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JOINT FIRE RESEARCH ORGANIZATION

A RADIOMETER FOR FIELD USE

by

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SUMMARY

A shielded, gold disc radiometer, specially designed for field use, is described. It measures thermal radiation in the range 0·01 to 1·2 cal^{-1} cm^{-2} s^{-1}. The calibration is not greatly affected by ambient temperature or by prolonged exposure and the error introduced by winds of up to 25 mile/h is less than 8 per cent.

April, 1959.

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INTRODUCTION

Most cellulosic materials may be exposed to radiation intensities of less than 0·1 cal cm^{-2} s^{-1} without any likelihood of their igniting or even charring, but if they are subjected to an intensity greater than 1·0 cal cm^{-2} s^{-1} ignition takes place within a few seconds.

It follows that the important range for thermal radiation measurements made in connexion with the hazard to buildings exposed to fires is from about 0·05 cal cm^{-2} s^{-1} to 1·5 cal cm^{-2} s^{-1}.

Instruments such as the Moll Thermopile (1) or the asbestos faced copper disc (2), although suitable for laboratory measurements, are too susceptible to draughts in the field and the error introduced by, say, a 10 mile/h wind would be over 100 per cent. It is necessary for any instrument to have as robust a construction as possible and be simple to operate e.g. without frequent zero adjustments.

DESIGN AND CONSTRUCTION OF THE RADIOMETER

A radiometer which has been developed for field use is illustrated in Plate 1. It consists basically of a gold disc to which is attached a 40-S.W.G. chromel-constantan thermocouple. The front face of the disc is coated with candleblack to increase its absorptivity and hence raise the thermo-electric output. The gold disc is mounted behind a thin (0.0010 - 0.0015 in.) mica window within a chromium-plated brass enclosure. A second disc is mounted within the enclosure and is shielded from the window. The thermocouple attached to this disc is connected in opposition to the other.

The blackened gold disc is only 0·004 in. thick to give a rapid response time and the 40-S.W.G. chromel and constantan wires are silver-soldered to it. The assembly is supported on ceramic posts which are secured by epoxy resins. Diagrams of the radiometer are shown in Fig. 1. On one version of the radiometer a ¼-in. diameter hole was drilled diametrically through the radiometer body through which coolant water could be passed if the radiometer was to be exposed to high intensity radiation for periods of more than about 5 minutes.

PERFORMANCE OF THE RADIOMETER

A typical calibration is given in Fig. 2. The factor limiting the maximum intensity to which the radiometer may be subjected is the temperature at which the candleblack on the exposed gold disc deteriorates. The temperature attained by the disc is a function not merely of the incident radiation but also of the body temperature of the instrument. For short periods of exposure (i.e. up to 5 minutes) radiation intensities of up to 1·2 cal cm^{-2} s^{-1} may be tolerated, whilst for an indefinitely prolonged exposure (i.e. exceeding 60 minutes) the intensity should not exceed 0·7 cal cm^{-2} s^{-1}.

Fig. 3 gives the output of the radiometer when it is subjected to a constant level of radiation of 0·5 cal cm^{-2} s^{-1}. From Fig. 2 the response time of the radiometer for a 95 per cent true scale reading is 10 seconds. It can also be seen that prolonged exposure reduces the output by 3 per cent with water running and about 15 per cent without water running. The slight variations superimposed on the gradual decline of output are due to fluctuations in the radiation source.

When a radiometer was removed from a refrigerator at $-10^{\circ}C$ and immediately subjected to radiation its output agreed with the normal calibration. This suggests that the radiometer calibration is substantially unaffected by ambient temperature.

It was then found that the effect of wind was greatly reduced by increasing the separation between the exposed disc and the mica window. The final design, in which the mica window is sandwiched between two front plates bolted to the radiometer body, is illustrated in Plate 1. Provided the exposed disc is not less than $\frac{1}{8}$ in. behind the mica window the effect of wind up to 25 mile/h was to reduce the radiometer output by less than 8 per cent. For a lower wind speed the reduction was less. The wind effect can be diminished further by using a thicker mica window, but this is undesirable as the selective absorption of incoming radiation is thereby increased.

