CROPICO

# CROYDON PRECISION INSTRUMENT CO.

## PRECISION POTENTIOMETER TYPE P.10

### OPERATING INSTRUCTIONS

#### SETTING UP PROCEDURE

The Potentiometer has little or no temperature co-efficient, but it must be remembered that the standard cell, standard resistances, etc., often used as accessories have significant temperature co-efficients; therefore, for work of the highest precision and to get the best possible results from your instrument it should be in a position where the temperature is approximately 20°C. It may of course be possible to use it in a temperature controlled room which would be an ideal situation.

Temperature stabilisation applies particularly to the standard cell upon which the accuracy of measurement is entirely dependent. Even in a temperature controlled room the standard cell should be filled with oil to ensure that both limbs are at the same temperature. And in some situations, subject to large ambient temperature changes, a temperature controlled box may be necessary. Also, the standard cell should be permanently placed in one position and never disturbed.

#### CONNECTION OF ACCESSORIES

It is advisable to connect all the accessories to the potentiometer by means of solid conductors, i.e. say 18 SWG insulated copper wire; the reason for this is to give a constant contact resistance at the connection points which is not always possible with multi-stranded flexible conductors.

(1) Connect a fully charged 2 volt accumulator to the terminals marked "BATT" making sure that the polarity is correct. This accumulator should be connected 3-4 hours prior to use to ensure that the potentiometer current is stable. It is also advisable to have a spare accumulator always ready for use which can be pre-stabilised by connecting a 100 ohm resistor between the terminals. It is recommended that a 2 volt accumulator is connected to the potentiometer at all times as this ensures that the instrument is always ready for use and the potentiometer current will have maximum stability; also that in addition standardisation is reduced to a minimum. Accumulators for supplying the potentiometer current should never be used for other applications.

(2) Connect standard cell to terminals marked "STD CELL". It is advisable to connect the conductors firstly to the potentiometer and then to the cell; this obviates the risk of shorting the cell from which it would take some considerable time to recover.

(3) Connect the galvanometer movement to terminals marked "GALV" on the potentiometer.

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## GALVANOMETER

If your work is mainly at the 1 volt setting on the potentiometer you will be using a galvanometer Type 2005/D 36 ohms sensitivity 190 mm/$\mu$A periodic time 2·5 secs. Size: 12 $\times$ 7 $\times$ 6 inches.

The operating sensitivity of this galvanometer is as follows:—

**Standardisation**

Approximate galvanometer deflection for a resolution of 4 parts $10^6$ = 1 mm

**Measurement of e.m.f.**

Approximate galvanometer deflection with test position short circuited

10$\mu$V change = 40 mm
1$\mu$V ,, = 4 mm
Projector lamp supply 4 volts.

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If you are using the potentiometer to measure small quantities or are endeavouring to work at the limit of its capabilities as regards accuracy, you will be using the scale stand model Type G.l. :

Resistance 10 ohms. Sensitivity 220 mm per $\mu$A

**Standardisation**

Approximate deflection for a resolution of 2 parts in $10^6$ = 1 mm

**Measurement of e.m.f.**

Approximate galvanometer deflection with test position short circuited.

