

"Taylor" — "Cambridge"

THE CAMBRIDGE
SCIENTIFIC INSTRUMENT COMPANY, LTD.,
CAMBRIDGE, ENGLAND.

THERMO-ELECTRIC COUPLE POTENTIOMETER.

Reprinted from "The Electrician," January 31, 1908.

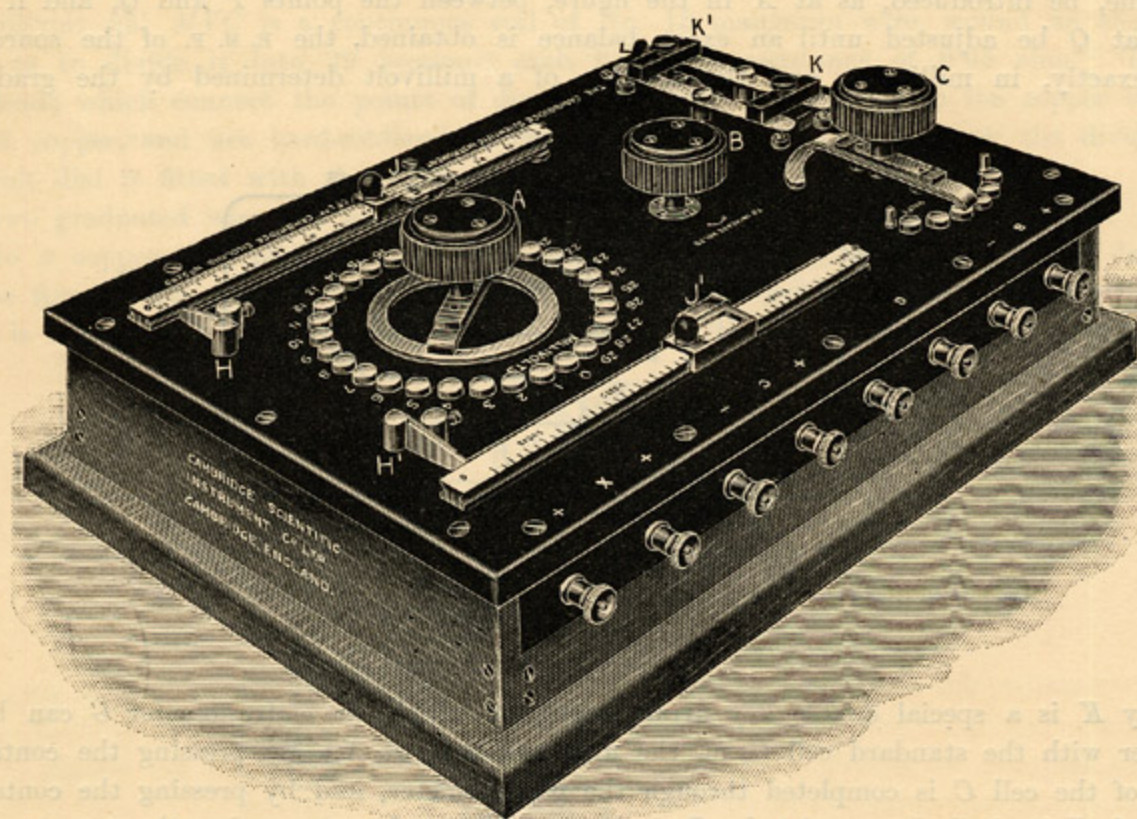


FIG. 1.

This potentiometer, made by the Cambridge Scientific Instrument Co., is designed for measuring accurately small differences of potential not exceeding 30 millivolts, and is intended specially for use with thermo-electric couples.

The method of measurement adopted in the instrument is an extension of the well-known potentiometer method, and enables the unknown potential difference to be accurately balanced by an adjustable potential difference standardised in millivolts by means of a standard cadmium cell. This adjustment can be made by direct reading to $\frac{1}{100}$ millivolt, and by estimation of tenths to 1 microvolt.

The arrangement of the potentiometer circuit is shown diagrammatically in Fig. 2. An accumulator cell, shown at B, supplies the current to the main circuit. Starting from the positive pole of the cell the current passes through the adjustable resistances R_1 and R_2 , the resistance coils BC and SC, and the graduated wire SS; then through the resistance coils marked MVC and the graduated wire VV to the negative pole of the cell.

