the application of the equation to special cases which lead to definite, but not necessarily identical, thermometric scales. There are three special cases of practical importance, corre­sponding to three essentially distinct experimental methods.

(i.) *Volumetric Method* (constant-pressure).—In this method V is variable and *p* and M are constant. This method was employed by Gay-Lussac, and is typified in the ideal thermo­meter with reservoir of variable capacity designed by Lord Kelvin *(Ency. Brit.,* ed. ix., vol. xi. p. 575, fig. 10). It corre­sponds to the method ordinarily employed in the common liquid-in-glass thermometer, but is not satisfactory in practice, owing to the difficulty of making a bulb of variable and measurable volume the whole of which can be exposed to the temperature to be measured.

(ii.) *Manometric Method* (constant-volume or density).—In this method *p* is variable and V and M are constant. Varia­tions of temperature are observed and measured by observing the corresponding variations of pressure with a mercury mano­meter, keeping a constant mass, M, of gas enclosed in a volume, V, which is constant except for the unavoidable but small expansion of the material of which the bulb is made.

(iii.) *Gravimetric Method* (constant-pressure).—In this method M is variable and *p* and V are constant. This method is gene­rally confounded with (i.) under the name of the constant­pressure method, but it really corresponds to the method of the weight thermometer, or the “ overflow ” method, and is quite distinct from an experimental standpoint, although it leads to the same thermometric scale. In applying this method, the weight M of the vapour itself may be measured, as in Regnault’s mercury-vapour thermometer, or in Deville and Troost’s iodine-vapour thermometer. The best method of measuring the overflow is that of weighing mercury displaced by the gas. The mass of the overflow may also be estimated by observing its volume in a graduated tube, but this method is much less accurate.

In addition to the above, there are mixed methods in which both *p* and V or M are variable, such as those employed by Rudberg or Becquerel; but these are unsatisfactory for pre­cision, as not leading to a sufficiently definite thermometric scale. There is also a variation of the constant-volume method (ii.), in which the pressure is measured by the volumetric compression of an equal mass of gas kept at a constant tempera­ture, instead of by a manometer. This method is experimentally similar to (iii.),\*and gives the same equations, but a different thermometric scale from either (ii.) or (iii.). It will be considered with method (iii.), as the apparatus required is the same, and it is useful for testing the theory of the instrument. We shall consider in detail methods (ii.) and (iii.) only, as they are the most important for accurate work.

10. *Construction of Apparatus.—*The manometric or constant­volume method was selected by Regnault as the standard, and has been most generally adopted since his time. His apparatus has not been modified except in points of detail. A description of his instrument will be found in most text-books on heat.

A simple and convenient form of the instrument for general use is Jolly’s (described in Poggendorff’s *Jubelband,* p. 82, 1874), and represented in fig. 3. The two vertical tubes of the manometer are connected by an india-rubber tube properly strengthened by a cotton covering, and they can be made to slide vertically up and down a wooden pillar which supports them; they are provided with clamps for fixing them in any position and a tangent screw for fine adjustment. The connexion between the bulb and the manometer is made by means of a three-way tap. The scale of the instrument is engraved on the back of a strip of plane mirror before silvering, and the divisions are carried sufficiently far across the scale for the reflections of the two surfaces of the mercury to be visible behind the scale. Parallax can thus be avoided and an accurate reading obtained without the necessity of using a cathetometer. In order to allow for the expansion of the glass of the reservoir a weight-thermometer bulb is supplied with the instrument, made from another specimen of the same kind of glass, and the relative expansion of the mercury and the glass can thus be determined by the observer himself. The volume of the air-bulb and that of the capillary tube and the small portion of the manometer tube above the small beak of glass, the point of which serves as the fiducial mark, are determined by the instru­ment-makers. The improvements introduced by Chappuis, of the International Bureau at Sèvres, in the construction of the con­stant-volume hydrogen thermometer selected by the committee for the determination of the normal scale, are described in the text-books (e.g. Watson’s *Physics).* The most important is the combination of the manometer and the barometer into a single instrument with a single scale, thus reducing the number of readings required. The level of the mercury in the branch of the mano­meter communicating with the bulb of the gas thermometer is adjusted in the usual manner up to a fixed contact-point, so as to reduce the contained gas to a constant volume. Simultaneously the barometer branch of the manometer is adjusted so that the surface of the mercury makes contact with another point fixed in the upper end of the barometer tube. The distance between the two contact-points, giving the pres­sure of the gas in the thermometer, is deduced from the reading of a vernier fixed relatively to the upper contact­point. This method of reading the pres­sure is probably more accurate than the method of the cathetometer which is usually employed, but has the disadvan­tage of requiring a double adjustment.

II. *Pressure Correction.—*In the prac­tical application of the manometric method there are certain corrections peculiar to the method, of which account must be taken in work of precision. The volume of the bulb is not accurately constant, but varies with change of pressure and tempera­ture. The thermal expansion of the bulb is common to all methods, and will be considered in. detail later. The pressure correction is small, and is determined in the same manner as for a mercury thermo­meter. The value so determined, however, does not apply strictly except at the temperature to which it refers. If the pressure-coefficient were constant at all temperatures and equal to *e,* the pressure correction, *dt,* at any point *t* of the scale would be obtainable from the simple formula

*dt=ep0t(t-ιo0)T0*  (10)

where *p0* is the initial pressure at the temperature T0. But as the coefficient probably varies in an unknown manner, the correction is somewhat uncertain, especially at high tempera­tures. Another very necessary but somewhat troublesome correction is the reduction of the manometer readings to allow for the varying temperatures of the mercury and scale. Since it is generally impracticable to immerse the manometer in a liquid bath to secure certainty and uniformity of temperature, the temperature must be estimated from the readings of mercury thermometers suspended in mercury tubes or in the air near the manometer. It is therefore necessary to work in a room specially designed to secure great constancy of tempera­ture, and to screen the manometer with the utmost care from the source of heat in measurements of high temperature. Regnault considered that the limit of accuracy of correction was one-tenth of a millimetre of mercury, but it is probably possible to measure to one-hundredth as a mean of several readings under the best conditions, at ordinary temperatures.

12. *Stem-Exposure.—*In all gas thermometers it is necessary in practice that the part of the gas in contact with the mercury or other liquid in the manometer should not be heated, but kept at a nearly constant temperature. The space above the mercury, together with the exposed portion of the capillary tube connecting the manometer with the thermometric bulb, may be called the “ dead space.” If the volume of the dead space is kept as nearly as possible constant by adjusting the mercury always up to a fixed mark, the quantity of air in this space varies nearly in direct proportion to the pressure, *i.e.* in proportion to the temperature of the thermometric bulb