10$\mu$V change = 350 mm
1$\mu$V ,, = 35 mm

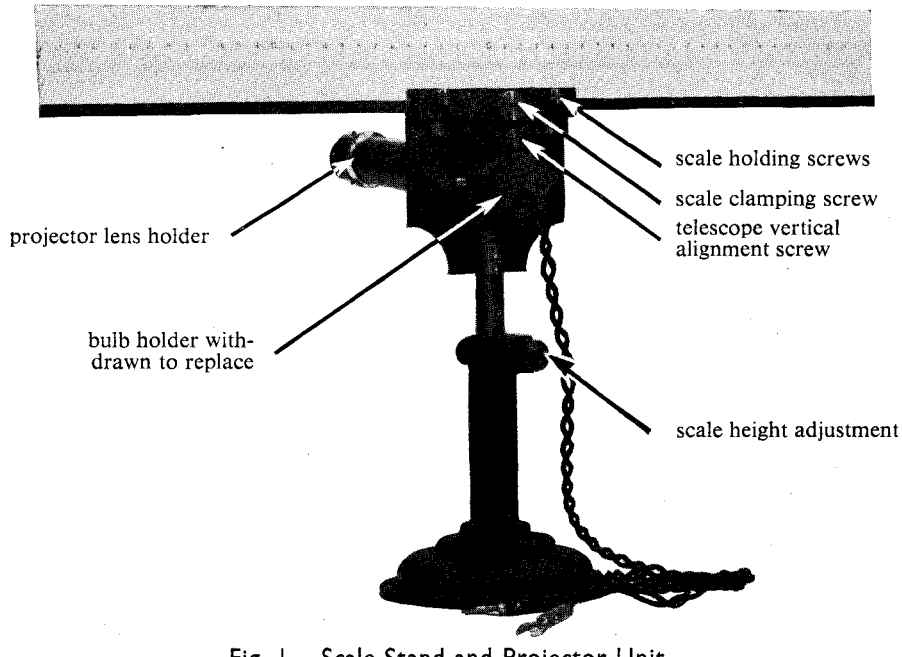


Fig. 1. Scale Stand and Projector Unit

**Assembly of Scale Stand and Projector**

(1) Remove the two scale holding screws and insert the scale with the zero position mid-way; replace the screws and tighten.

(2) Connect light source, i.e. bulb to 12V supply from battery or mains transformer.

## Mounting of Galvanometer

The scale stand and projector unit should be fixed on a firm base, and placed so that the scale is at the correct viewing height and position for the observer. The galvanometer unit should then be placed approximately 2 metres from the projector in the same vertical plane and in line with the projector.

The galvanometer movement is unclamped by rotating the knurled screw beneath the lens in an anti-clockwise direction.

The bulb filament is focussed on the mirror by sliding the lens holder of the projector in or out.

By movement of the telescope vertical alignment screw, the angle of the projector may be altered to align the spot centrally on the mirror.

On freeing the clamping screw at the rear of the galvanometer unit the unit can be pivoted on its support to bring the spot on to the scale. After tightening the clamping screw the torsion head can be adjusted to zero the spot.

The hairline can be brought into the vertical position by rotating the lens holder in the projector. Repeat the above operations to obtain the best results.

## OPERATION

Prior to actually measuring an e.m.f. it is necessary to standardise the potentiometer current against the standard cell as follows:—

Measure the temperature of the standard cell by removing the centre plug and inserting a thermometer in its place.

Set the potentiometer standard cell values dial at the appropriate position as per the following table, the standard cell has a temperature co-efficient of approximately —40 microvolts per °C.

| Temperature in °C | 31·8 | 30·9 | 30·0 | 29·0 | 28·0 | 27·1 | 26·2 | 25·2 | 24·2 | 23·2 | 22·2 | 21·0 | 19·7 | 18·5 | 17·2 | 14·0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Standard Cell Values Volts | 1·01800 | 805 | 810 | 815 | 820 | 825 | 830 | 835 | 840 | 845 | 850 | 855 | 860 | 865 | 870 | 880 |

Set the "standardise-test" switch in the standardise position with the galvanometer series resistance dial in the $10^6$ position (minimum sensitivity) press the galvanometer key and adjust the 5 dial current regulator on the right hand side of the instrument until the galvanometer balances at zero, repeat on all positions of the galvanometer series resistance until the galvanometer is balanced at the position of maximum sensitivity, i.e. 0.

The potentiometer is now standardised and ready to measure the voltage under test.

The "standardise-test" switch is now set in the test position and the voltage measured adopting the following procedure.

## MEASUREMENT OF E.M.F.

Connect the voltage source to be measured to test terminals 1, 2, 3 or 4 (making sure that the polarity is correct) and set the selector switch to the corresponding position.

Select the range by means of the plug x by 1 or x by 0·1. The plug should be pressed firmly into the required position.

Range x by 1 —0·00001 to 1·8 volts in steps of 10 microvolts.

Range by x 0·1 —0·000001 to 0·18 volts in steps of 1 microvolt.

Set the galvanometer series resistance switch in position $10^6$ and balance the potentiometer by means of the three voltage measuring dials, repeat on all positions of the galvanometer series resistance until the galvanometer balances in the position of maximum sensitivity. The reading on the voltage measuring dials is then multiplied by the range plug setting.

