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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

A SOURCE OF RADIATION EMPLOYING A TUNGSTEN FILAMENT LAMP AND AN ELLIPSOIDAL MIRROR

by

D. L. Simms, R. W. Pickard and Margaret Law

SUMMARY

A description is given of the construction and performance of a simple apparatus giving intensities of radiation of 1 – 5 cal cm^{-2}. s^{-1} over an area of 1 cm^2.

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1. Introduction

Although the focussing power of an ellipsoidal mirror is well known, only recently has this method been used to heat materials by radiation(1)(2)(3). The use of a carbon arc as a source giving intensities of radiation of up to 15 cal cm^{-2} s^{-1} has already been described(3). The apparatus necessary is elaborate, however, and for lower intensities (1 - 5 cal cm^{-2} s^{-1}) a much simpler system with a tungsten filament lamp as the source is also in use at the Joint Fire Research Organization(4).

2. The apparatus

The apparatus is shown in Fig. 1. The diameter of the mirror is 45.7 cm (18 in.) and the two foci are at 17.8 cm (7 in.) and 53.3 cm (21 in.) from the centre. The mirror is front-silvered glass since with back-silvering the glass would absorb part of the radiation; the surface is protected with a thin layer of transparent lacquer.

A 1,000 watt tungsten lamp is placed so that the centre of the filament, which measures 1.4 cm x 1.5 cm, nominal (0.55 in. x 0.59 in. nominal) is at the first focus, the plane of the filament being the focal plane. The intensity of radiation received at the second focus is varied by altering the power input to the lamp, the power supply being fed through a stabilizing unit and varied by means of an auto transformer.

3. Intensity of radiation

The intensity distributions in the second focal plane and along the axis have been measured by a water-cooled thermopile(5) and are shown in Figs. 2 and 3. The variation of peak intensity with power input is shown in Fig. 4, the value being 5 cal cm^{-2} s^{-1} at the rated operating power of 1 Kw.

It is apparent from Fig. 2 that an area of about 1 cm^2 is receiving an intensity of radiation within 90 per cent of the peak value. The size of the irradiated area affects the ignition time(6) and it is desirable to have this area as large as possible. In an attempt to increase the irradiated area, a 2,000 watt lamp with a larger filament area was substituted, but the resulting image was unsatisfactory as the wider spacing of the filament resulted in an uneven distribution of radiation. No useful improvement was obtained on exploring the axial distribution as any gain in uniformity of irradiated area was offset by a large reduction in intensity of radiation.

4. Quality of radiation (7)

The colour temperature of the lamp when running with full load is stated to be 2,900°K(8), its blackbody or radiating temperature being somewhat lower. Reducing the power input reduces the blackbody temperature but changes the quality of the radiation.

The variation of the blackbody temperature of the filament with power input over the range of intensities has therefore been measured, using an optical pyrometer. The temperatures for higher power inputs were found by extrapolation using the relation[9]

$$\log T = a \log R$$

where T is the temperature of the filament in °K

R is the resistance of the filament in ohms

and a is a constant.

The variation of temperature with power input is shown in Fig. 5. For the filament temperatures used in the experiments on ignition the variation in energy distribution is unlikely to have a significant effect.

5. References

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(9) ibid, p.2449.

