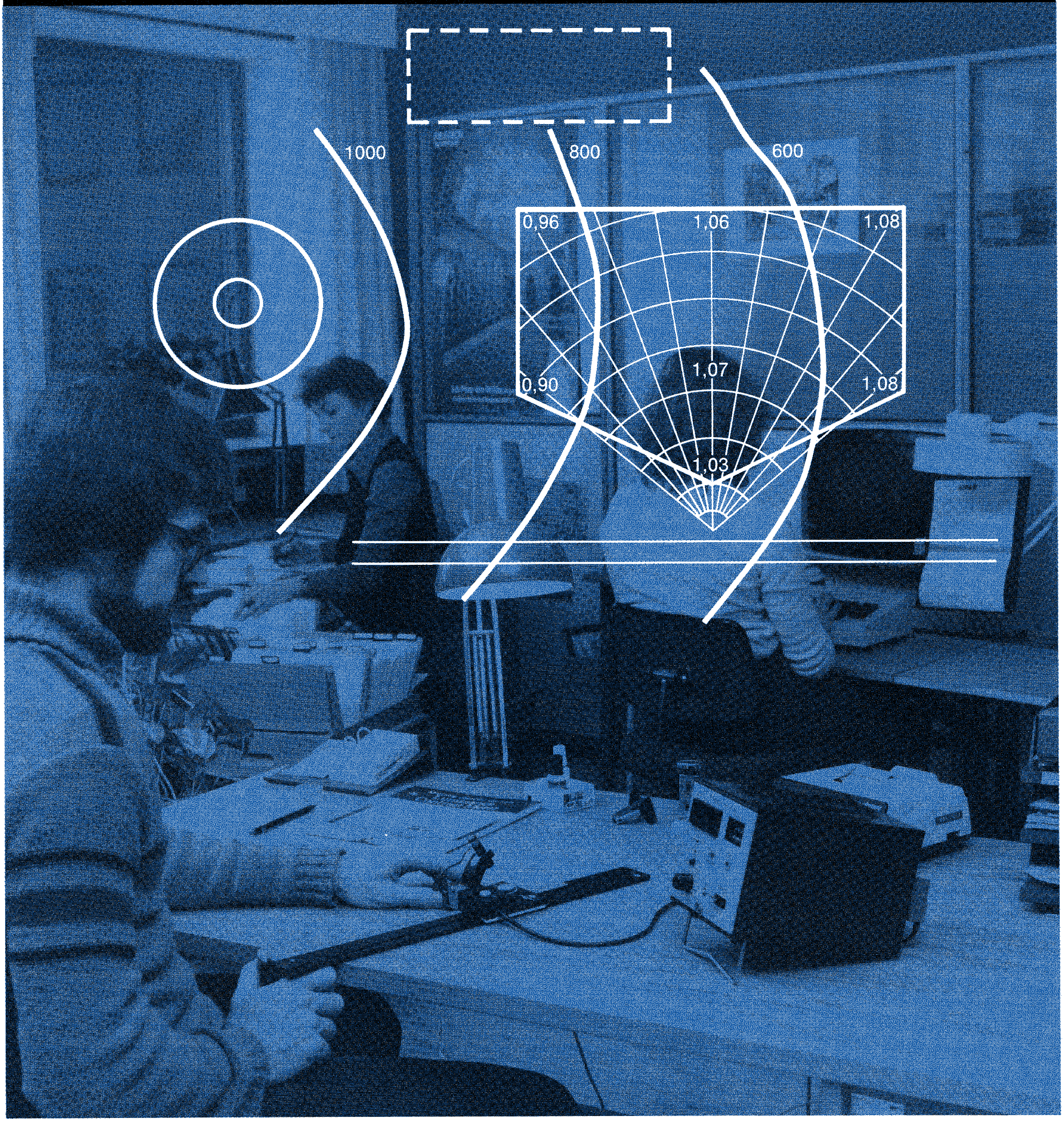
Brüel & Kjær application notes

Measurements of Contrast Rendering in different Lighting Installations with different Desk Lamps



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Measurements of Contrast Rendering in different Lighting Installations with different Desk Lamps

by *Lars Agesen,* Brüel & Kjær

Introduction

The Brüel & Kjær Luminance Contrast Meter has now (1984) been in use for about 3 years. It has attracted a good deal of interest, and the ceramic and glass based contrast standard is being recognized by the CIE as a standard object, enabling objective comparisons between lighting installations.

This Application Note has three sections:

1. General description of contrast measurements
2. Desk top study
3. Interaction between general and localized illumination

I General Description

Surface reflection

For an observer to be able to see any structure or any detail of an object, some kind of visual contrast is necessary. The contrast might be a contrast in luminance, or a contrast in colour, or both.

The contrast might be provided by differences in reflectance properties, orientation or microstructure.