The wind effect was found to be slightly affected by changes in the incident intensity, the radiometer body temperature, the thickness of the mica window and its separation from the exposed disc.

FIELD USE OF THE RADIOMETERS

The robustness of the instrument is best described in terms of an accident to several radiometers which were substantially identical with the type illustrated in Plate 1. These were to be used in a series of experimental building fires on the banks of the St. Lawrence in Canada during January and February, 1958. During transit the containing box was broken and several radiometers received blows of sufficient force to dent the solid brass enclosures to a depth of $^1/_{32}$ in. As a result the discs were of course displaced. They were relocated approximately in the field, and it was later found in the laboratory that the calibrations had not been affected.

Conclusion

The instrument will measure thermal radiation levels in the range 0·01 to 1·2 cal cm^{-2} s^{-1} and is convenient for use in the field since it is robust and is not greatly affected by wind. For exposures of less than 5 minutes or intensities less than 0·7 cal cm^{-2} s^{-1}; no water supply is required for cooling.

Acknowledgement

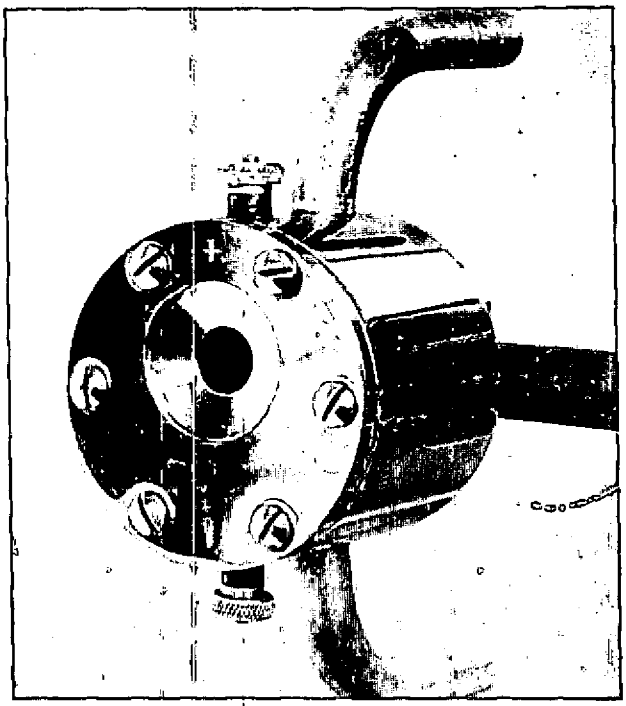
The radiometer described in this note is based on one designed by P. L. Hinkley and R. J. French for use with intensities of radiation up to 0·25 cal cm^{-2} s^{-1}.

References

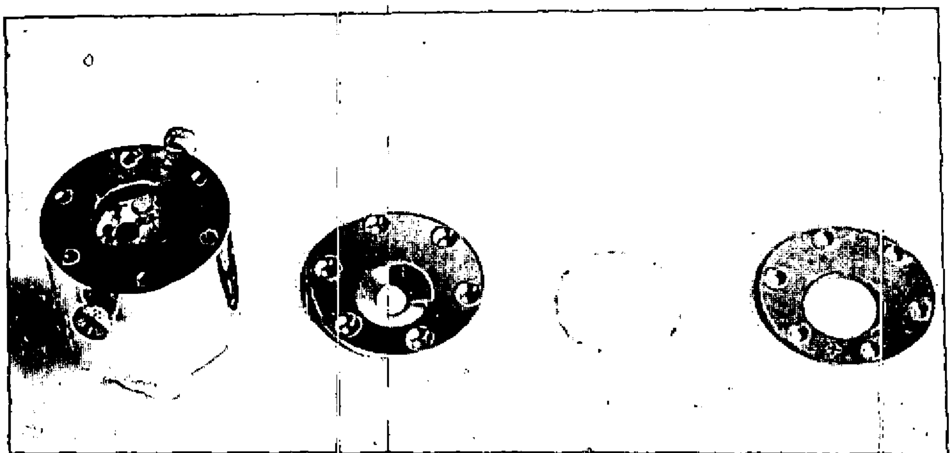
(1) MOLL, W. J. H. A thermopile for measuring radiation. Proc. Phys. Soc. Lond., A, 1922-3, 35, 257-60.