The total resistance in the circuit is arranged so as to give a fall of potential of about 1 volt per 50 ohms circuit resistance, and the resistance coils BC and SC are adjusted so that the fall of potential from the point M to a point, N , on the wire SS is approximately equal to the E.M.F. of a cadmium cell. The adjustable resistances R_1 and R_2 are introduced as a means of adjusting the resistance of the circuit; R_1 gives a rough adjustment with a range of 10 ohms, and R_2 gives a fine adjustment with a range of about 2.5 ohms.

The wire SS is graduated so that the reading shown at any point on it is the P.D. between that point and the point M on the basis of a fall of exactly 1 volt per 50 ohms resistance in the circuit. If, therefore, a standard cell, C , is connected up in the usual way between M and the point N on the wire which marks its E.M.F. at the existing temperature, and an exact balance be obtained (by means of the adjustable resistances R_1 and R_2) between the E.M.F. of the cell and the P.D. between the points M and N , the whole circuit becomes accurately adjusted to a fall in potential of 1 volt per 50 ohms circuit resistance.

The coil MVC is a continuous coil in 29 sections, each of which is accurately adjusted to a resistance of 0.05 ohm. On the basis of 1 volt per 50 ohms the fall of potential in each section is thus exactly 1 millivolt. Similarly, the resistance of the wire VV being 0.06 ohm, the fall of potential along its length is 1.2 millivolts. Thus, in the portion of the circuit between the points P and Q , including the coils MVC and the wire VV , there is an available fall of potential of 30.2 millivolts. If, therefore, a thermo-electric couple or any unknown source of E.M.F., less than 30 millivolts in value, be introduced, as at X in the figure, between the points P and Q , and if the point of contact at Q be adjusted until an exact balance is obtained, the E.M.F. of the source can be measured, exactly, in millivolts, and the fraction of a millivolt determined by the graduation of the wire.

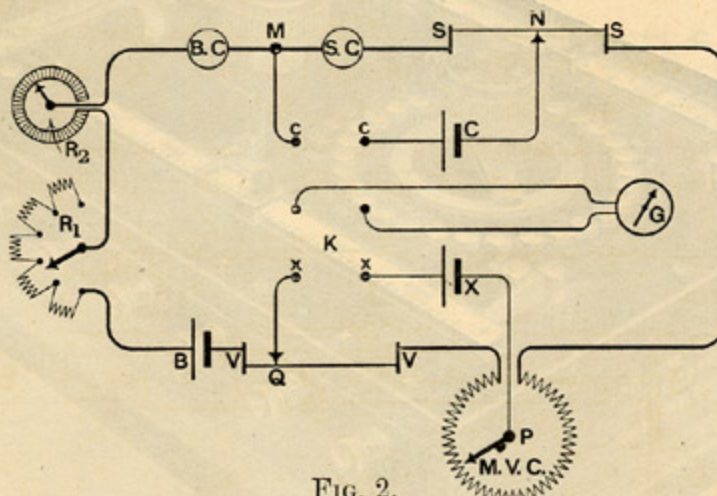


FIG. 2.

The key K is a special double key arrangement, by which the galvanometer G can be put in circuit either with the standard cell C , or the unknown P.D. at X . By pressing the contacts at cc the circuit of the cell C is completed through the galvanometer, and by pressing the contacts at xx the circuit of X is similarly completed. It is thus possible, when measuring the P.D. at X , to test the accuracy of the fundamental adjustment for the standard cell without disturbing any of the connections. It is also possible, by locking the contacts at xx , to follow the variation of a variable P.D. at X .

In the construction of this potentiometer a circuit of the type described above is attached to a sheet of ebonite and enclosed in a box of which the ebonite sheet forms the cover. The dials and other adjusting appliances are arranged in the usual way on the upper face of this ebonite top.

The arrangement of the potentiometer circuit in the box is shown diagrammatically in Fig. 3, which is lettered to correspond with Fig. 2.

The terminals B , G , C and X are provided respectively for the insertion of the accumulator cell, the galvanometer, the standard cell and the unknown P.D.