One important type of visual task is white paper with some kind of writing or printing. This visual task makes itself visible by a systematic difference in reflectance properties of the two types of material involved. It is obvious that the reflectance of the paper is much higher than that of the print. Perhaps it is less obvious that the reflectance of the printing is normally more **specular** than that of the paper.

The specularity of a reflective surface might be the most important description of that surface — apart from the overall averaged reflection in itself. The degree of specularity can be illustrated by Fig. 1, showing the extreme cases: totally specular reflection (a) and totally diffuse reflection (b). (c) is a mixed type of reflection, which of course is the most common, and (d) is the special case of retroreflection (important to road traffic at night).

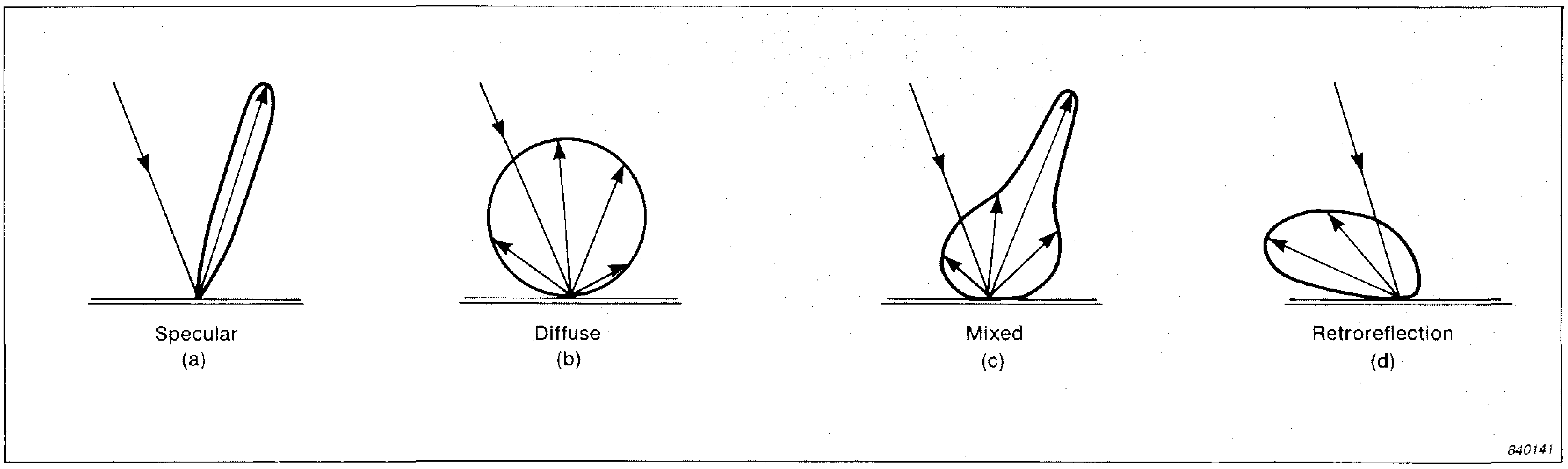

Fig. 1. Main types of reflexion

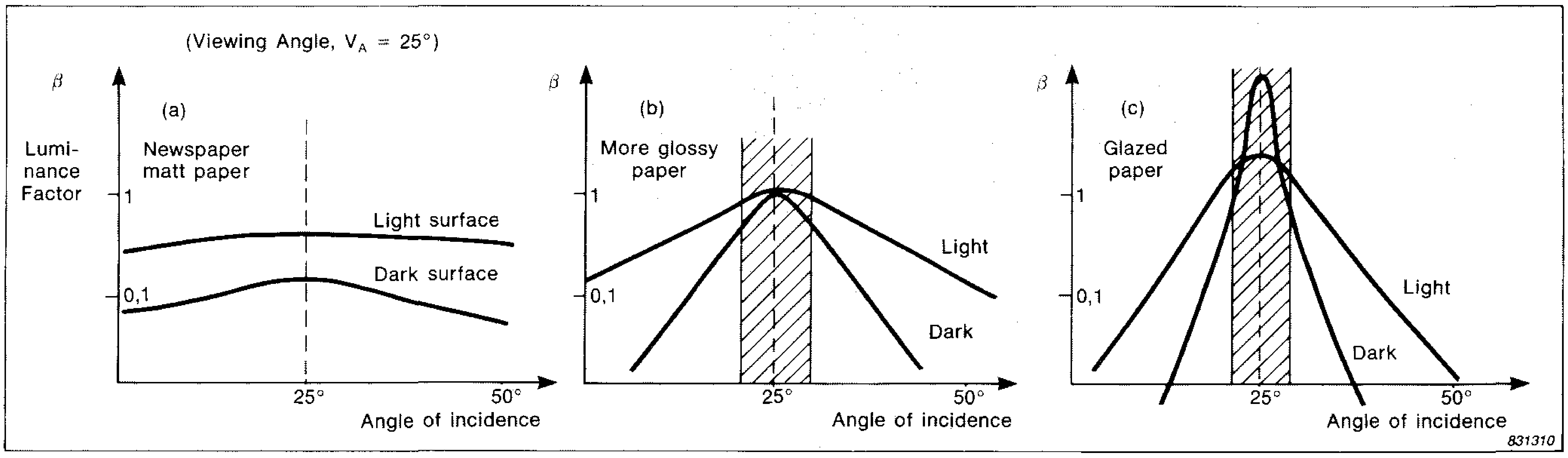

Fig. 2. Luminance factor characteristics for different kinds of paper material. The viewing angle is fixed to 25° with the vertical, while the angle of incidence is varied from 0° to 90°

The interesting fact about a given type of paper with printing is that the print tends to be more specularly reflecting than the paper. There is one exception — the case of newspaper with print — where print and paper tend to have about the same reflectance characteristics.

Fig. 2 shows examples of reflectance characteristics for different kinds of material, so-called *luminance factors*, i.e. the luminance of the material under the specified conditions divided by the luminance of a totally reflecting and perfectly diffusing surface under the same conditions. In Fig. 2 luminance factors are shown for a fixed viewing angle of 25° — for different angles of incident light. Fig. 2 (a) illustrates very matt paper with print, e.g., a newspaper, and it is seen that the two (logarithmic) curves are close to being parallel with each other — which means that the contrast will be fairly independent of the angle of incident light. The contrast is defined as the difference in luminance divided by a reference luminance (see below).