(2) WEBSTER, C. T. and GREGSTEN, M. J. A disc-type radiometer. Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization F.R. Note No. 160/1955.

PC.

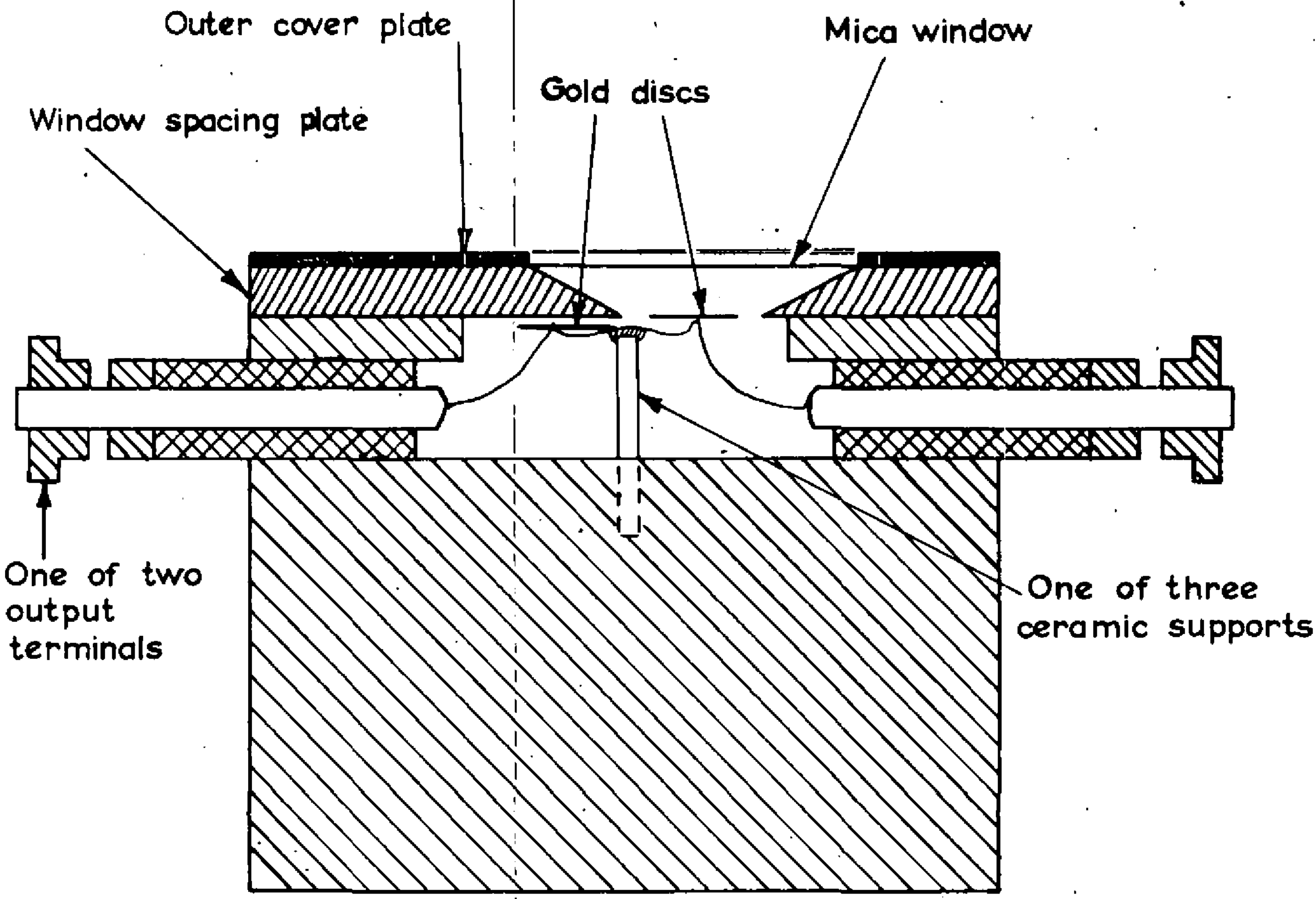