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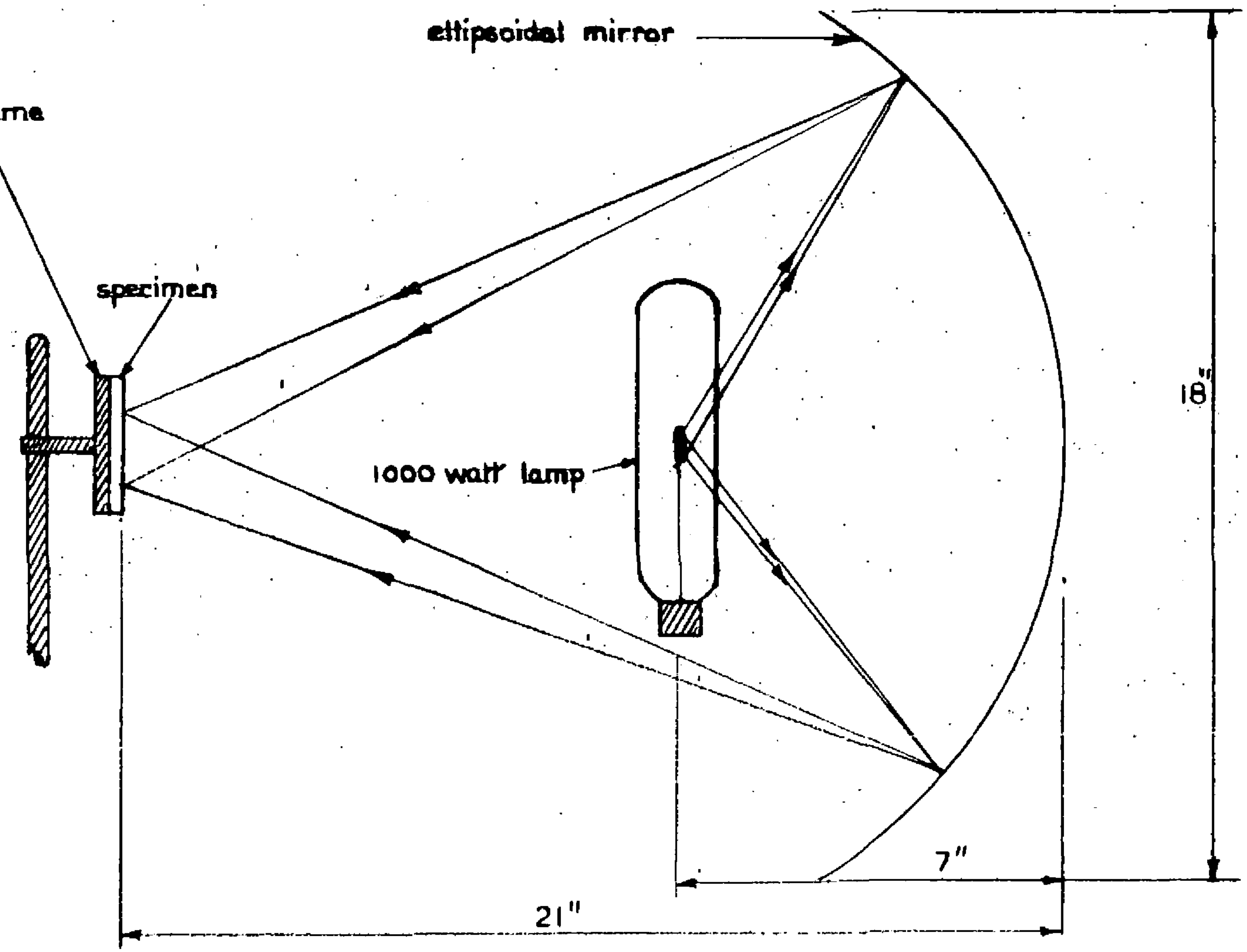