The adjustable resistance R_1 for rough adjustment is made up of five coils of manganin wire, each of 2 ohms resistance, with copper stud-and-lever contacts arranged as shown in the figure. The fine adjustment resistance R_2 is a continuous coil of manganin wire of about 2.5 ohms resistance, arranged so as to admit of continuous variation of the resistance included in the circuit. It is

possible by means of these adjustable resistances to make the standard cell adjustment with an accumulator cell in the circuit ranging in E. M. F. from 1.8 to 2.14 volts.

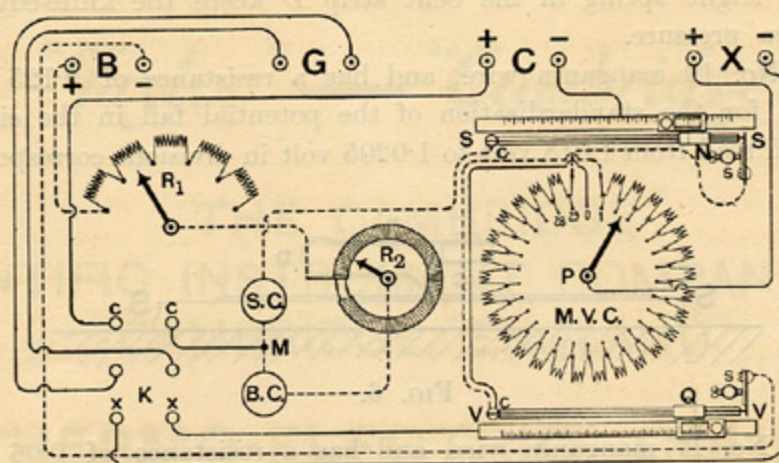


FIG. 3.

The resistance coils *BC* and *SC* are coils of No. 28 manganin wire wound on bobbins with adequate surface exposure for radiation. The resistance of the coil *BC* is about 42.5 ohms, and that of *SC* about 51 ohms.

The millivolt coil *MVC* is a continuous coil of No. 18 manganin wire, wound as shown in the figure, so as to divide it into 29 sections, each having a resistance of 0.05 ohm. The tapping potential leads which connect the points of division between the sections to the copper studs of the dial are of copper, and are hard-soldered to the coil at the bends which mark the division points. The millivolt dial is fitted with the usual stud-and-lever contacts made in copper.

The two graduated wires *SS* and *VV* are arranged in the same way. One end of the wire is attached to a copper plug at *c*, and the other end is held by the spring and screw device shown at *s* in the figure. The general arrangement of the wire, the graduated scale, and the sliding contact piece is indicated in Fig. 4; the scale is shown at *L*, the contact piece in two connected parts

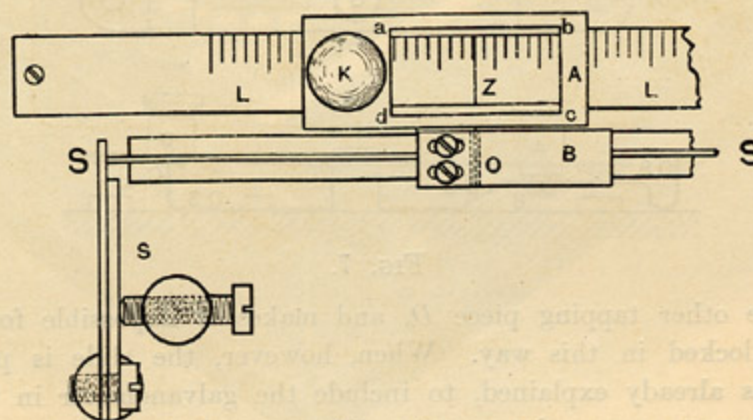


FIG. 4.

at *A* and *B*, and the wire at *SS*. The contact piece is moved by means of the knob *K*, and its position on the scale is read by means of the index line *Z*, which is drawn on the transparent celluloid window, *a, b, c, d*, in line with the knife-edge *C*, which makes contact with the wire.

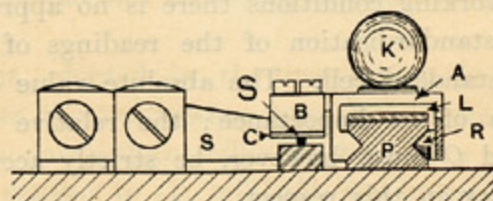


FIG. 5.

