ROAD RESEARCH LABORATORY

Ministry of Transport

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THE EFFECT OF DIRT ON VEHICLE HEADLAMP PERFORMANCE

by

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CONTENTS

THE EFFECT OF DIRT ON VEHICLE HEADLAMP PERFORMANCE

ABSTRACT

The effect of various degrees of obscuration by dirt on the performance of headlamps removed from vehicles in use has been investigated. Reductions in intensity of over 90 per cent have been measured. The loss of light is accompanied by a change in the beam distribution which causes the amount of light reaching the important parts of the road to be reduced more than the unwanted stray light; under some conditions the light emitted above the horizontal is actually increased by the presence of dirt.

Many drivers probably do not realise that these large losses may occur after quite short periods of driving in bad weather conditions.

1. INTRODUCTION

It is common knowledge that dirt on the surface of a vehicle headlamp lens will reduce the amount of light passing through it but little information is available on the magnitude of the loss or on the effect of dirt on the light distribution. The subject is obviously relevant to road safety and experiments have been carried out in the laboratory to assess this.

Measurements were made on headlamps as removed from vehicles in use. They were selected to show the following degrees of obscuration:-

Lamp 'A' (British sealed beam lamp)

Slight spattering by dirty water over a basically clean lens, i.e. dirt barely noticeable except by close inspection. This might be the condition of a lamp after a short period of driving in heavy showers.

Lamp 'B' (British sealed beam lamp)

Covered with a more or less uniform film of fine particles as might be built up in wet conditions on high speed roads.

Lamp 'C' (British pre-focus lamp)

Very obviously dirty, with a thick film of mud caused by driving during thawing conditions after snow.

These examples were chosen because they appeared to cover the range likely to be encountered in practice. Photographs of the actual lamps tested are shown in Plates 1, 2 and 3. It was found difficult to illustrate the different degrees of obscuration photographically; in particular, Lamp 'A' appears dirtier in the photograph than it actually was.

2. TEST PROCEDURE

Each headlamp was tested by the method standardised at the Road Research Laboratory for obtaining beam distribution; both main and dipped beams were measured before and after cleaning.

Briefly, the lamp is mounted in a goniometer assembly measuring azimuth and elevation; the goniometer is fitted with stepping motor drives allowing azimuth and elevation to be altered independently in increments of 0.1° and an X-Y plotter follows the movements of the goniometer so that the azimuth and elevation of the lamp at any instant can be plotted. The intensity of the light is measured by a vacuum photocell, at 25 m (82 feet), subtending an angle of approximately 5', and the photocell output is indicated on a digital voltmeter. The narrow acceptance angle of the photocell together with the movements of the goniometer form a scanning system which enables the intensity at any point in the beam (definied by the azimuth and elevation angles) to be measured. By plotting points at which the same intensity is indicated on the digital voltmeter ise-candela contours can be drawn.

The beam distributions for the three lamps, dirty and clean, are shown in Figs 1, 2 and 3, together with the results of measurements of the intensities on the horizontal transverse line through the "hotspot".

On comparing the results for lamp 'A' in the dirty and clean conditions it was noticed that there was some distortion of the beam distribution in that the horizontal spread was reduced slightly more than the vertical spread. In order to see whether this effect was greater with the lamps having higher degrees of obscuration measurements were made of the intensities in a vertical plane through the axis of the lamp, i.e. straight ahead, for the remaining two lamps 'B' and 'C'. The results are shown in Figs 4 and 5.

3. DISCUSSION OF RESULTS

As was expected the main effect was the reduction of the maximum intensity of the light emitted but the magnitude of the loss is perhaps surprisingly high - 24 per cent, 50 per cent and 93 per cent for the main beams and 22 per cent, 49 per cent and 92 per cent for the dipped beams for lamps 'A', 'B', and 'C' respectively. This loss is not constant in all directions, a fact best illustrated by Fig. 2, which shows the contours of lamp 'B'. Considering the main beam, a comparison of the maximum intensities of this lamp, clean and dirty, shows a ratio of 2:1 and there are several pairs of contours of this ratio. It will be seen that near the central zone of the beam there is almost perfect coincidence between the 30.000 cd. clean and the 15.000 cd. dirty contours and also between the 20.000 cd. clean and the 10.000 cd. dirty contours, but further out there is progressively greater separation, showing that the reduction in intensity becomes less away from the centre of the beam.

Further a study of the 1.000 cd. 'dirty' contour for the main beam B is interesting: not only does it diverge markedly from the 2.000 cd. 'clean' contour at the top and bottom of the beam but it also crosses the 1.000 cd. 'clean' contour at the top showing that in this region there is actually more light emitted in the dirty condition than in the clean. A similar effect is noticeable with the dipped beam of the same lamp ('B'), which is more serious for seeing conditions of both driver and opposing drivers, and also with the main beam of lamp 'A'. It does not occur with lamp 'C' because of the greater overall obscuration but all the results show the same tendency for the beam to become rounder, with less transverse spread, as the amount of dirt increases, indicating that the efficiency of the lens is reduced, possibly by unwanted internal reflections.