**Note**

## CHECKING STANDARD CELL DIAL CALIBRATION

The Standard Cell dial is infinitely variable. The small divisions represent 10 parts per million and its reading can be estimated to 1 part per million. In order to take full advantage of this resolution when on work of the highest precision the Standard Cell dial can be specially calibrated as follows:—

Connect the Standard Cell to the " 1 " test terminals and the selector switch to position 1. With the "standardise-test" switch to test and the measuring dials set to the value to be calibrated (say 1·01860). The galvanometer is balanced by the current control rheostat in the usual manner.

Transfer the Standard Cell to the Standard Cell terminals of the potentiometer, set the " standardise-test " switch to standardise and balance the galvanometer to zero by adjusting the Standard Cell dial. The balance point would be the correct position for 1·01860 volts. This process can be repeated and a complete calibration made.

## STANDARD CELLS

The e.m.f. of these saturated acid cells is 1·01859 volts absolute at 20°C. The temperature co-efficient of e.m.f. is approximately —0·00004V/°C between 15°C and 25°C, but varies with temperature. To ascertain the e.m.f. at any temperature between 10°C and 40°C the following formula can be used.

$$dE = -40{\cdot}6(t-20) - 0{\cdot}95(t-20)^2 + 0{\cdot}01(t-20)^3$$

where

dE is the difference in microvolts from the e.m.f. at 20°C and t is the temperature in degrees centigrade.

The following table, which has been prepared from the above equation, gives the e.m.f. of a cell in volts absolute at various temperatures between 10°C and 40°C.

| Temperature (°C) | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
|---|---|---|---|---|---|---|---|
| e.m.f. (volts abs) | 1·01889 | 1·01877 | 1·01859 | 1·01836 | 1·01810 | 1·01780 | 1·01748 |

### Voltage Measurement

Potential differences up to 1·8 volts can be measured directly on the potentiometer, and the inclusion in the circuit of a volt ratio box type V.R.2. will extend the range of measurement to 600 volts.

As seen from fig. 2 voltmeters are calibrated by connecting them across the volt ratio box, the applied voltage varied, and a number of potentiometer readings taken at various points on the voltmeter scale.

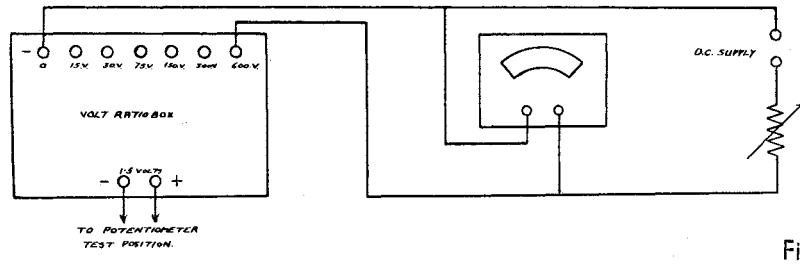


Fig. 2

## Current Measurement

A standard resistance of suitable value is connected in the circuit in which the current is to be measured. The resistance is chosen so that the current produces across its terminals a p.d. of convenient value. For maximum accuracy of measurement we would suggest a p.d. of 1 volt.

Ammeters are calibrated by connecting them in series with a standard resistance, varying the current through them and taking potentiometer readings at various points on the scale.

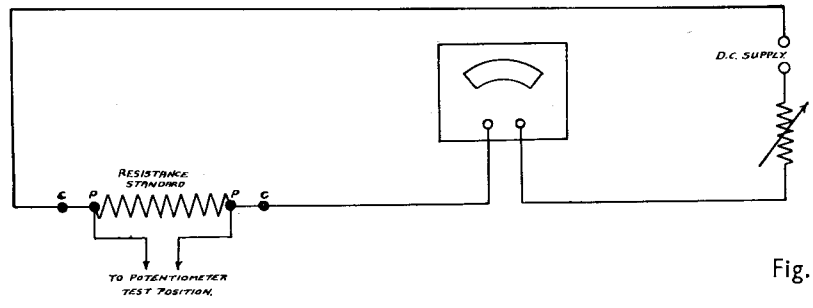


Fig. 3

## Resistance Measurement

The resistance to be measured is connected in series with a standard resistance of similar value, a steady current is maintained in the resistors and the p.d. compared on the potentiometer.