Assembled radiometer with tube for water cooling

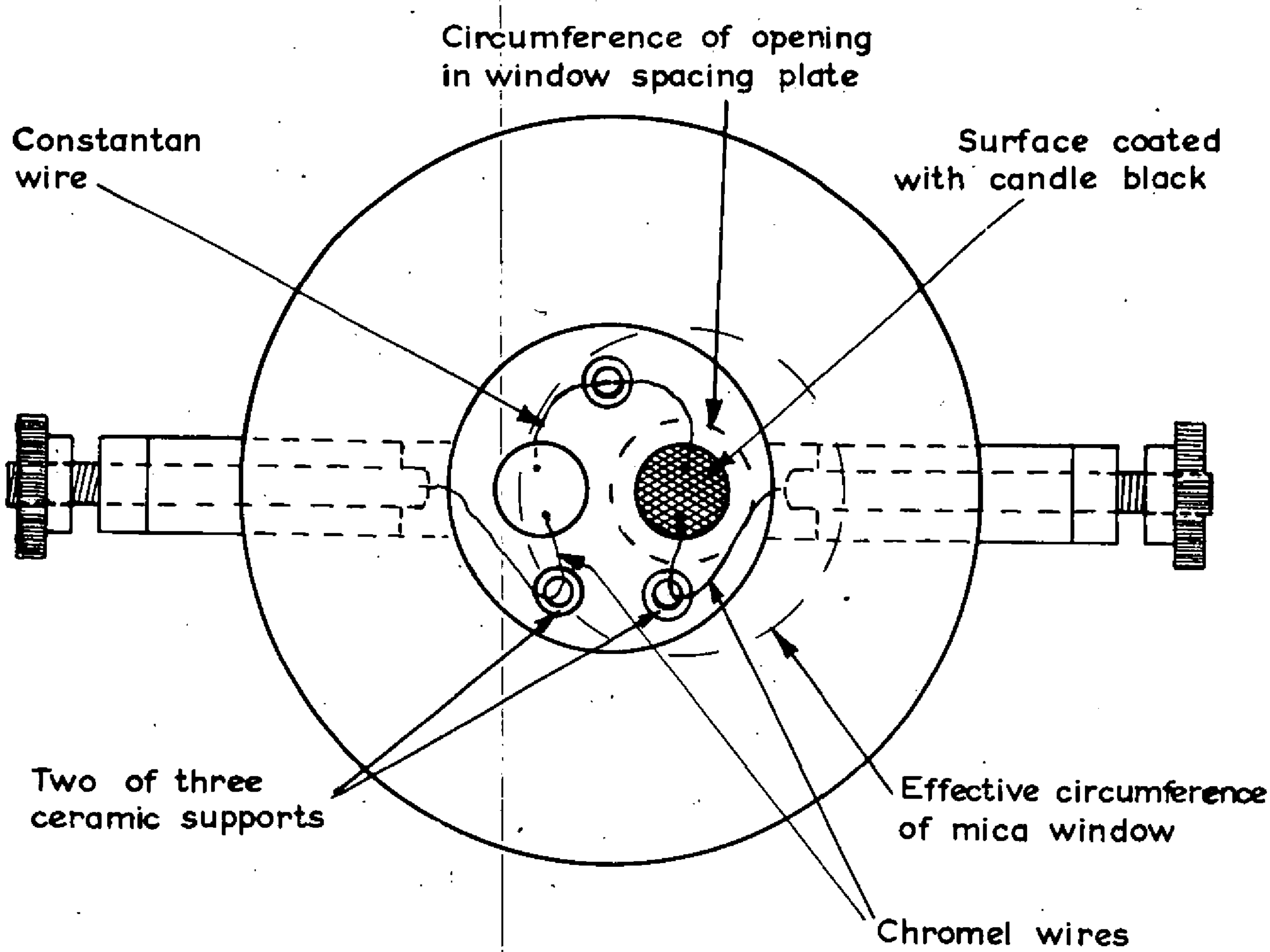


Radiometer without provision for water cooling with front plates and mica window detatched

PLATE. I.