The transverse plots of intensity show more directly how the amount of useful light is reduced by dirt and it will be appreciated from the previous paragraph that the reduction will be accompanied by a relatively increased vertical spread of light.

Figure 4, which shows the vertical 'section' of the dipped beam of lamp 'B' straight ahead, confirms the increase in the intensity above the horizontal shown by the first survey of this lamp. The increased intensity at angles of $\frac{1}{2}^{o}$ or more above the horizontal means more glare for opposing drivers in some road situations. In the dirty condition the intensity at 10^{o} up is some 50 per cent greater than when the lamp is clean and in fact exceeds the specification limit of 125 cd; a lamp in this condition would give increased backscatter in mist and fog. Figure 5, the corresponding curve for lamp 'C' shows that by far the greatest reduction in intensity occurs in the hotspot zone of the beam and that above and below this the intensity is much less affected; the ratio of useful to stray light is therefore substantially reduced by the dirt on the lens. The ratio on the hotspot is 10:1, the ratio at 10^{o} up from a beam is only 3:2.

The distance at which a driver can see an object in the road depends on many factors including the reflective properties and position of the object, the characteristics of the road surface and the presence of other lights, particularly those of opposing vehicles, as well as the driver's eyesight. However, it has been found from previous experimental work(1) that for a given set of conditions, there is an approximately linear relationship between the seeing distance and the logarithm of the intensity.

Under typical conditions an object in the road, on the nearside of the car, would be seen at approximately 73 m (240 feet) with dipped headlights in a clean condition, giving a beam intensity of about 4 500 candelas in the direction of the object. If the intensity is reduced to one-half the seeing distance would be about 49 m (160 feet) and with a reduction to one tenth, 30 m (100 feet). Thus when headlamps become noticeably dirty there may be reductions of about 30 - 60 per cent in the seeing distance.

4. CONCLUSIONS

Even a slight coating of dirt on the lens can significantly reduce the light output of the lamp.

The beam distribution is altered in such a way that the beam becomes rounder as the amount of dirt increases and so its effectiveness is reduced. The greatest reduction in intensity occurs in the region of the hotspot; above and below there is either a smaller reduction or, under some circumstances, an increase. Thus the intensity directed towards the important parts of the road are reduced substantially whilst the glare intensities directed towards opposing drivers are either reduced less or, occasionally, increased. For the same reasons drivers have greater difficulties due to backscatter in mist and fog with dirty headlights than with clean headlights.

5. ACKNOWLEDGEMENT

This report was prepared in the Road Layout and Lighting Section of the Safety Division.

6. REFERENCE

(1) JEHU, V. J. A method of evaluating seeing distances on a straight road for vehicle meeting beams. *Trans. illum. Engng Soc., Lond.*, 1955, *20* (2), 57-68.