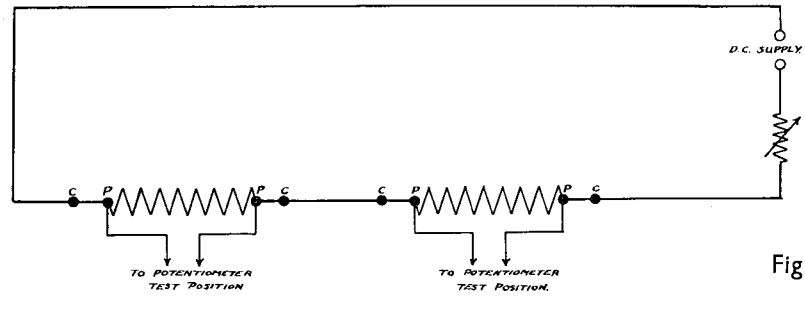


Fig. 4

$$Rx = \frac{Rs\ Vx}{Vs}$$

Rx = unknown resistance
Rs = standard resistance
Vx = volt drop across Rx
Vs = volt drop across Rs

When measuring resistance by this method it is not necessary to standardise the potentiometer against the standard cell. It is often convenient to adjust the current through the standard and the unknown resistor until the volt drop across the standard is equal to the actual known resistance value. Using this procedure the value of the unknown resistor is equal to the potentiometer dial readings in ohms. Example as follows:—

Value of Rs in ohms = 1·00025

Set the potentiometer dials to 1·00025 volts. Adjust the current through the unknown and test resistor until the potentiometer is balanced. Then measure the volt drop across the unknown resistor and read off directly in ohms.

Vincent Bar...

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# TEST CERTIFICATE

## PRECISION POTENTIOMETER

**TYPE P10**

SERIAL No. 12.099 DATE 25. March 1964

Temperature 20°C

### MEASURING SECTIONS

The value of the ratio of the voltage across any measuring section of the potentiometer to the voltage across section 10 of the dial marked " X by 0·1 " did not differ from its nominal value by more than 0·000005.

### STANDARD CELL SECTION

The value of the ratio of the voltage across each section of the dial marked " STD. CELL VALUES " to the voltage across section 10 of the dial marked " X by 0·1 " is given in Table.

| Section | Value when used on range | |
|---|---|---|
| | " X by 1 " | " X by 0·1 " |
| 1·01800 | 1·01800 | 10·1800 |
| 1·01820 | 1·01820 | 10·1820 |
| 1·01840 | 1·01840 | 10·1840 |
| 1·01860 | 1·01860 | 10·1860 |
| 1·01880 | 1·01880 | 10·1880 |

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N. V. Riles.

## STANDARD CELL

**TYPE S.C.2**

SERIAL No. ..... DATE .....

Temperature 20°C

Cell A = ..... Volts absolute

Cell B = ..... Volts absolute

*p.p.* Croydon Precision Instrument Co.

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## CROYDON PRECISION INSTRUMENT CO.

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Printed in United Kingdom

To use Croydon P10 Vernier Potentiometer as a calibrated D.C. mV. source:

1/ Standardise the potentiometer as follows;

(a) Connect 2V. source to Batt. terminals, Std. Cell to appropriate terminals and Galv. to Galv. terms. L30 may be used for 2V. supply and HP 3465A DVM for galv.

(b) Set Standardise/Test switch to Standardise

(c) Press Galv. Key in and adjust Current Regulator i.e. 5 switches on right hand side to obtain a null. Galv. series resistance knob should be on 0 for max. sensitivity

The Vernier Potentiometer is now calibrated. To use for measuring an unknown voltage, the Std. cell may be removed and the standardise/test switch set to test. Connecting the unknown voltage to one of the 4 sets of terminals will enable the voltage to be read off the 3 volts scales when these have been adjusted for a null on the Galv.

2/ After standardising, the vernier potentiometer may be used as an accurate mV. source by disconnecting

both the Galv. and the Std. cell and shorting the galv. terminals. A voltage can be set by the volts switches to appear @ any one of the 4 sets of terminals (nos. 1-4) selected by the switch below. The standardise/test switch is set on test.

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(b) Set Standardise/Test switch to Standardise

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The Vernier Potentiometer is now calibrated. To use for measuring an unknown voltage, the Std. cell may be removed and the standardise/test switch set to test. Connecting the unknown voltage to one of the 4 sets of terminals will enable the voltage to be read off the 3 volts scales when these have been adjusted for a null on the Galv.

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