Example 2 (b) shows more glossy paper with print, and it is now seen that the two curves are just touching each other at the point of the specular direction — that is where the angle of incident light is just equal to the angle of observation. In this case there must be a certain band around the specular direction, where luminance contrast is very poor. In fact, it is zero at the 25° point.

Example 2 (c) shows glazed paper with print, and this time the print is so much more specular than the paper on which it is printed that its luminance in a small band is even **larger** than that of the paper, which means "negative" contrast in a very narrow angular band, and anyway very poor contrast in a certain band around the specular direction.

The above illustration already shows that the contrast which the observer sees is a combined effect of the inherent characteristics of the material surfaces and the illuminating geometry.

It follows that such a thing as the contrast rendering ability of an illuminating system does not exist on its own: it can only be defined relative to a given visual task. Since the designer of an illuminating system seldom knows exactly what kind of visual tasks is going to be used, but nevertheless wants to know something about the general contrast rendering capability of his design — the idea has arisen of using just one standardized visual task as a measuring intermediary. By moving such a task around in a work area, either on a single desk top or in an entire room, and by measuring the luminance contrast for each position of the task, a contrast rendering mapping of that work area is possible.

Such a standard task has been developed by Brüel & Kjær — the Luminance Contrast Standard Type 1104. This task is composed of two surfaces mounted on the same disc, with very well-specified and well-controlled reflectance characteristics, (Fig. 3 and 4, table 1).