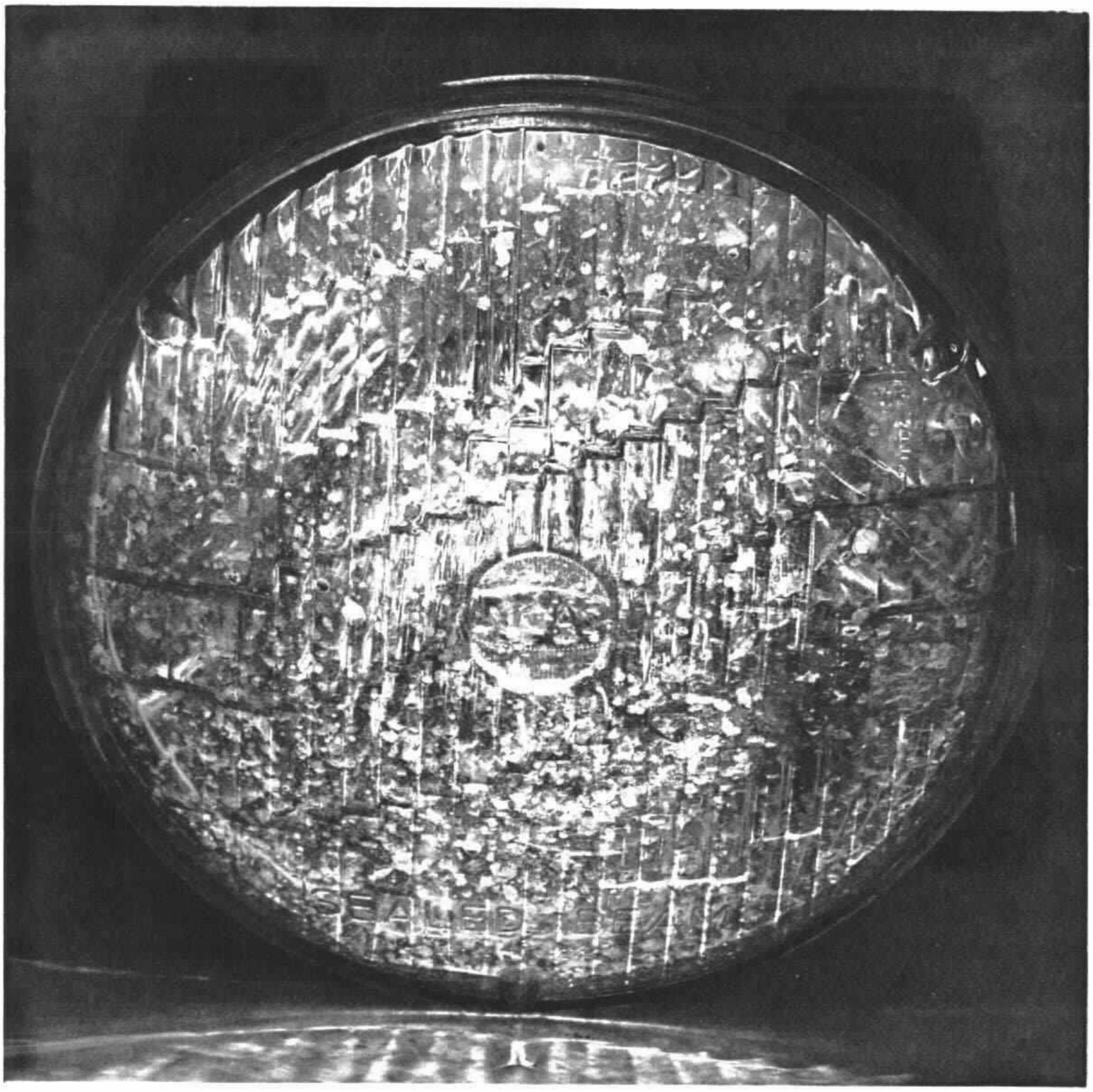

Plate 1

Lamp 'A', British sealed beam B3557/67

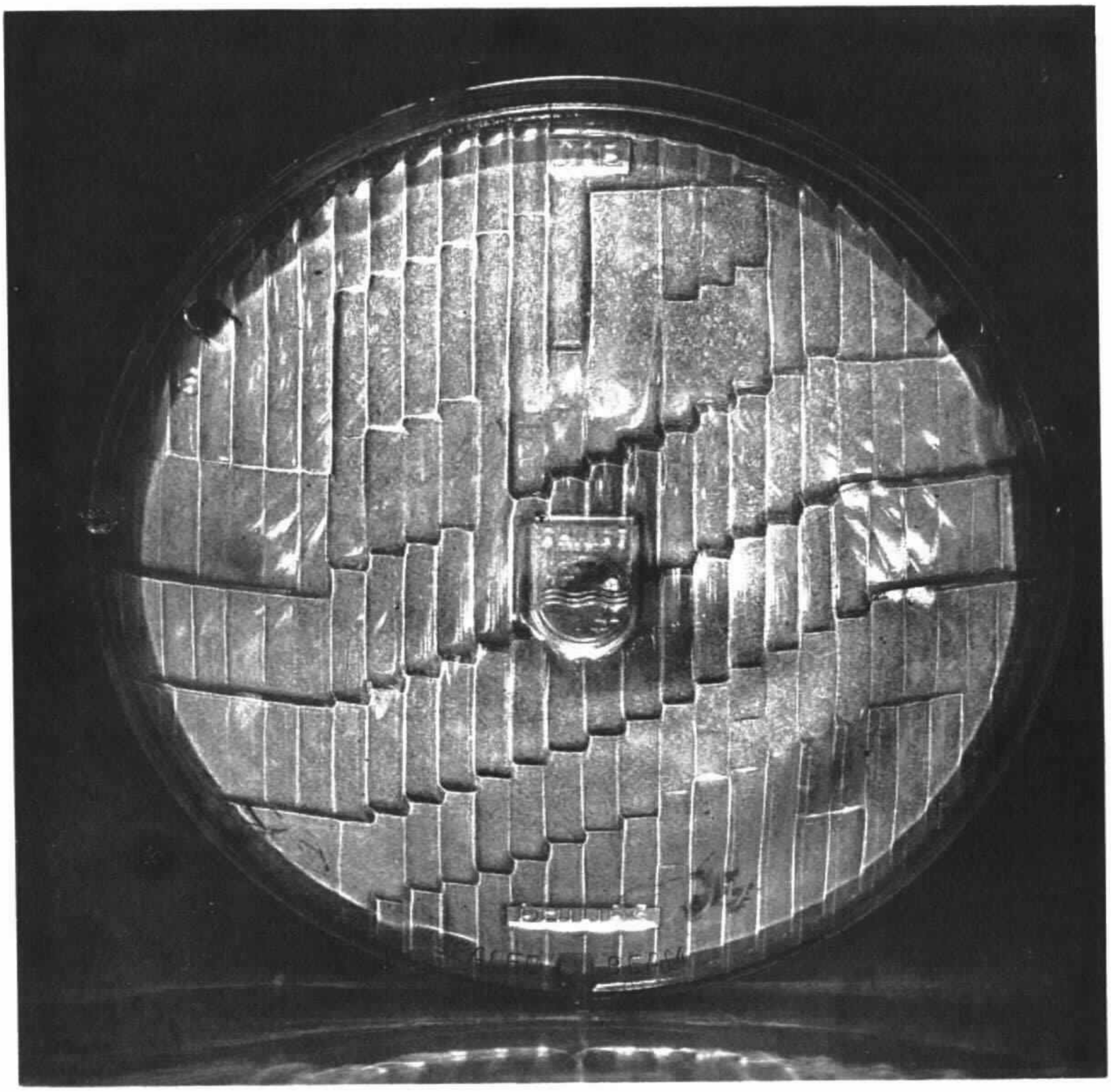

Plate 2

Lamp 'B', British sealed beam B3558/67

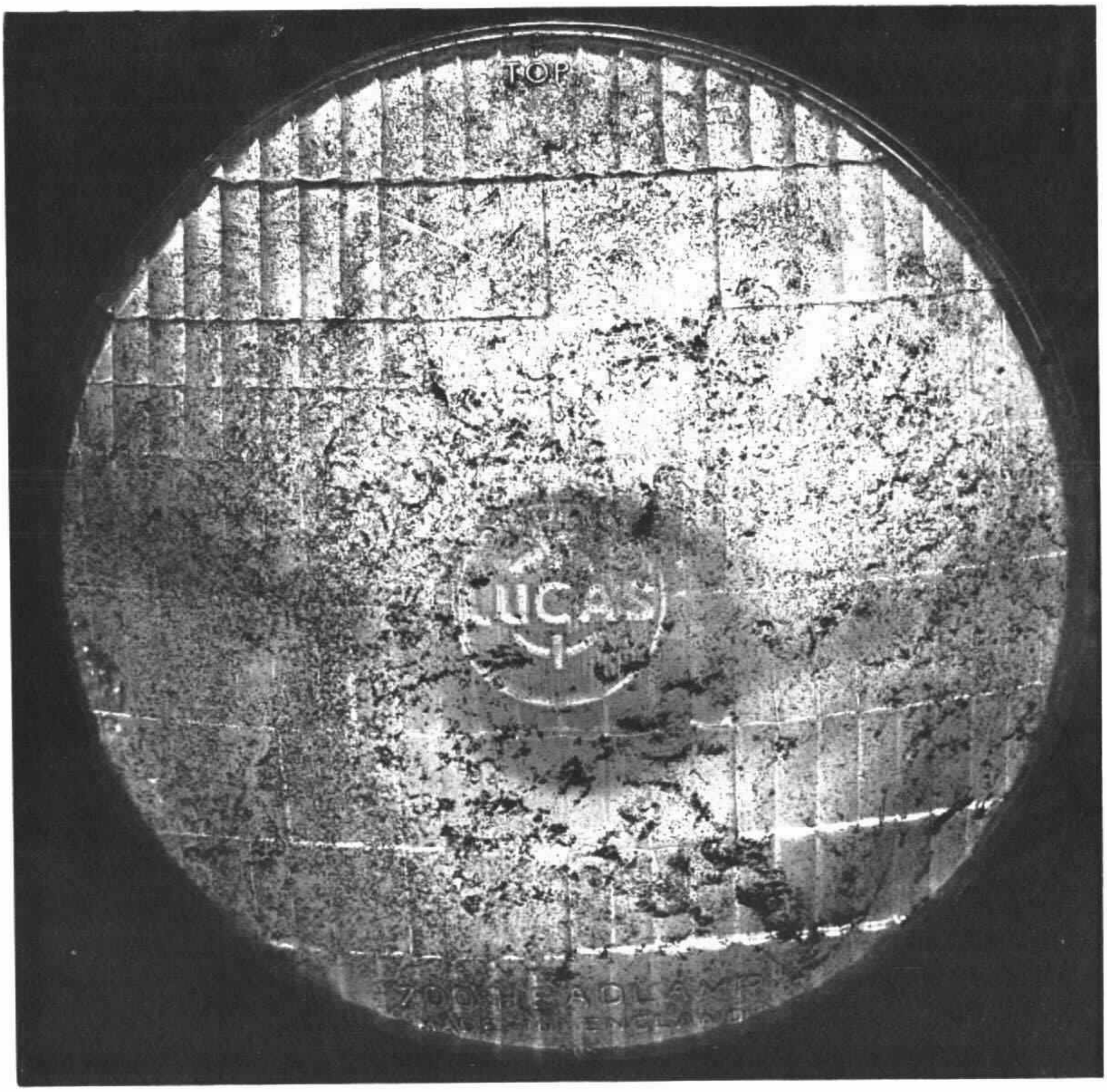

Plate 3

Lamp 'C', British pre-focus lamp B3556/67

