The Environmental Comparator

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Many ecological investigations depend upon measuring accurately the light intensity and the temperature in conditions where it is inconvenient to use a conventional calorimeter or mercury thermometer. An environmental comparator has been developed to fulfil this need. In addition, the comparator can be coupled to a simple calorimeter which can be readily constructed in schools[1] and used for teaching a number of principles of chemistry.[2]

Construction of the Environmental Comparator

The comparator and its probes can be made in Australia for an approximate cost of $20. The environmental comparator may be constructed from the following components:

> 5A or 500mA ammeter; 10kΩ linear or logarithmic carbon track potentiometer; 5kΩ linear or logarithmic carbon track potentiometer; double pole double throw switch; 2 banana plug terminals; 2×9V transistor radio batteries; radio knobs to fit the potentiometers preferably with a built-in scale; protective diodes (see Fig. 1); solder and insulated copper wire.

Our environmental comparator was made using a 'Peak' brand microammeter which has sufficient room inside to fit the necessary components making a very compact easily transportable instrument.

Assemble the parts as follows:

1. Convert the ammeter or milliammeter to a microammeter reading 0—5 or 0—500 units. This is done by removing the shunt wire and series resistor and replacing the latter with a simple copper link as shown in Fig. 1. Most modern meters are fitted with protective diodes to prevent damage due to accidental misuse. These should not be removed. If the diodes are absent in the meter, they should be fitted (Fig. 1).

2. Using a cork borer, bore holes in a plastic case in positions as shown in Fig 2. The size of the holes depend on the size of the potentiometers and switch to be used.
3. Wire up the circuit as shown in Fig. 3, using the wiring aid shown in Fig.4.

The original terminals on the front of the meter are now used to connect the various probes. A 10kΩ linear or logarithmic potentiometer is used as a balance control. Its function is to allow the meter needle to be brought on the scale regardless of the value of the resistance of the probe. Once the needle is on the scale, the value of the balance potentiometer is left constant. A 5kΩ linear or logarithmic potentiometer is used as a standard against which the unknown resistance is balanced. Its value must remain constant for a set of readings. A 5kΩ linear or logarithmic potentiometer is used to adjust the sensitivity of the instrument. For the temperature probe, it is used at full sensitivity. For the light probe, it is set to give full scale deflection for maximum light level and then left constant.

The double pole double throw switch is used to select either the power pack or the 9V batteries as a power source for the instrument. The current drawn from the batteries is approximately 6×10^{-3} amps. The batteries may be conserved by supplying power to the unit only when a reading is being taken.

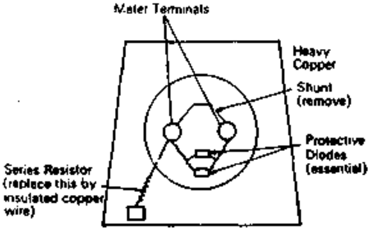

Figure 1 Diagram showing shunt and protective diodes of meter viewed from below.

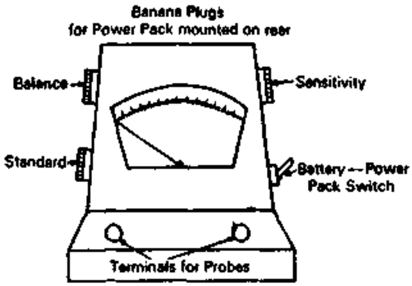

Figure 2 Positioning potentiometers and switch on the meter.

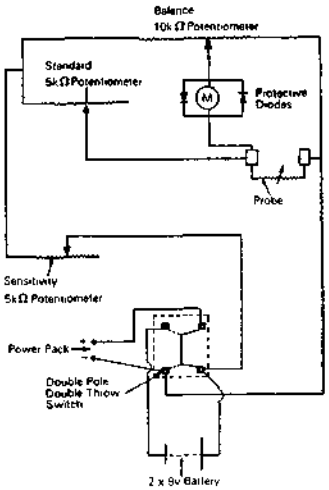

Figure 3 Circuit diagram for the environmental comparator.

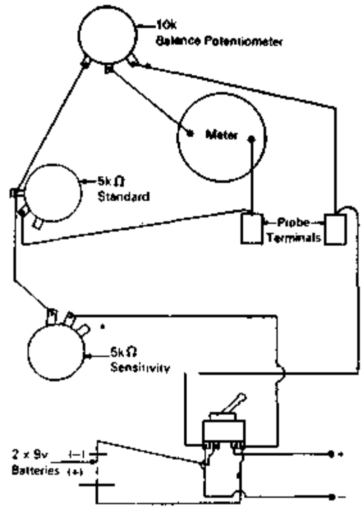

Figure 4 Wiring aid for environmental comparator.