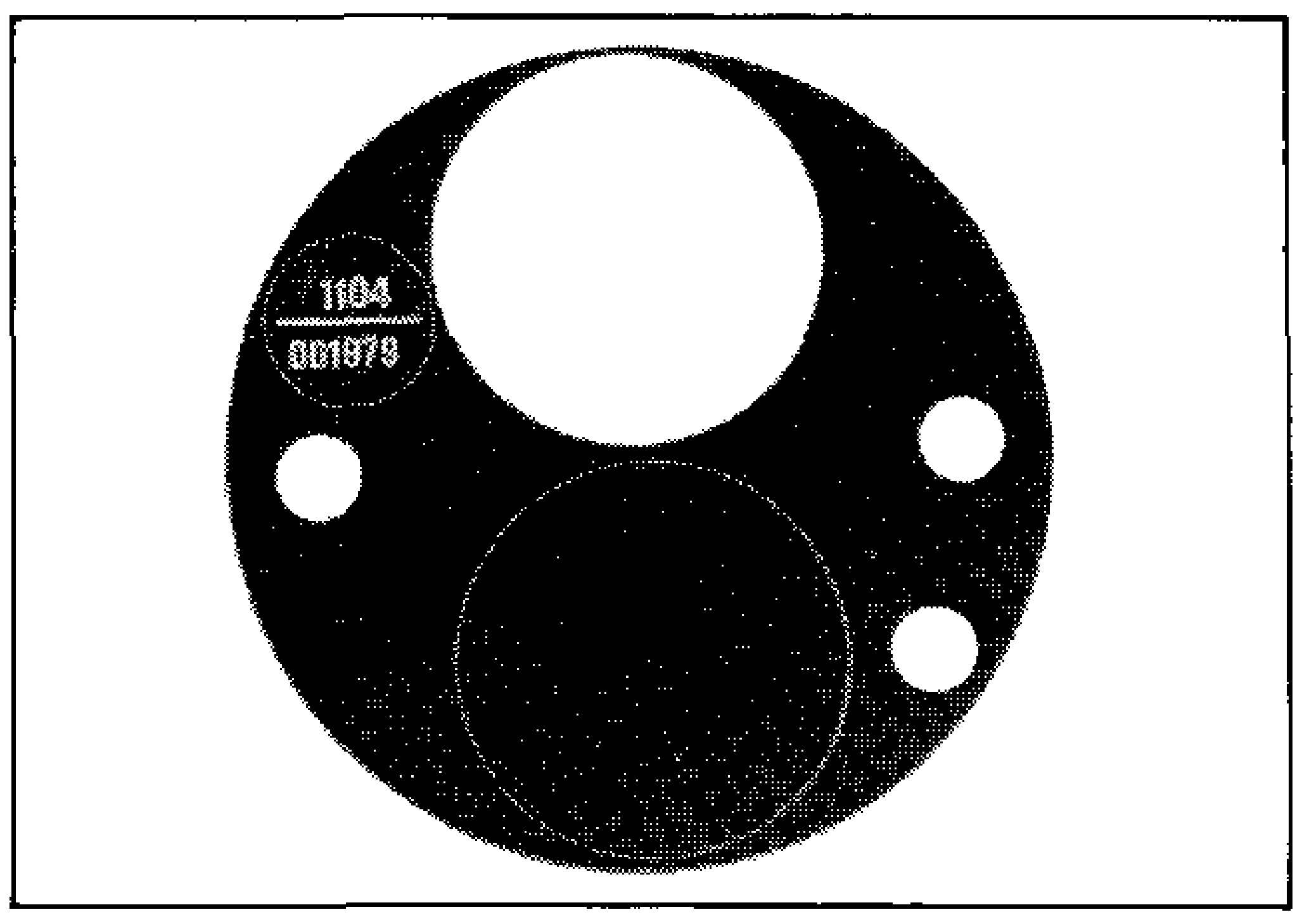

Fig. 3. The B&K standard task

These characteristics are related to each other in a way which places the task somewhere between example (b) and example (c) of Fig. 2. It might have been the perfect compromise to choose example (b), where the two curves exactly touch, but a need for high resolution resulted in the choice described, (Fig. 4)