SECTION THROUGH RADIOMETER



RADIOMETER WITH COVERS REMOVED

FIG.1. DIAGRAMS OF RADIOMETER

Scale: twice full size

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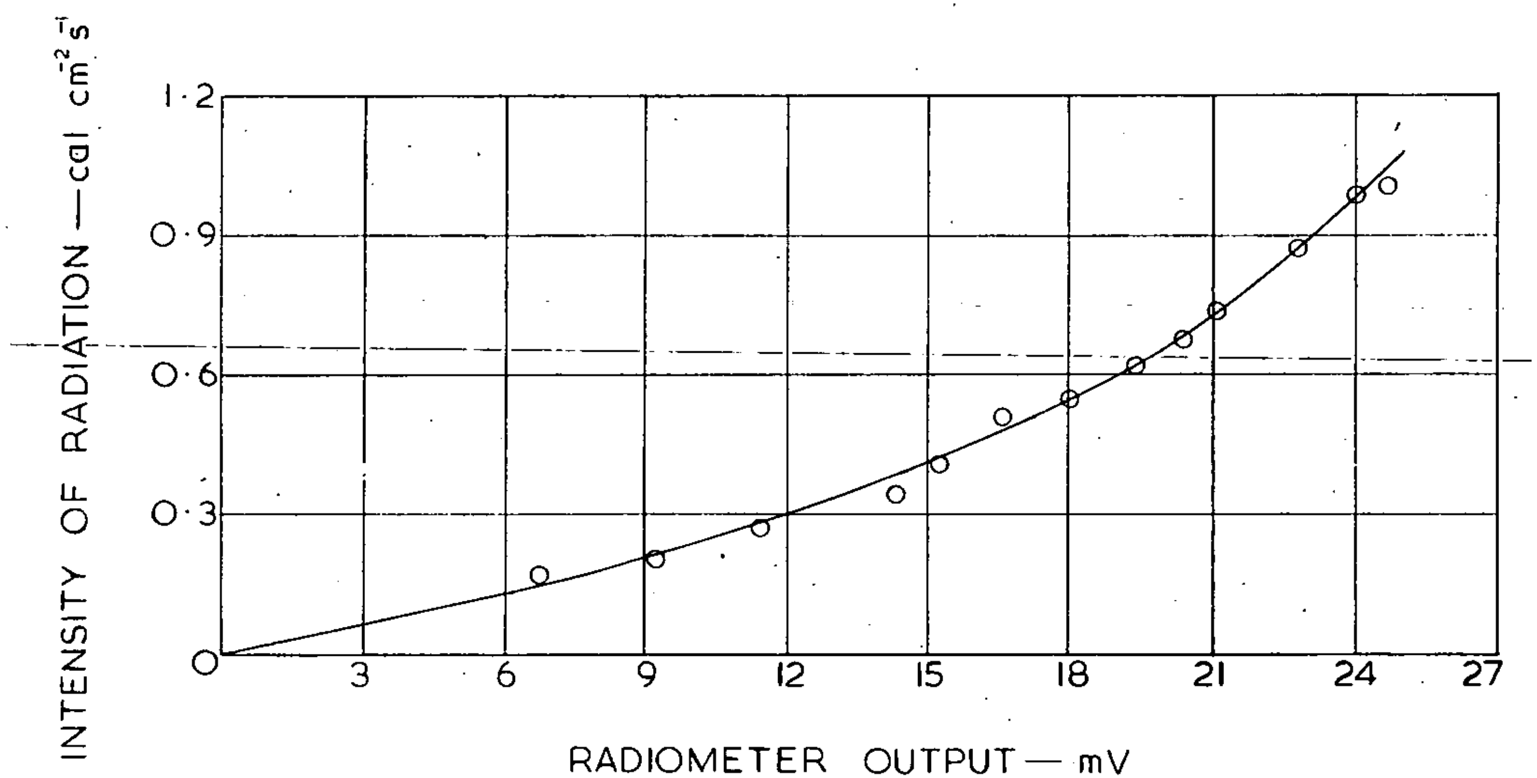