The connection between these parts is more clearly shown in the cross-section view given in Fig. 5. The scale *L* is screwed on to a strip of copper, *P*, which is connected to one end of the tapping circuit of the standard cell. The sliding contact piece *AB* makes contact between this strip

of copper and the wire by means of the spring wire contact indicated at *R*, and the knife-edge contact at *C*. The arrangement of this knife-edge contact at *C* is shown by the small sectional drawing in Fig. 6; the slight spring in the bent strip *D* keeps the knife-edge in contact with the wire under a steady even pressure.

The wire *SS* is of No. 19 manganin wire, and has a resistance of 0.125 ohm; the graduations on its scale as arranged for the standardisation of the potential fall in the circuit by the E. M. F. of the standard cadmium cell read from 1.018 volt to 1.0205 volt in divisions corresponding to $\frac{1}{20}$ millivolt.

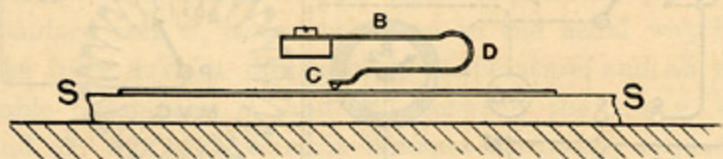


FIG. 6.

The wire *VV* is of No. 17 manganin wire, and has a resistance of 0.06 ohm; the graduations on its scale read from zero to 1.2 millivolt in divisions corresponding each to $\frac{1}{100}$ millivolt. It is thus possible, as stated above, to read to *one microvolt* by estimating tenths on this scale.

The simplicity of the sliding piece and the arrangement of the coils *MVC* make it possible to adjust for a balance easily and quickly. A rapid variation in the temperature of a thermo-couple can thus be readily followed; this is especially useful in the determination of the freezing point of a metal or in plotting a cooling curve.

The essential details of the key *K* are shown in plan and section in Fig. 7. When the draw slide *DS* is drawn forward, as in the figure, the slot *L* engages with the screw *B* on the underside of the tapping piece *A*, and locks the contacts at *xx* firmly down; at the same time the stud *C*

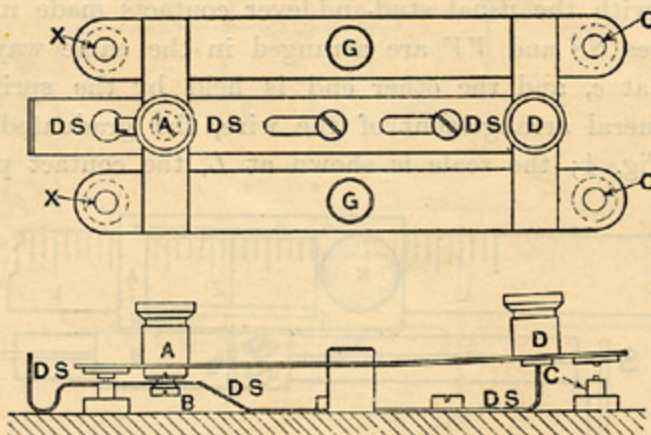


FIG. 7.

comes directly under the other tapping piece *D*, and makes it impossible for the *cc* contacts to be made while the key is locked in this way. When, however, the slide is pushed back, the key is free and can be used, as already explained, to include the galvanometer in the circuit of either the standard cell or the unknown source of E. M. F. at *X*, as may be required.

Fig. 1 gives a general view of the top of the instrument in which the several parts described above can easily be recognised.

In order to minimise the troubles due to thermo-electric effects, the only metals used in the construction of the bridge are copper and manganin; the thermo-electric powers for these two metals is so small that under ordinary working conditions there is no appreciable thermo-electric effect.

It will be noticed that the standardisation of the readings of the potentiometer in *millivolts* is derived from the E. M. F. of the standard cell. The absolute value of the "ohm" used in the adjustment of the circuit resistance is of no importance; the relative values of the resistances in the circuit between the points *M* and *Q* must, however, be strictly accurate, and every care is taken to secure the highest possible accuracy in this respect.

PRICE

Packed f.o.b. cars at port of entry in U.S.A., duty paid \$ 230.00

U. P. 250 : 9 : 08.