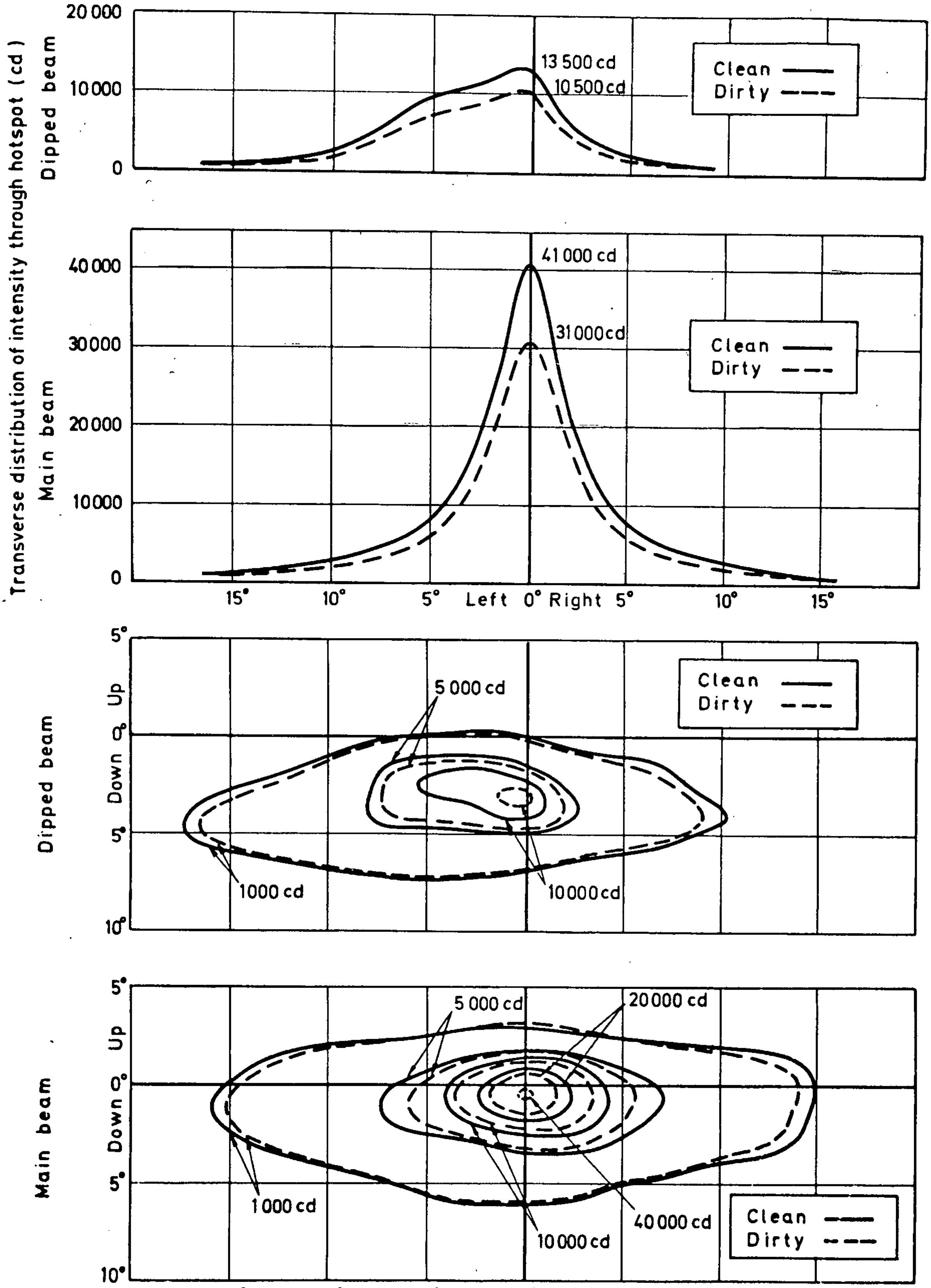

Fig. 1. LAMP 'A' TRANSVERSE DISTRIBUTIONS AND ISO-CANDELA DIAGRAMS

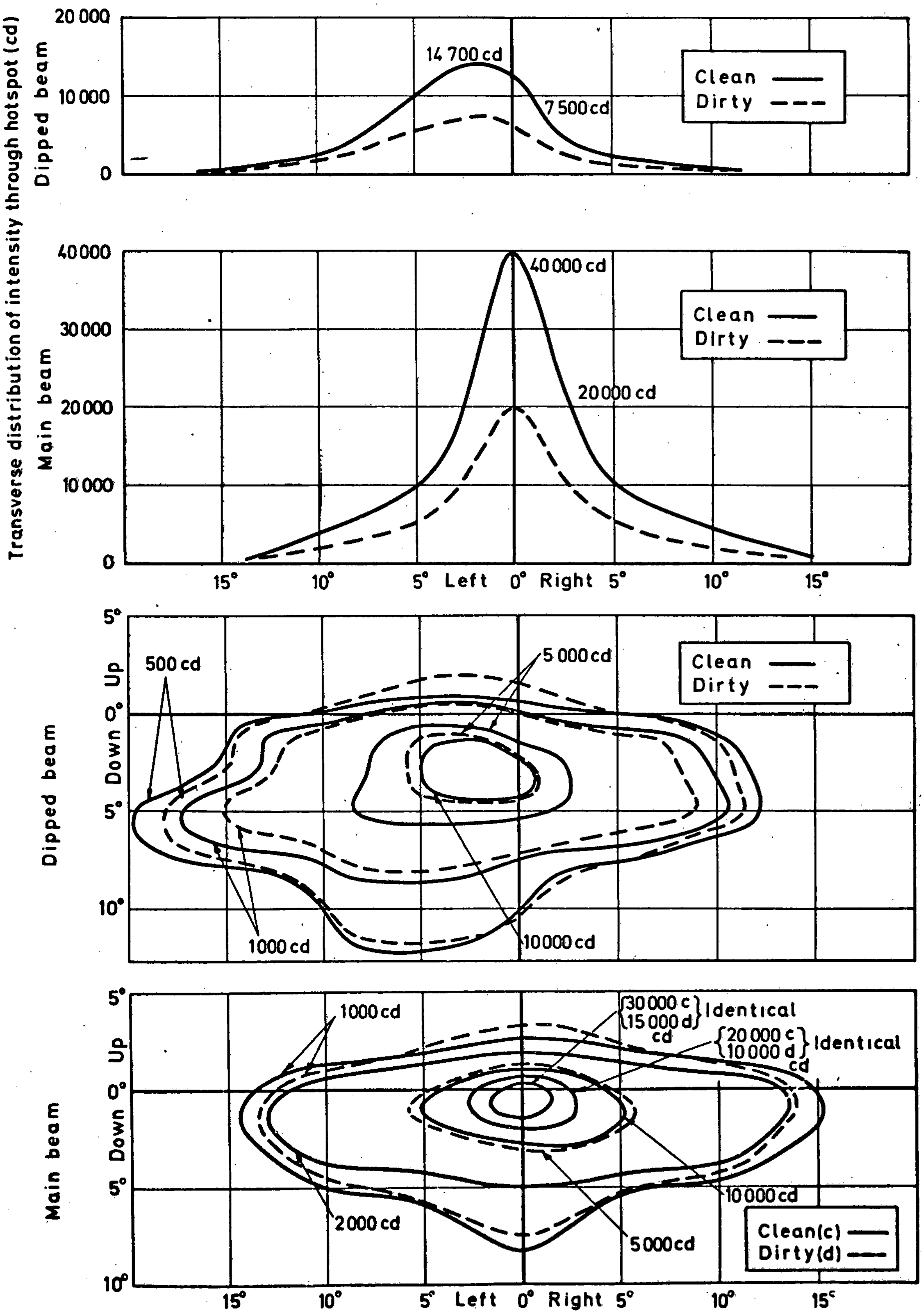

Fig. 2. LAMP 'B' TRANSVERSE DISTRIBUTIONS AND ISO-CANDELA DIAGRAMS

