the comparison of platinum thermometers with the constant­volume nitrogen thermometer by Harker and Chappuis *(Phil. Trans.* A. 1900), working at the International Bureau at Sèvres, over the range 0° to 650° C. It has also been shown to satisfy very closely the observations on the variation of electrical resistance of other metals over wide ranges of tem­perature. Although the theoretical explanation of the formula has not yet been given, owing to our ignorance of the true nature of electrical conduction and of the molecular constitution of metals, it may be regarded from an empirical point of view as being one of the most accurately established of all thermometric formulae. It will be observed that it also represents the simplest possible type of divergence from the thermodynamical scale.

24. *Methods and Apparatus.—*The methods of electrical thermometry may be roughly classified under two heads as (1) deflection methods, in which the temperature is deduced from the observed deflection of a galvanometer; and (2) balance methods, in which the resistance or the electromotive force is balanced against a known adjustable resistance or potential difference. The former methods arc most suitable for rough work and rapid reading, the latter for accurate measurements. In the practice of the deflection method it is customary to use a movable-coil galvanometer, the sensitiveness of which can be varied by varying the resistance in circuit, or by varying the stiffness of the suspension. The accuracy attainable is of the order of one-half of 1 per cent. on the deflection, and is limited by variations of resistance of the galvanometer, and by the imperfect elasticity of the suspension. In any case the scale of the galvanometer should be calibrated or tested for uniformity. In this kind of work the thermocouple has the advantage over the resistance thermometer in that the latter requires an auxiliary battery to supply the current; but in many cases this is no disadvantage, because it permits a greater latitude of adjustment, and makes it possible to obtain greater power than with the thermocouple.

In cases where it is desired to obtain greater accuracy with­out abandoning the quickness of reading which is the principal advantage of the deflection method, it is possible to combine the two methods by balancing part of the potential difference by means of a potentiometer and using the galvanometer for the small changes only. In cases where the greatest accuracy is required, a very sensitive galvanometer should be used, and the whole of the potential difference should be balanced as nearly as possible, leaving very little to depend on the deflection of the galvanometer. The degree of sensitiveness and accuracy obtainable depends primarily on the delicacy of the galvano­meter, on the power available, and on the steadiness of the conditions of experiment. For thermometry of precision the resistance thermometer possesses three very great advantages over the thermocouple: (1) The power available, owing to the use of a battery, is much greater; (2) it is possible completely to eliminate the errors due to accidental thermal effects by reversing the battery; (3) the Wheatstone bridge method can be employed in place of the potentiometer, so that the con­stancy of the battery is immaterial, and it is not necessary to use a standard cell. The conditions to be satisfied in the attain­ment of the greatest possible accuracy in the measurement of temperature by this method differ somewhat from those which obtain in ordinary measurements of resistance, so that a special type of apparatus has been evolved for the purpose, a brief description of which will be given.

25. *Compensated Bridge Apparatus.—*It is necessary that the thermometer should be connected to the measuring apparatus by wires or “ leads ” of considerable length, generally at least two or three metres, in order to avoid exposing the galvanometer and resistance box, or other delicate parts of the apparatus, to changes of temperature. It is also essential that the leads should not be too thick or heavy, for convenience in handling and to prevent conduction of heat along the stem of the thermometer. The resistance of that part of the leads which is exposed to variations of temperature necessarily changes, and would give rise to serious errors if it were not determined or compensated. The method now generally adopted in accurate work is to compensate the variations of resistance of the leads by an exactly similar pair of dummy leads called the “ compensator ” and connected as shown diagrammatically in fig. 6. The battery, consisting of a single cell, with a rheostat and reversing key in circuit, is connected to the terminals AB of the two equal resistance coils AG, GB, which form the ratio arms of the balance. These coils must be carefully tested for equality of temperature-coefficient, and placed in close proximity to each other so as to be always at the same temperature. If they are interwound on the same reel, they must be most carefully insulated from each other. In parallel circuit with the ratio coils arc connected the compensator CC' and the balancing resistances C'E, on one side of the bridge-wire EF, and the compensating resistances FP and the pyrometer and leads PRP' on the other side. The galvanometer is connected to the point G between the ratio coils, and to the sliding contact D on the bridge-wire. Since the ratio coils are always equal, equal changes of resistance on either side of D are eliminated, and do not affect the balance. Thus the changes of the pyrometer leads PP' are balanced by the equal changes of the compensator leads CC' on the other side. As a further refinement, which is of some importance in delicate work, the ends of the compensator leads arc connected by a short piece of the same wire as the pyrometer coil. For instance, in observing the variations of temperature of the steam in the cylinder of a steam engine at different points of the stroke with a very delicate thermometer made of wire one-thousandth of an inch in diameter *(Proc. Inst. C. E.,* vol. cxxxi. fig. 16, p. 23), the ends of the fine wire attached to the thick leads could not follow the rapid varia­tions of temperature, and it was found necessary to adopt this device to eliminate the end-effect. It is also useful in other cases to eliminate the effect of conduction along the leads in cooling the ends of the fine wire coil. The. balancing resistances C'E are made of some alloy such as manganin or platinum-silver, the resistance of which varies very little with change of temperature. Platinum­silver is probably the best material, as it can be perfectly annealed at a red heat without risk of burning, and is then extremely constant. Unless the box can be kept at an absolutely constant and uniform temperature, which is not impossible but often inconvenient, it is necessary to allow for the change of resistance of the balancing coils C'E due to change in the temperature of the box. The tem­perature of the coils cannot be accurately determined with a mercury thermometer unless they are immersed in oil, but even in that case it is necessary to know the temperature-coefficient of each individual coil. A more convenient and accurate method, which eliminates the correction automatically, is to compensate each individual coil of the balancing coils C'E by a corresponding com­pensating coil at FP on the other side of the bridge-wire. The compensating coils are made of platinum, also annealed at a red heat, and each is placed in the box in close proximity to the coil it is intended to compensate. Each balancing coil and its com­pensator are tested together at various temperatures between 10° and 30° C., and are adjusted until their difference remains constant for any small variation of temperature in the neighbour­hood of 20° C. This method of compensation was applied by the writer in 1887, but has not been generally adopted on account of the labour involved in adjusting the coils. The absolute values of the resistances are immaterial, but it is necessary to know the relative values with the greatest possible accuracy. For this reason it is preferable to arrange the . resistances in the binary scale, each resistance being equal to twice the next smaller resist­ance, or to the sum of all the smaller resistances, the two smallest resistances being made equal. This arrangement permits the greatest accuracy of comparison in the simplest manner with the fewest observations. The bridge-wire EF provides a continuous scale for reading small changes of resistance. Any change of resistance of the pyrometer coil necessitates the movement of the balance point D through an equivalent resistance along the bridge­wire. The equivalent resistance of the bridge-wire per unit length of the attached scale is preferably adjusted, by means of a shunt shown in parallel with it in fig. 5, to be an exact submultiple of