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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
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A SIMPLE RADIATION DOSAGE METER

by

P. G. Smith

This report describes work carried out by the Fire Research Station for the Ministry of Supply under E.M.R. contract 7/Text/104/R3. and any enquiries relating to it should be addressed to The Director of Materials and Explosives Research and Development, Ministry of Supply, Shell Mex House, Strand, London, W.C.2.

SUMMARY

A simple radiation dosage meter is described, which uses temperature sensitive paint as an indicator. Calibration curves are given.

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1. Introduction

This note describes the construction and calibration of a simple instrument for measuring the total amount of heat falling on a given area in a short time. A metal plate is coated with a paint which melts at a fixed temperature and a small area of the plate is exposed to radiation behind a circular aperture. The total area of the paint which subsequently melts is a measure of the radiation dosage.

2. Construction of the meter

The meter is illustrated in Fig. 1.

A 38 S.W.G. copper plate is used for dosages in the range 5 to 18 cal. cm^{-2} and a 26 S.W.G. steel plate for dosages in the range 16 to 60 cal. cm^{-2}. The rear surface is coated with a "Tempilaq" paint which melts at 66°C and the exposed surface is coated with candle black so that it absorbs the incident radiation. The aperture is a circular hole 1.9 cm. in diameter in a sheet of 16 S.W.G. polished aluminium.

The polished aluminium and the painted plates are separated by two vertical strips of asbestos paper 0.05 in. (0.13 cm.) thick. In addition a rear shield is necessary to minimise cooling effects due to draughts. This shield is separated from the plate by about 1/10 in. and may be made of any convenient thin metal sheet the sides being closed. The whole is secured together by four 4 B.A. bolts which could also be used to support the assembly in some form of frame.

Even if the rear shield is highly reflecting aluminium, a screen is required to protect the instrument from radiation from the sun. Such a screen should not interfere with the free flow of air from the atmosphere to the spaces between the plate and the front and rear shields.

3. Calibration

The source of radiation used for calibration was a carbon arc lamp (1) which has a maximum intensity of radiation of about 12 cal.$cm^{-2}s^{-1}$. The steel plate dosage meter was exposed to this intensity for various times so that for a dosage of 90 cal.cm^{-2} the exposure time was 7.5 s. and for a dosage of 18 cal. cm^{-2} the exposure time was 1.5 s. It was possible to calibrate the copper plate dosage meter for dosages below 12 cal.cm^{-2} by altering the intensity of radiation, while keeping the exposure time at approximately 1 second. For high dosages it was necessary to increase the exposure times slightly up to a maximum of 1.5 s.

The use of a long exposure time at low intensities to simulate high intensities for short exposures is liable to error. To investigate this effect for these meters a calibration of the steel plate was carried out with the output intensity of the carbon arc source halved and hence the exposure times doubled. It will be shown elsewhere that the correction is small and that in practice it is sufficient to take the calibration obtained with the higher intensity. This is shown in Figs. 2 and 3 for the steel and copper plates respectively.

The calibrations also depend on the ambient temperature. In the calibration experiments this varied from 21 to 29°C and to allow for the variation the following correction has been introduced. The energy received 'E' initially raises the plate temperature to a value $\frac{E}{\rho c l}$ above the ambient temperature θ_A

where ρ is the density of the plate,

c is the specific heat of the plate,

l is the thickness of the plate.

The temperature above ambient at which the paint melts is $(66 - \theta_A)$ °C and it is the ratio of these two temperature differences which determines the area of paint melted. Hence the correction for ambient temperature should take the form $\frac{E}{66 - \theta_A}$. The calibrations have been normalized to an ambient temperature of 16°C so the ordinates in Figs. 2 and 3 are $E\left(\frac{50}{(66 - \theta_A)}\right)$.

The temperatures reached by the exposed part of the plate will in the field more nearly reach the theoretical maximum $\frac{E}{\rho c l}$ because of the lower sideways conduction. These temperatures can be of the order of 1000°C or over.

The steel plate, slightly roughened and oxidized, was blackened and then exposed to a high intensity to burn off the film. It was then allowed to cool and re-exposed to a dose of 20 cal.cm^{-2} and the spread was the same as for a plate on which the film had not been destroyed. The copper plate behaved in the same way. The performance of the meters is therefore not limited by the burning of the carbon black.

4. Reference

(1) HINKLEY, P. L. A source of high intensity radiation employing an arc lamp and an ellipsoidal mirror. Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization F.R. Note No. 270/1956.