FIG. 2. A TYPICAL RADIOMETER CALIBRATION CURVE

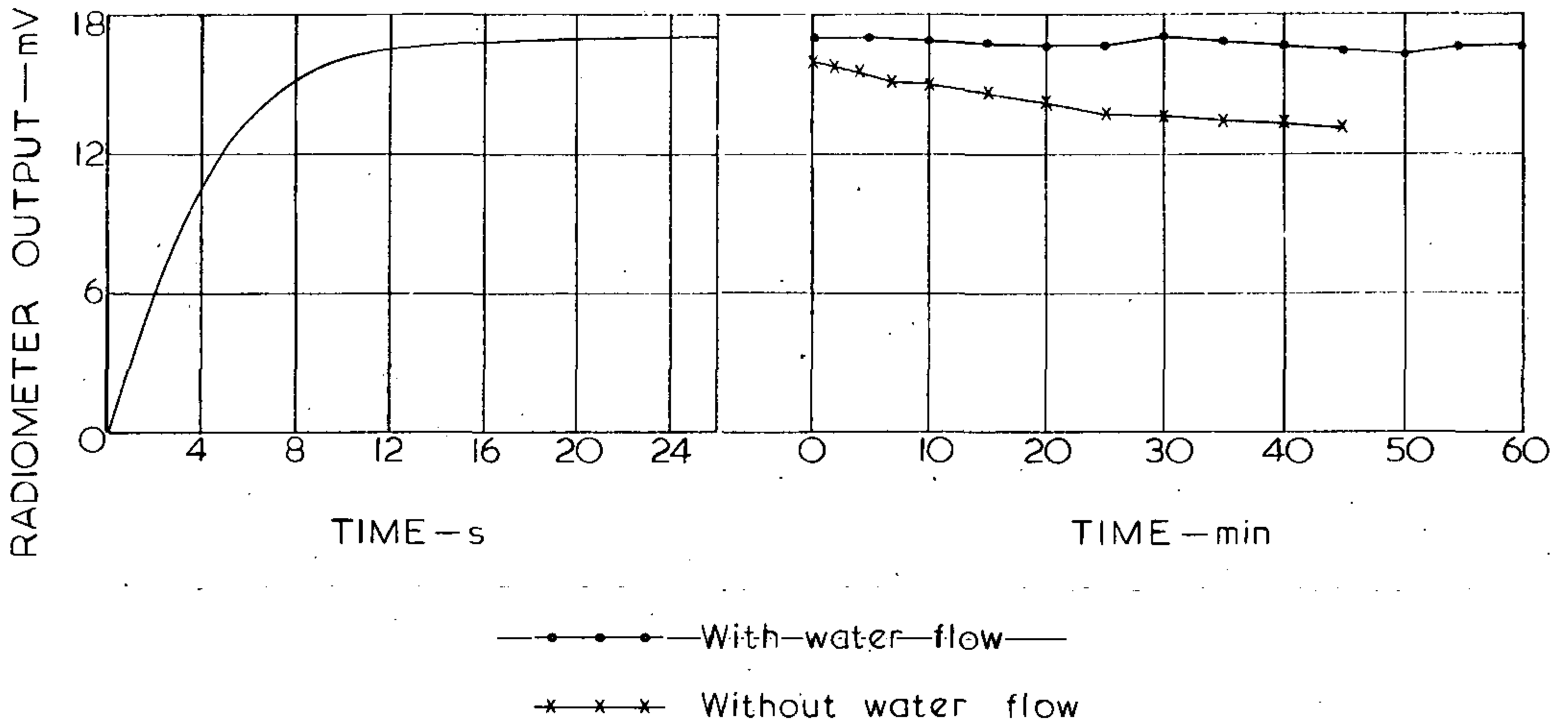

FIG. 3. VARIATION OF RADIOMETER OUTPUT WITH TIME