PYROMETRY

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Optical pyrometers are based on the laws of black body radiation e.g. Wien's Law $E_\lambda = C_1 \lambda^{-5} . e^{-C_2/\lambda T}$, where λ is the mean wave length of the radiation used - generally 6650 A.U. i.e. a narrow red band, [redacted]d. Thus black sources equally bright in this colour are at the same temperature. For a non-black body of emissivity ε at temperature T

$$E_\lambda = \varepsilon \cdot C_1 \lambda^{-5} \; e^{-C_2/\lambda T} .$$

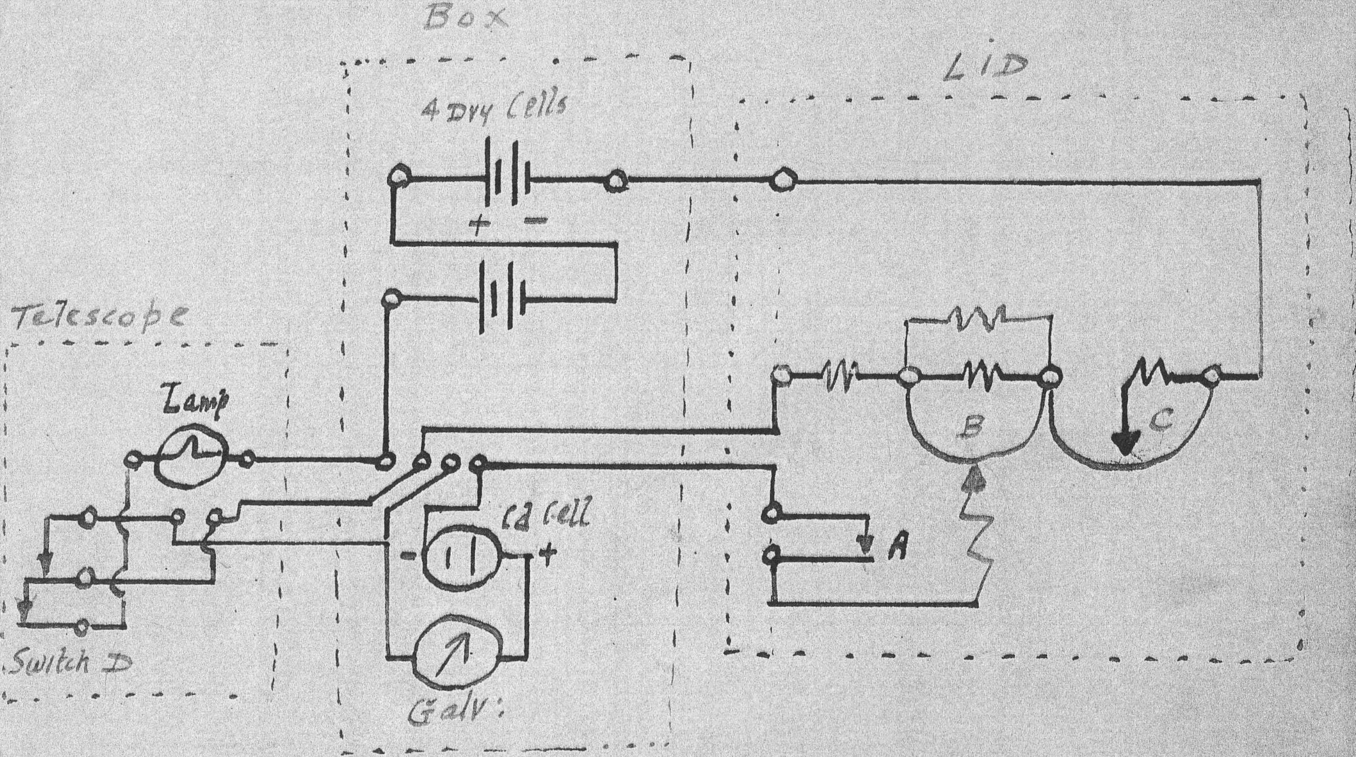
If such a source matched a black body at temperature B the temperatures B and T would be unequal since

$$\varepsilon \cdot e^{-C_2/\lambda T} = e^{-C_2/\lambda B} .$$

B is called the brightness temperature: it is the temperature of an equally bright black body.

Since $\frac{C_2}{\lambda} \left(\frac{1}{T} - \frac{1}{B}\right) = \log \varepsilon$ therefore $T > B$, since $\varepsilon < 1$.

For tungsten, ε ranges from 0.46 at 1200° K to 0.40 at 3000° K for the colour used. All optical pyrometers are calibrated to read the value of B.



Turning large knob, both contacts B and C move, key D being closed.
" small ", only " B moves, Key A being closed also, in order to introduce Cd cell for potentiometer balance.
In both cases, scale drum rotates.