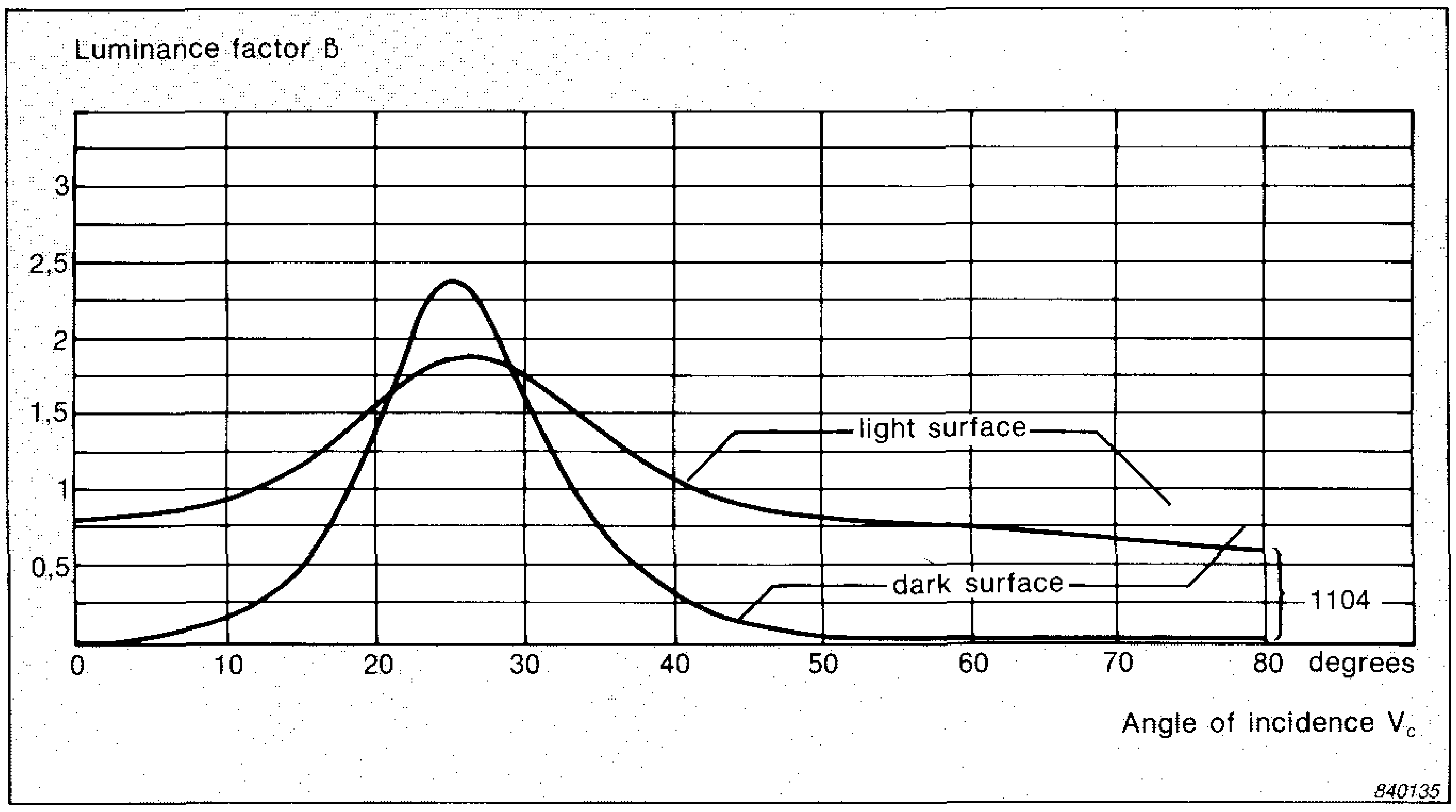

Fig. 4. a Luminance factor characteristics for the B&K standard task

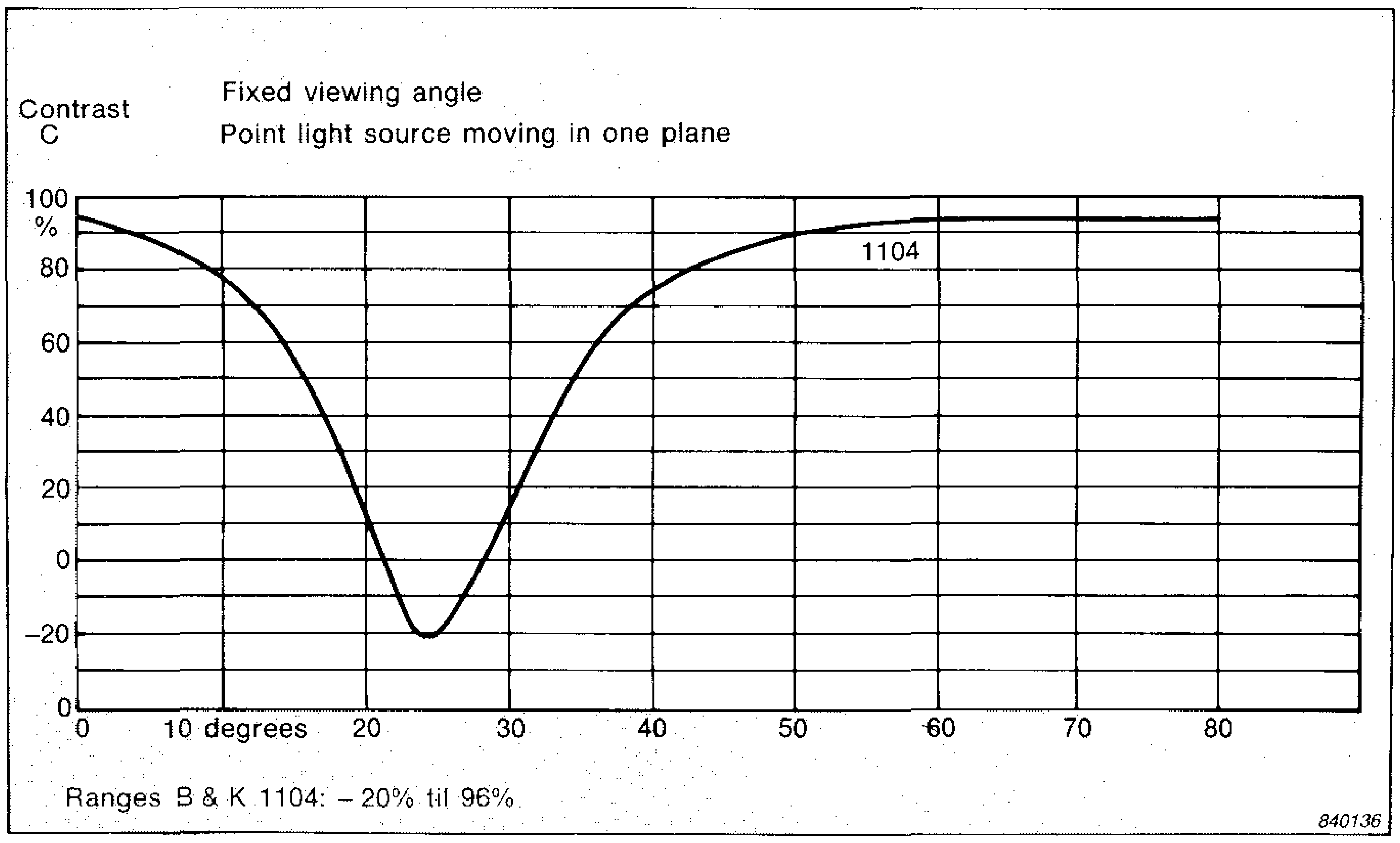

Fig. 4. b Contrast characteristics for the B&K standard task

Light Surface

	V_B \ V_C	0	3	5	7	10	15	20	25	30	35	40	45	50	60	70	80
$V_A = 5°$	0	1,480	1,669	1,718	1,696	1,537	1,190	0,959	0,852	0,801	0,775	0,760	0,748	0,737	0,708	0,655	0,534
	5	1.480	1,667	1,712	1,690	1,501	1,180	0,959	0,851	0,801	0,774	0,759	0,747	0,736	0,707	0,655	0,530
	10	1,480	1,663	1,706	1,681	1,515	1,170	0,953	0,849	0,798	0,772	0,757	0,746	0,735	0,706	0,653	0,530
	20	1,480	1,649	1,656	1,651	1,485	1,148	0,944	0,843	0,789	0,771	0,756	0,744	0,734	0,706	0,653	0,530
	50	1,480	1,567	1,552	1,489	1,322	1,045	0,894	0,820	0,781	0,763	0,750	0,740	0,730	0,702	0,650	0,529
	90	1,480	1,430	1,350	1,259	1,105	0,915	0,832	0,790	0,767	0,753	0,743	0,734	0,726	0,698	0,647	0,529
	120	1,480	1,310	1,230	1,140	1,010	0,855	0,809	0,779	0,760	0,750	0,742	0,734	0,726	0,698	0,647	0,529
	180	1,480	1,300	1,210	1,120	0,995	0,850	0,789	0,771	0,758	0,749	0,742	0,734	0,726	0,698	0,647	0,529

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	V_B \ V_C	0	5	10	15	20	23	25	27	30	35	40	45	50	60	70	80
$V_A = 25°$	0	0,804	0,859	0,977	1,234	1,663	1,881	1,954	1,921	1,757	1,347	1,050	0,909	0,839	0,764	0,700	0,573
	5	0,804	0,856	0,971	1,218	1,625	1,823	1,880	1,847	1,691	1,308	1,035	0,900	0,834	0,763	0,698	0,571
	10	0,804	0,855	0,965	1,194	1,520	1,686	1,707	1,686	1,531	1,218	1,000	0,885	0,824	0,760	0,696	0,570