FIG. 1. LAMP AND MIRROR SOURCE OF HIGH INTENSITY RADIATION

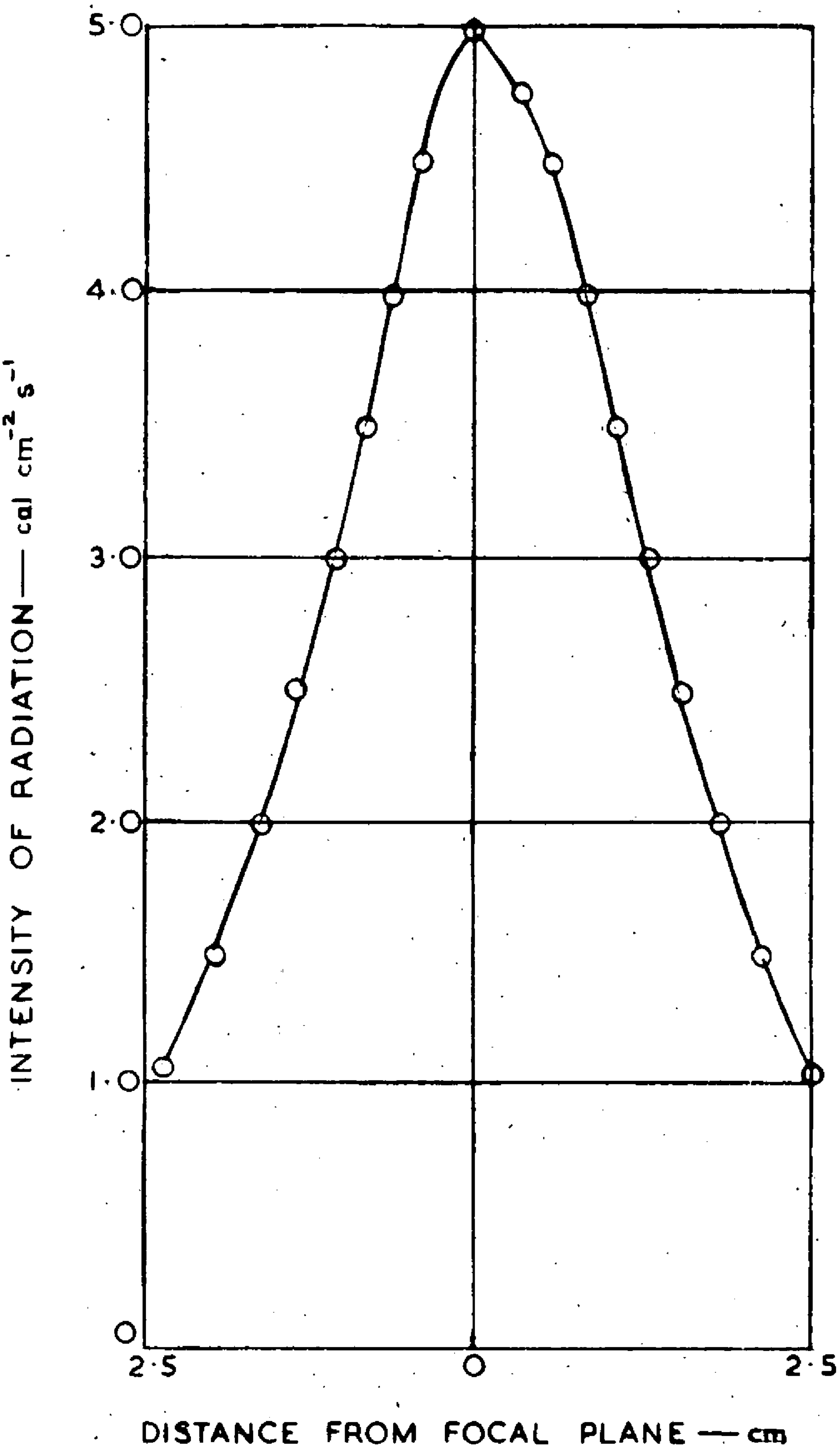

FIG. 2. INTENSITY DISTRIBUTION ACROSS