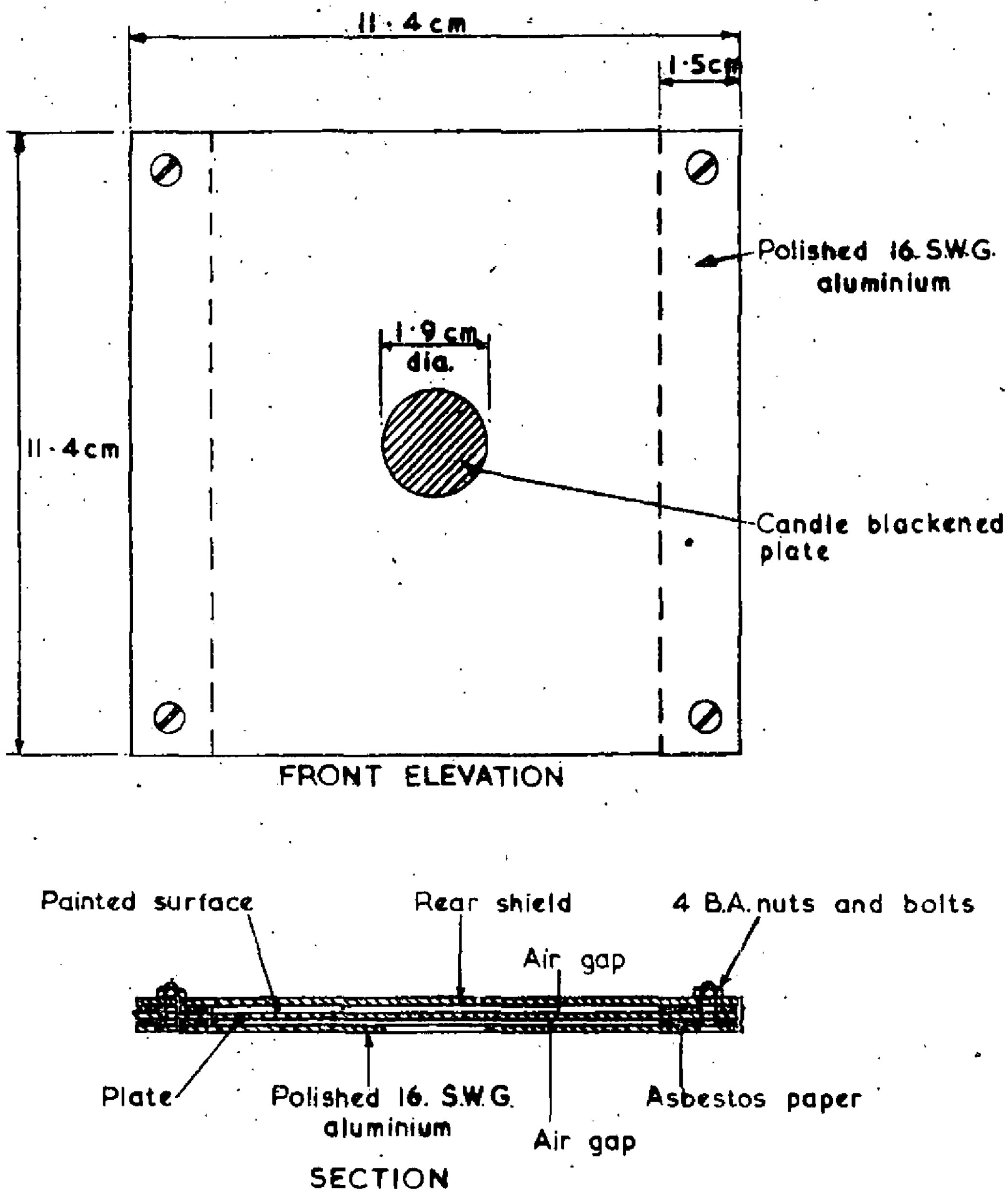

FIG.1. DIAGRAM OF METER

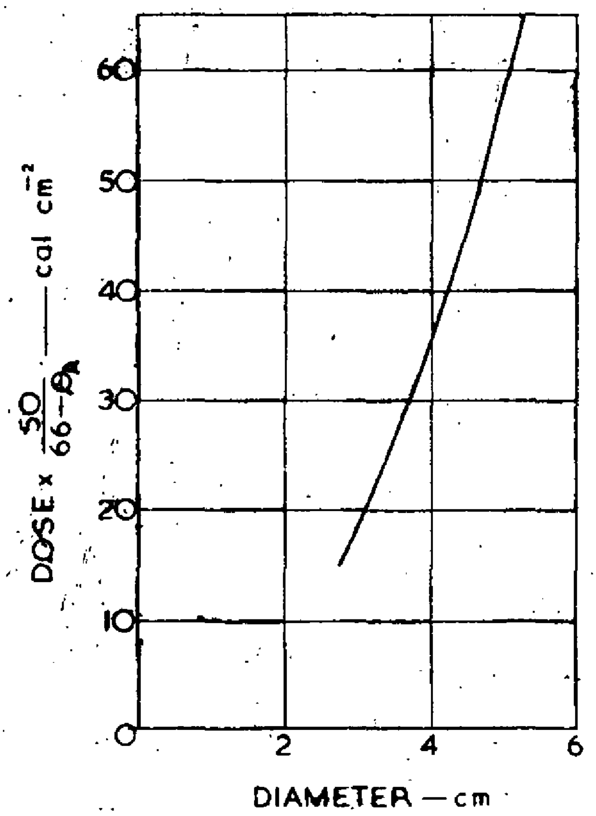

FIG.2. DIAMETER OF MELTED AREA ON STEEL PLATE

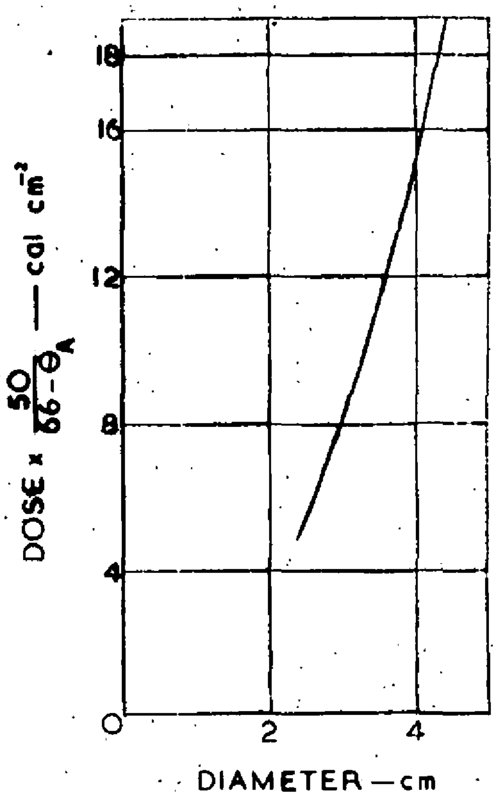

FIG.3. DIAMETER OF MELTED AREA ON COPPER