LEEDS, NORTHRUP OPTICAL PYROMETER.

Table for tungsten lamps.

T° K	B° K	T - B° K
1600	1509	91
1800	1684	116
2000	1857	143
2200	2026	174
2400	2192	208
2600	2356	244
2800	2516	284
3000	2673	327

375

Approx. $T - B = \frac{T}{8} - 100$ (correct to 10°) ?

More exactly $T - B = (3.66 \times 10^{-5})T^2 - 3$ (correct to 2°).

Two instruments are available, both of the disappearing filament type, made by the Cambridge Instrument Co. and the Leeds, Northrup Co. respectively.

The <u>first</u> has two ranges, 900°-1800° C., and 1400°-3500° C. It is meant to be used with a nickel-iron wet battery of 3 volts. If this is not available, a 4 volt accumulator may be used, but <u>a resistance of 3 ohms must be included in the battery circuit</u>. In this instrument, the temperature readings are on the scale of an ammeter, hence as long as the internal lamp holds its calibration, the readings will be correct.

The <u>second</u> instrument has three ranges 775°-1225°, 1075°-1750° and 1500°-2850° C. The temperature scale is on the drum of the adjusting rheostat and it is operated by four dry cells mounted inside. The temperature readings therefore depend on the E.M.F. of the dry cells, and a potentiometer control (including a cadmium cell and galvanometer) is used to maintain the correct E.M.F. To use this instrument, the <u>large</u> knob is turned until the filament disappears; then, keeping the main switch closed, the <u>small</u> knob is pushed in to introduce the potentiometer circuit, and turned until the galvanometer indicates a balance. The reading on the drum then gives the correct temperature. This must be done for every reading.

<u>Measurements</u>.

Two measurements are carried out (i) calibration of a platino-rhodium thermocouple and (ii) relation between temperature and applied voltage for a tungsten lamp. The L.N. pyrometer is the more convenient for the first measurement: for the latter, either pyrometer may be used.

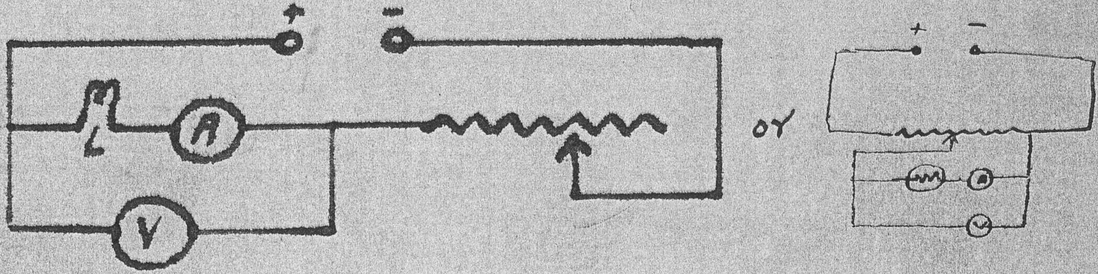
<u>I. Thermocouple calibration.</u>

The couple tube is mounted axially in an electric furnace, with the couple at the centre of the furnace. Either D.C. or A.C. supply may be used - the latter giving a wider range of temperature. The couple is joined to a good millivoltmeter, reading up to ~~12~~ 24 m.v. Readings should begin as soon as the couple is red hot - at which stage the pyrometer must be focussed accurately on the end of the tube enclosing the couple. Unless focussing is perfect the temperature indications will not be correct. As a furnace is an enclosure, no correction is necessary to the temperature readings. Take readings at about every 50° C. until the furnace reaches a steady state: then switch off the power, and take readings as the furnace cools down. Leave the couple inside the furnace until it cools down. Assuming a relation $\log E = A + B \log t$, plot $\log E$ in micro-volts against $\log t$ (excess above room temperature) and determine A and B from the linear graph. Standard values (with cold junction in ice) are

$A = 0.248$; $B = 1.232$ in micro-volt units.

Lamp temperatures: Use lamp P (240 volts, 60 watts, 700 lumens) for the test.

Connect lamp with rheostat, ammeter and voltmeter, as in diagram, to D.C. mains.



Starting with filament just red hot, take readings at about every 10 volts up to the maximum. Focus sharply on the centre of the coiled-coil. Tabulate voltage against true temperature, using the table above to derive T from B. As a check, calculate the resistance at every reading, and deduce the temperature from the standard relation $R/R_o = (T/T_o)^{1.205}$ for tungsten filaments. R_o and T_o refer to room temperature and R_o must be measured on a good Wheatstone bridge, using minimum current. Tabulate temperature values and compare with those given by the pyrometer.