	20	0,804	0,852	0,943	1,101	1,270	1,319	1,319	1,275	1,190	1,021	0,906	0,841	0,802	0,749	0,689	0,564
	50	0,804	0,828	0,851	0,864	0,855	0,843	0,835	0,825	0,811	0,792	0,776	0,763	0,752	0,722	0,670	0,549
	90	0,804	0,798	0,788	0,778	0,769	0,765	0,762	0,759	0,755	0,750	0,745	0,737	0,730	0,704	0,655	0,545
	120	0,804	0,785	0,771	0,764	0,754	0,752	0,750	0,748	0,745	0,741	0,737	0,731	0,725	0,701	0,649	0,529
	180	0,804	0,776	0,756	0,755	0,752	0,750	0,748	0,745	0,741	0,737	0,737	0,725	0,725	0,700	0,648	0,528

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	V_B \ V_C	0	10	15	20	25	30	35	40	43	45	47	50	55	60	70	80
$V_A = 45°$	0	0,744	0,762	0,783	0,823	0,908	1,106	1,552	2,400	2,885	3,087	3,142	2,857	2,068	1,501	1,025	0,786
	5	0,744	0,762	0,783	0,821	0,901	1,081	1,470	2,117	2.432	2,580	2,546	2,355	1.784	1,358	0,983	0,760
	10	0,744	0,761	0,781	0,815	0,884	1,019	1.266	1,577	1,687	1,726	1,696	1,590	1.322	1,114	0,893	0,710
	20	0,744	0,760	0,775	0,799	0,837	0,891	0,950	0,989	0,988	0,982	0,969	0,941	0,891	0,846	0,758	0,622
	50	0,744	0,751	0,755	0,757	0,759	0,758	0,756	0,753	0,749	0,747	0,745	0,740	0,730	0,716	0,667	0,548
	90	0,744	0,741	0,739	0,736	0,735	0,733	0,729	0,727	0,724	0,722	0,720	0,717	0,705	0,695	0,645	0,532
	120	0,744	0,736	0,733	0,731	0,728	0,726	0,723	0,721	0,717	0,715	0,713	0,711	0,693	0,686	0,638	0,521
	180	0,744	0,733	0,730	0,728	0,725	0,723	0,721	0,717	0,715	0,713	0,711	0,693	0,686	0,684	0,636	0,519