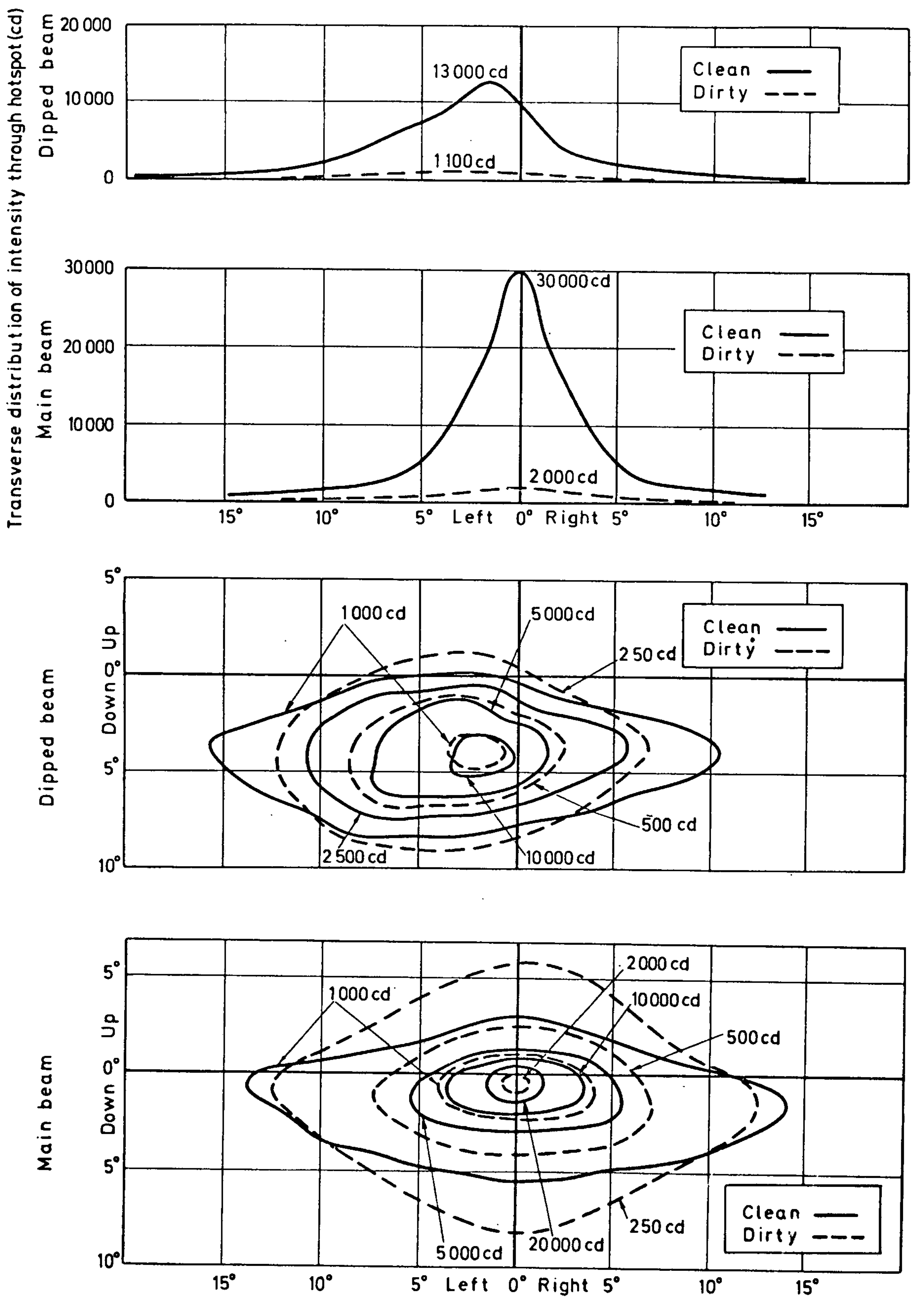

Fig. 3. LAMP 'C' TRANSVERSE DISTRIBUTIONS AND ISO-CANDELA DIAGRAMS

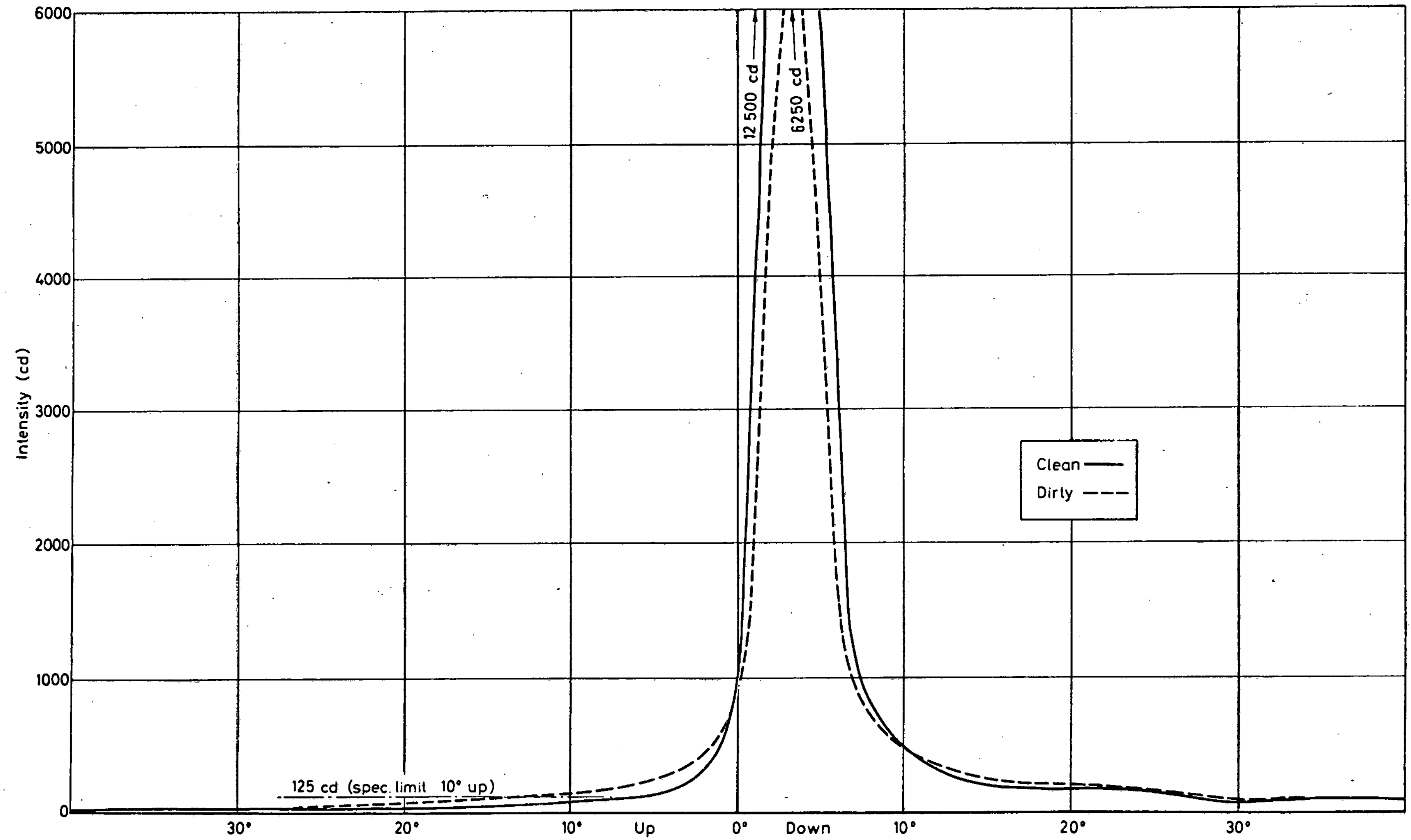

Fig. 4. LAMP 'B', INTENSITY IN VERTICAL PLANE THROUGH AXIS OF LAMP

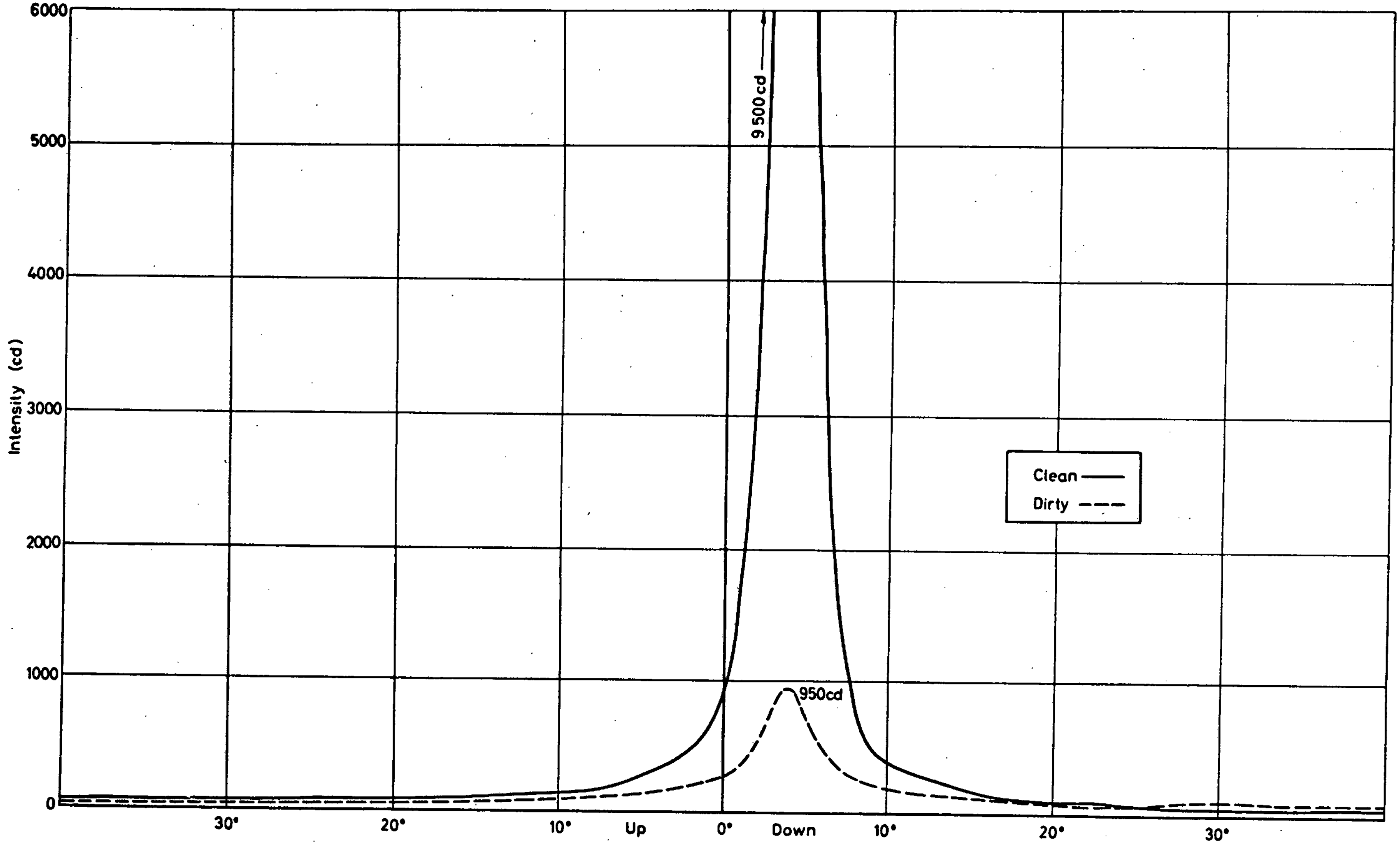

Fig. 5. LAMP 'C', INTENSITY IN VERTICAL PLANE THROUGH AXIS OF LAMP

ABSTRACT

The effect of dirt on vehicle headlamp performance: N. T. COX: Ministry of Transport, RRL Report LR 240: Crowthorne, 1968 (Road Research Laboratory). The effect of various degrees of obscuration by dirt on the performance of headlamps removed from vehicles in use has been investigated. Reductions in intensity of over 90 per cent have been measured. The loss of light is accompanied by a change in the beam distribution which causes the amount of light reaching the important parts of the road to be reduced more than the unwanted stray light; under some conditions the light emitted above the horizontal is actually increased by the presence of dirt.

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