thermometer acquires the temperature of its surroundings very rapidly (two or three minutes are usually sufficient); it can be read easily to tenths of a degree Fahr. ; and, above all, it ascertains temperature at exact points of depth, and has thus revealed layers of remarkably varying temperature @@5 which could not have been detected by the other instruments in use.

The loaded wooden frame originally employed for reversing the thermometer is unsatisfactory, and” Magnaghi’s reversing gear actuated by the revolution of a small propeller set in motion by the water when the thermometer is drawn up briskly, is not to be trusted in shallow water or where there are rapid currents. When the pin is withdrawn the thermometer case turns over and is clamped by a side-spring on the frame. Rung@@6 adopted a simpler and better though somewhat clumsy frame, in which the thermometer was made to turn by slipping a weight down the line.

The United States Fish Commission@@7 employ the thermometer in a frame adapted for use on a wire sounding line, and also actuated by a messenger, but the thermometer is not clamped on turning over. The Scottish marine station produced@@8 a modification of Magnaghi’s frame, the propeller being replaced by a forked lever held down by a spiral spring and raised when the thermometer is to be reversed by the impact of a Rung’s messenger (fig. 8). A messenger placed on the line below, and hung by a loop to the upper groove of the thermometer, is let go when the thermometer turns and reverses another instrument lower down. Instead of being lashed to the sounding line, the frame is retained by a ram’s horn spiral below and clamped by a small vice at the upper end. Buchanan has modified and simplified the frame, combining its mode of attachment to the line with the American method of reversing.

Neumayer@@9 has attempted to use a photo­graphic thermograph for deep-sea work, the light being supplied by a Geissler tube excited by a small battery. Siemens’s electrical ther­mometer has also been experimented with,@@10 but has hardly been brought to a practicable state, and the same may be said for the use of thermoelectric junctions.

Hypsometer.—The boiling-point thermome­ter or hypsometer may be used to obtain an independent measure of the pressure of the atmosphere, and so to determine an altitude or verify an aneroid barometer. It consists of a very delicate mercury thermometer gradu­ated only for 20 or 25 degrees Fahr. in the neighbourhood of the boiling point of water and divided on the stem into tenths. A large aneurism on the tube a little above the bulb should allow the freezing point to be verified from time to time on the portion of stem beneath it. The thermometer is hung in a cylindrical tin vessel in which water is boiled by a spirit lamp placed underneath. The bulb must be raised considerably above the level of the water, and the whole stem to the top of the mercury column immersed in the steam. After steam has been escaping freely for some time the temperature is read, and by reference to a table the barometric pressure, and consequently the altitude, is obtained.

Clinical Thermometers.—The first use to which thermometers were applied was the study of the temperature of the blood in fevers ; and the constancy of the temperature of the healthy human body was for a century considered sufficient to entitle it to the posi­tion of a fixed point in graduating thermome­ters. The increased importance now attached to temperature in disease has led to the pro­duction of many forms of clinical thermo­meter. The large instruments intended to be read in situ are now entirely superseded by small maximum self-registering thermometers. Graduation is carried to one-fifth of a degree, and the usual range is about 25 degrees Fahr., —from 85° or 90° to 110o or 115o. Olive-shaped bulbs have been used, but a cylindrical form is most common. There should be an arrangement like that suggested for hypso­meters to enable the freezing point to be verified. Casella’s thermo­meter on Phillips’s system has a small expansion on the stem, followed by a contraction, to prevent the index following the rest of the mercury into the bulb when the instrument is not in use. The “half-minute thermometer” is quick in action ; it has a bulb of very small diameter and an extremely fine bore, the mercury thread being rendered visible by Hicks’s arrangement of a lens- fronted stem. Immisch’s avitreous thermometer is recommended for clinical use on account of its small size, convenient shape, and non-liability to get out of order.

Thermometers for Technical Purposes.—These are made in an infinite variety of forms, adapted to the various processes of manu­facture and industry. The scale is often dispensed with in these instruments, a movable pointer being fixed at the point at which the mercury is to be kept. Air or steam thermometers (see Pyro­meter) are rapidly superseding mercury instruments for all tem­peratures above the boiling point of water. The cheap German paper-scale thermometers are largely used, fitted in wooden cases,

@@@1 “ *Challenger Narrative,* ii., App. I., 1882.

@@@2 For a general account of deep-sea thermometers, see Buchanan, *Proc. R. S. E.,* x. 1878, 77; and “ *Chal." Reports,* Narrative, vol. i., 1884, p. 84.

*@@@3 Ann. Chim. Phys.,* [3], 1845, xv. 1.

*@@@4 Ergebnisse der Untersuchungensfahrt der Drache.* Berlin, 1886, p. 2.

@@@5 Mill, *Jour. Scot. Met. Soc.* [3], 1886, No. iii. p. 289.

@@@6 *Den Tekniske Forenings Tidskrift,* 1883.

@@@7 *Report,* 1882.

@@@8 Mill, *Proc. R. S. E.,* xii., 1884, 928.

@@@9 *Nature,* viii. 195.

@@@10 “ *Challenger" Reports,* Narrative, 1884, i. p. 95.