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Dark Surface

	V_B \ V_C	0	3	5	7	10	15	20	25	30	35	40	45	50	60	70	80
$V_A = 5°$	0	1,150	1,767	1,924	1,822	1,265	0,485	0,191	0,090	0,052	0,034	0,026	0,021	0,019	0,016	0,016	0,014
	5	1,150	1,760	1,911	1,805	1,236	0,480	0,190	0,090	0,052	0,034	0,026	0,021	0,019	0,016	0,016	0,014
	10	1,150	1,743	1,882	1,768	1,198	0,468	0,184	0,087	0,051	0,034	0,026	0,021	0,019	0,016	0,016	0,014
	20	1,150	1,691	1,799	1,660	1,130	0,446	0,179	0,085	0,051	0,034	0,026	0,021	0,019	0,016	0,016	0,014
	50	1,150	1,395	1,353	1,144	0,733	0,290	0,127	0,068	0,041	0,028	0,023	0,019	0,017	0,016	0,015	0,014
	90	1,150	1,000	0,803	0,588	0,365	0,153	0,078	0,046	0,031	0,023	0,019	0,017	0,016	0,015	0,014	0,013
	120	1,150	0,750	0,540	0,395	0,240	0,106	0,058	0,036	0,026	0,021	0,017	0,016	0,015	0,014	0,014	0,013
	180	1,150	0,640	0,435	0,300	0,175	0,083	0,047	0,031	0,024	0,020	0,017	0,015	0,014	0,014	0,014	0,013

790150

	V_B \ V_C	0	5	10	15	20	23	25	27	30	35	40	45	50	60	70	80
$V_A = 25°$	0	0,050	0,092	0,203	0,545	1,471	2,160	2.350	2,226	1,579	0,631	0,257	0,129	0,078	0,043	0,032	0,025
	5	0,050	0,092	0,202	0,527	1,369	1,975	2,105	1,975	1,394	0,572	0,242	0,124	0,076	0,042	0,032	0,025
	10	0,050	0,091	0,194	0,482	1,120	1,507	1,566	1,441	1,030	0,454	0,208	0,111	0,070	0,040	0,030	0,025
	20	0,050	0,087	0,170	0,348	0,600	0,672	0,659	0,583	0,447	0,230	0,129	0,079	0,054	0,035	0,028	0,024
	50	0,050	0,068	0,087	0,097	0,090	0,080	0,073	0,066	0,055	0,042	0,033	0,027	0,023	0,020	0,019	0,016
	90	0,050	0,046	0,040	0,033	0,027	0,024	0,022	0,021	0,019	0,017	0,016	0,015	0,014	0,014	0,014	0,013
	120	0,050	0,037	0,028	0,022	0,019	0,017	0,016	0,015	0,015	0,014	0,013	0,013	0,013	0,013	0,013	0,011
	180	0,050	0,031	0,022	0,019	0,017	0,016	0,015	0,015	0,014	0,013	0,012	0,012	0,012	0,012	0,012	0,011

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	V_B \ V_C	0	10	15	20	25	30	35	40	43	45	47	50	55	60	70	80
$V_A = 45°$	0	0,017	0,028	0,042	0,069	0,134	0,312	0,893	2,656	4,207	4,815	4,650	3,328	1,429	0,648	0,255	0,156
	5	0,017	0,028	0,041	0,067	0,127	0,281	0,734	1,868	2,662	2,879	2,721	2,069	1,007	0,513	0,222	0,141
	10	0,017	0,028	0,040	0,064	0,114	0,227	0,473	0,874	1,050	1,067	0,985	0,816	0,495	0,307	0,162	0,111
	20	0,017	0,027	0,036	0,053	0,080	0,121	0,169	0,198	0,199	0,192	0,181	0,162	0,128	0,102	0,073	0,058
	50	0,017	0,022	0,024	0,026	0,027	0,027	0,026	0,025	0,024	0,024	0,024	0,023	0,023	0,023	0,022	0,021
	90	0,017	0,016	0,016	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,015	0,014
	120	0,017	0,015	0,014	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,012
	180	0,017	0,013	0,013	0,013	0,012	0,012	0,012	0,012	0,012	0,012	0,012	0,012	0,012	0,012	0,012	0,011

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Table 1. Luminance factors for the light and the dark standard surfaces. Angular system defined in Fig. 5

It should be noted that the reflection characteristic of a surface is a three-dimensional parameter. Thus it can only be described thouroughly in a system of matrices or by mathematical modelling.Table 1 is such a system of matrices, but it only covers three selected angles of observation: 5°, 25° and 45°. See Fig. 5 for angular system.