Construction of probes

In the construction of the probes, any variable resistance may be used provided that its value varies within the range of 200Ω to 40kΩ. The greater the variation in resistance, the greater the sensitivity.

1. *Light Sensitive Probe*

Place a cadmium sulphide photo-resistor inside a glass tube as shown in Fig. 5.

The light sensitive probe is very sensitive and the sensitivity control needs to be used to keep the needle of the meter on the scale when going from full sunlight to complete darkness. Made carefully, the probe is water proof and may be immersed indefinitely in water but not in strong acid bases or in organic solvents.

2. *Temperature Sensitive Probe*

The temperature sensitive probe may be constructed in two ways depending on the type of the thermistor available. The best type of thermistor is the bead type. This has a very fast response with changes in temperature. A temperature sensitive probe using a bead thermistor was constructed as shown in Fig. 6. The clear plastic sleeve must be water tight. The top end of the glass tube is sealed with araldite to make it water tight.

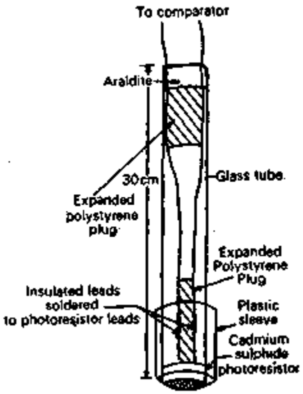

Figure 5 Light sensitive probe.

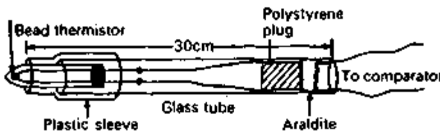

Figure 6 Bead thermistor temperature sensitive probe.

A cheap readily available thermistor is the brimistor (catalogue No. CZ10 available from Dick Smith Electronics in Australia). A temperature sensitive probe using the brimistor was constructed as follows:

> Remove one lead from the brimistor, solder a piece of insulated copper wire to the other lead and then embed one end of the brimistor and the bared end of the second lead in Wood's metal as shown in Fig. 7.

The brimistor temperature sensitive probe is not as quick to respond to temperature changes as the bead thermistor one. However, if the brimistor is small, the response time should be less than one minute. Temperature readings taken by the temperature sensitive probes should be accurate to $\pm$ 1/3°C.

Calibration of the brimistor temperature sensitive probe

The temperature sensitive probe was connected to a meter and placed in a vacuum flask. Water at various temperatures was placed in the vacuum flask and the temperature of the water was recorded with a thermometer calibrated in tenths of a degree. The meter reading was also recorded and a calibration curve was obtained by plotting the meter reading against temperature (Fig. 8). The brimistor should not be exposed to temperatures greater than 60°C.

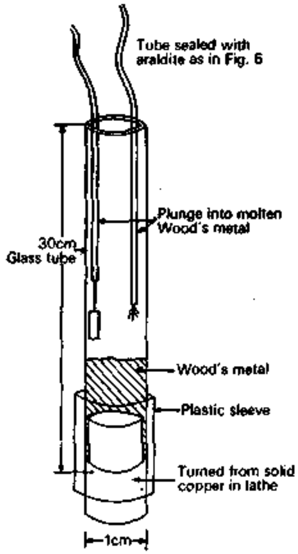

Figure 7 Brimistor temperature sensitive probe.

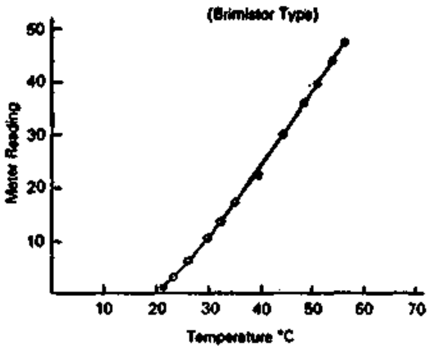

Figure 8 Calibration curve for the temperature sensitive probe.

Notes

1. Fogliani, C. L.and Townsend, I.T. (1974) *Australian Science Teachers Journal*, 20:3, 109.
2. —— (1974) *Teaching Principles of Chemistry by a Simple Calorimeter.* Mitchell College for Advanced Education Publication, pp. 38-53. This is available at a cost of $5.

Detailed information on the construction of the colorimeters are contained in the following two publications available from Mr C Fogliani, Mitchell College of Advance Education, Bathurst, 2795, Australia.

1. Fogliani, C L (ed) *Proceedings of the Workshop on Low Cost Locally Produced Equipment.* MCAE 1984 (Cost $10)
2. Fogliani, C L (ed) *Proceedings of the Workshop on Fabrication of Low Cost Instrumentation* MCAE, 1985 (Cost $6)