SECOND FOCAL PLANE OF ELLIPSOIDAL MIRROR

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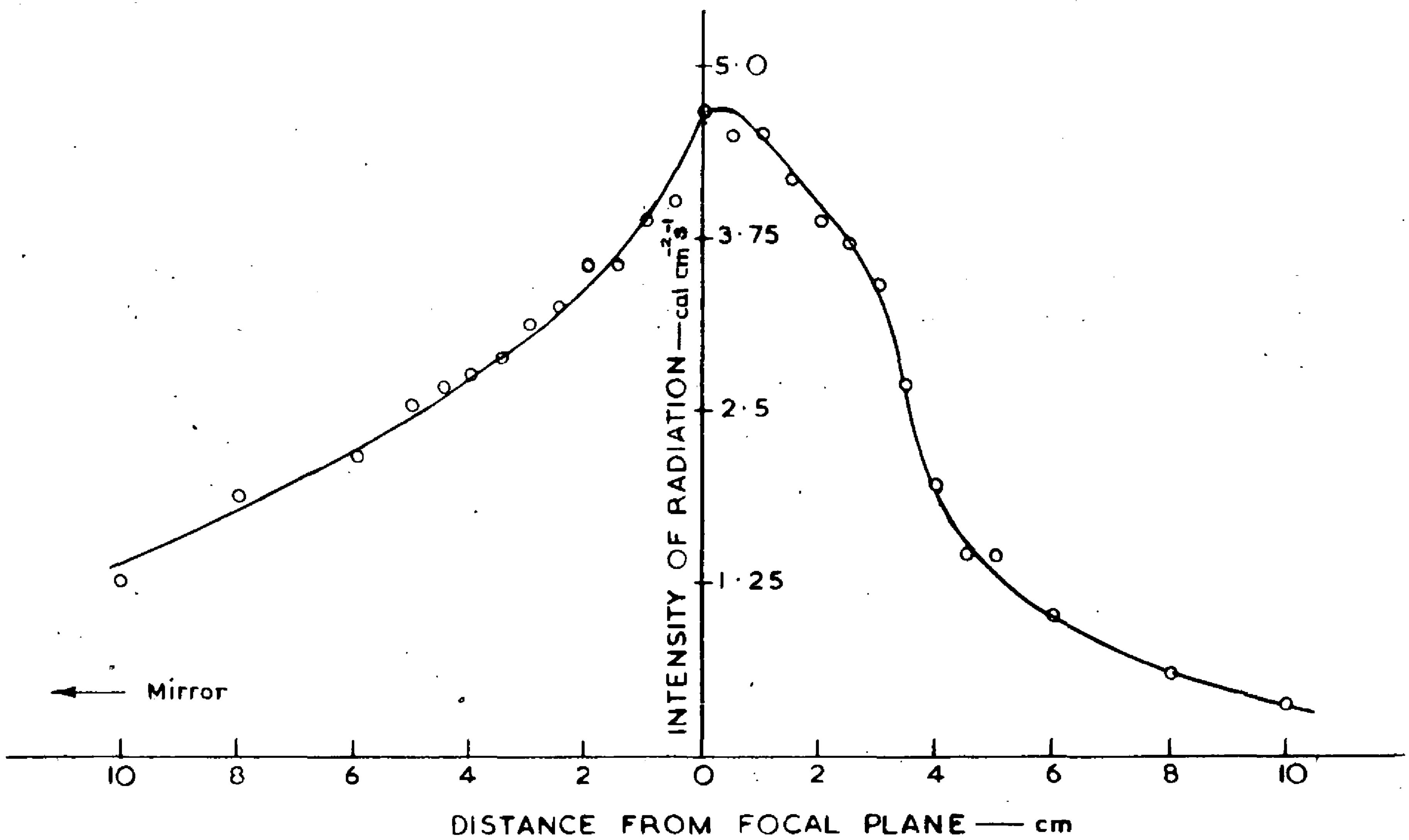

FIG 3 AXIAL DISTRIBUTION OF INTENSITY

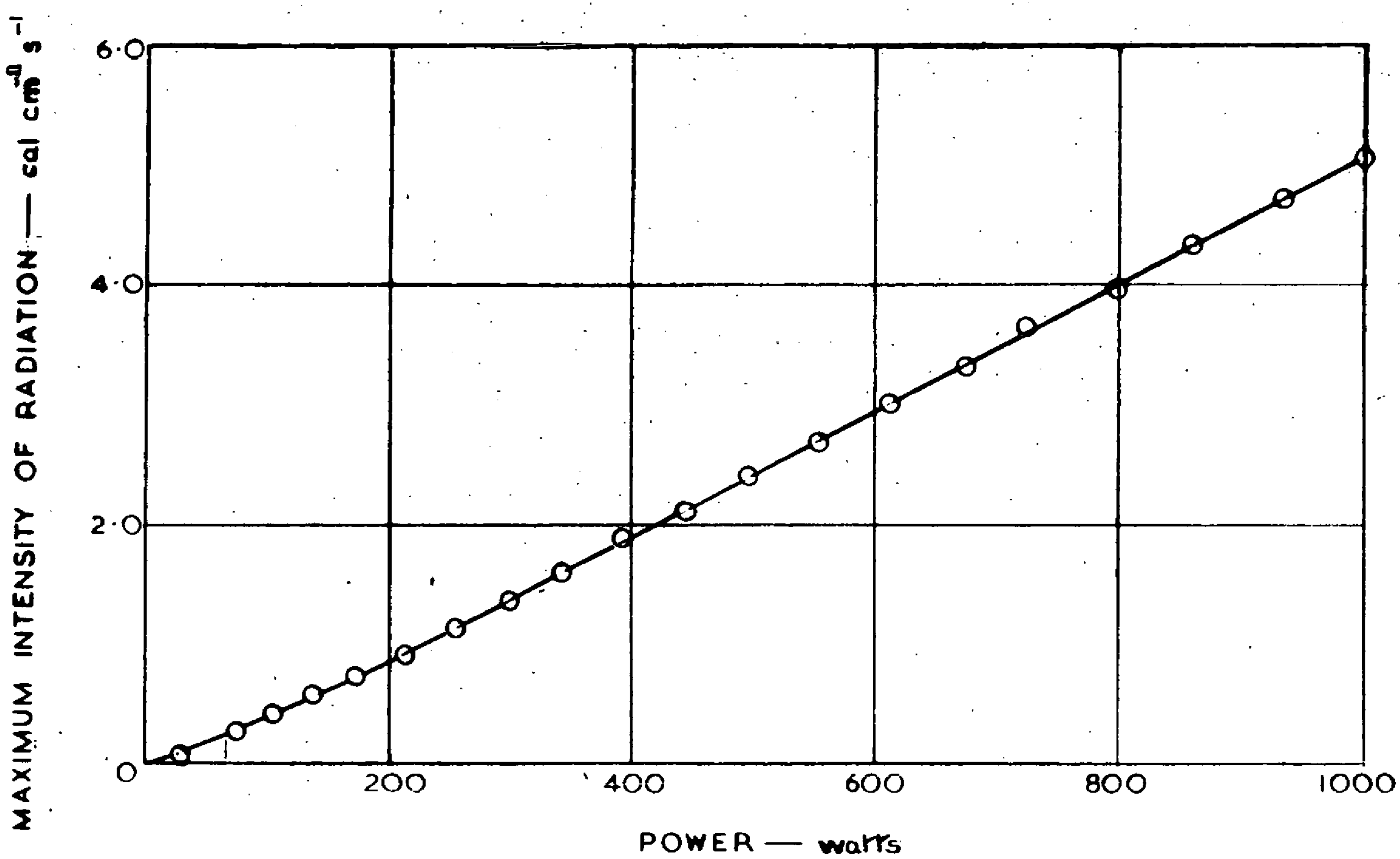

FIG. 4. PEAK INTENSITY AT FOCUS

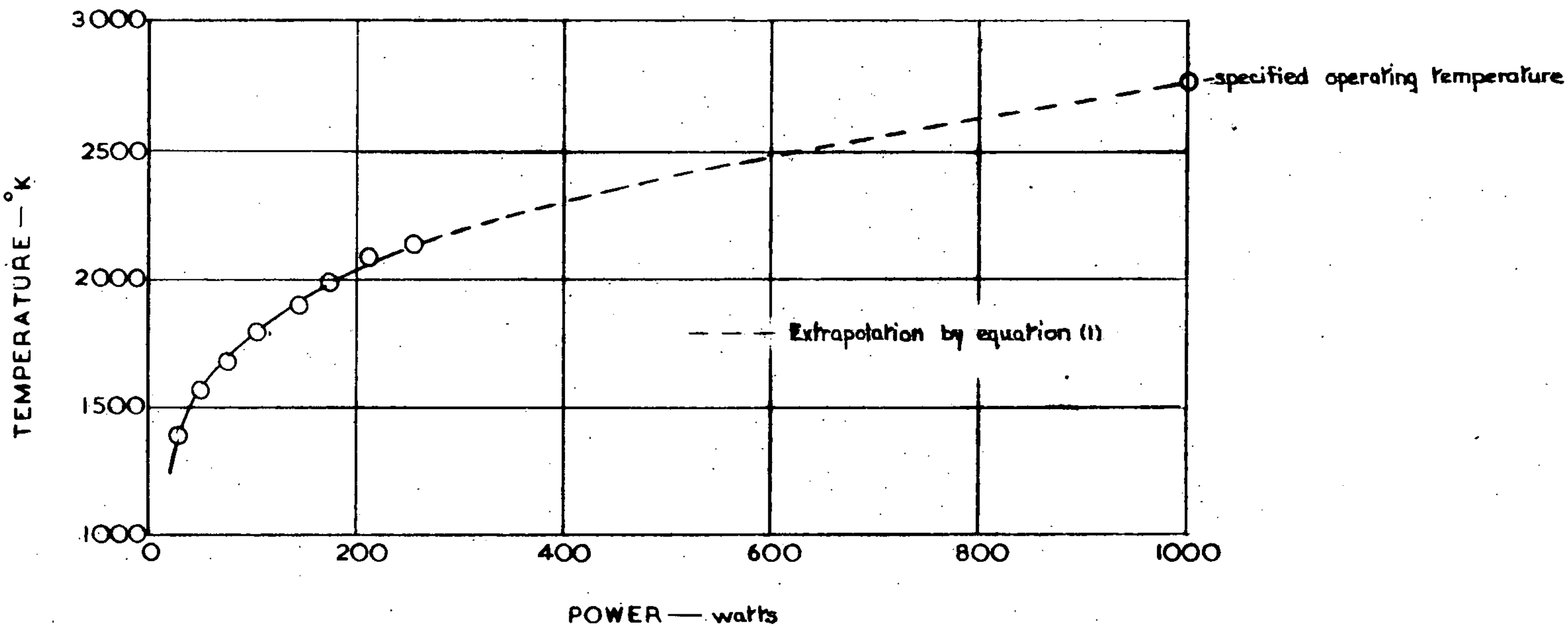

FIG. 5 TEMPERATURE OF THE TUNGSTEN FILAMENT