Luminance Contrast

Luminance Contrast for plane paper material with characters is normally defined as

$$C = \frac{L_p - L_c}{L_p}$$

where L_p is the luminance of the paper, and L_c the character luminance. The denominator of the definition should ideally be the adaptation luminance for the observer eye. This adaptation luminance is generally accepted to be approximated by the paper luminance alone.

To allow comparison between different tasks used as measuring intermediaries, the international commission for illumination, the CIE, has proposed a measurement parameter which refers the measured contrast in the actual situation to the "inherent" contrast of the used task. This "inherent" contrast of the task is defined as the contrast of the task in a **completely diffuse** illumination. The proposed measurement parameter is called Contrast Rendering Factor, CRF, and the formal definition is:

$$CRF = \frac{C_{actual}}{C_{diffuse}}$$

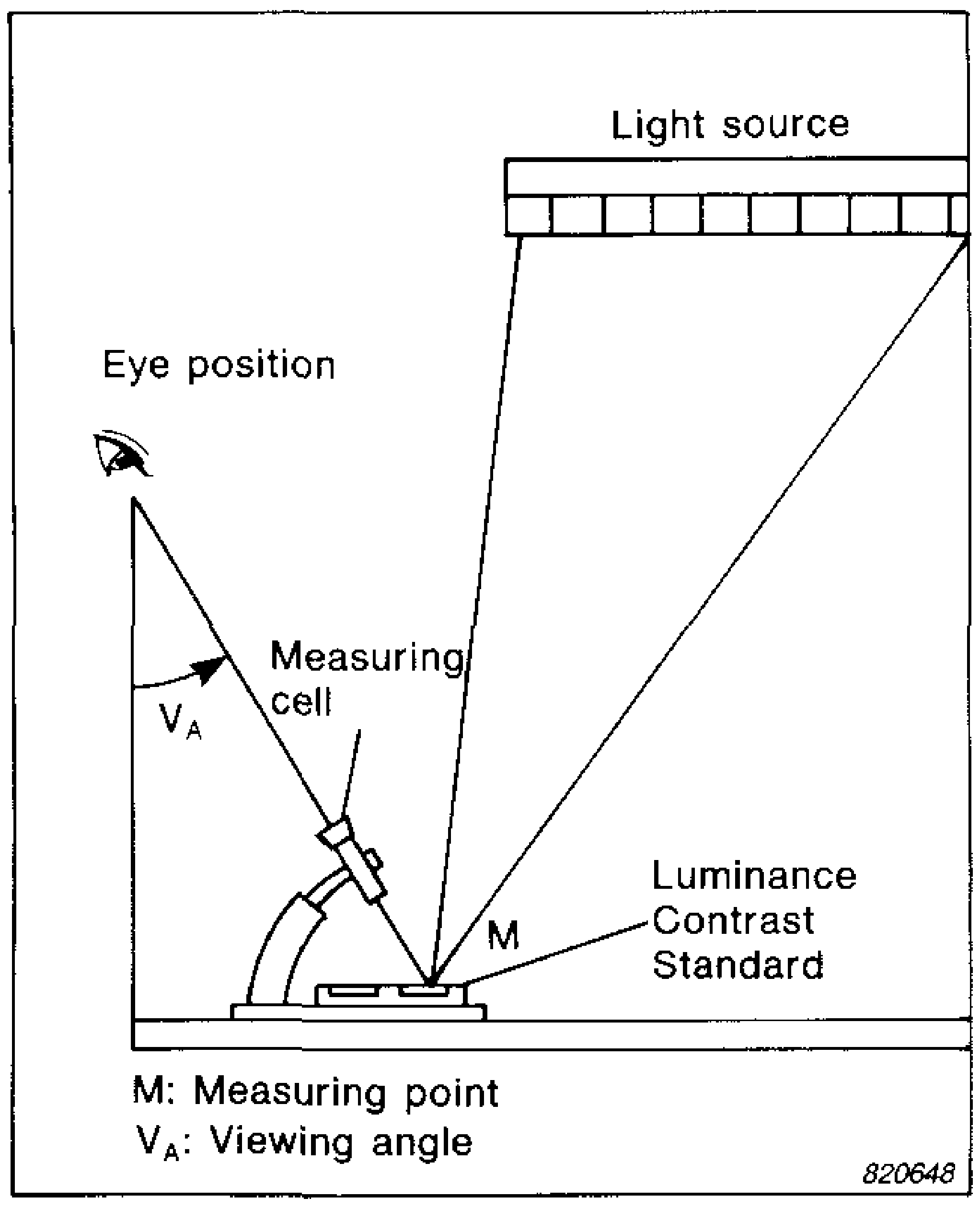

Fig. 6. Side view of measurement set up

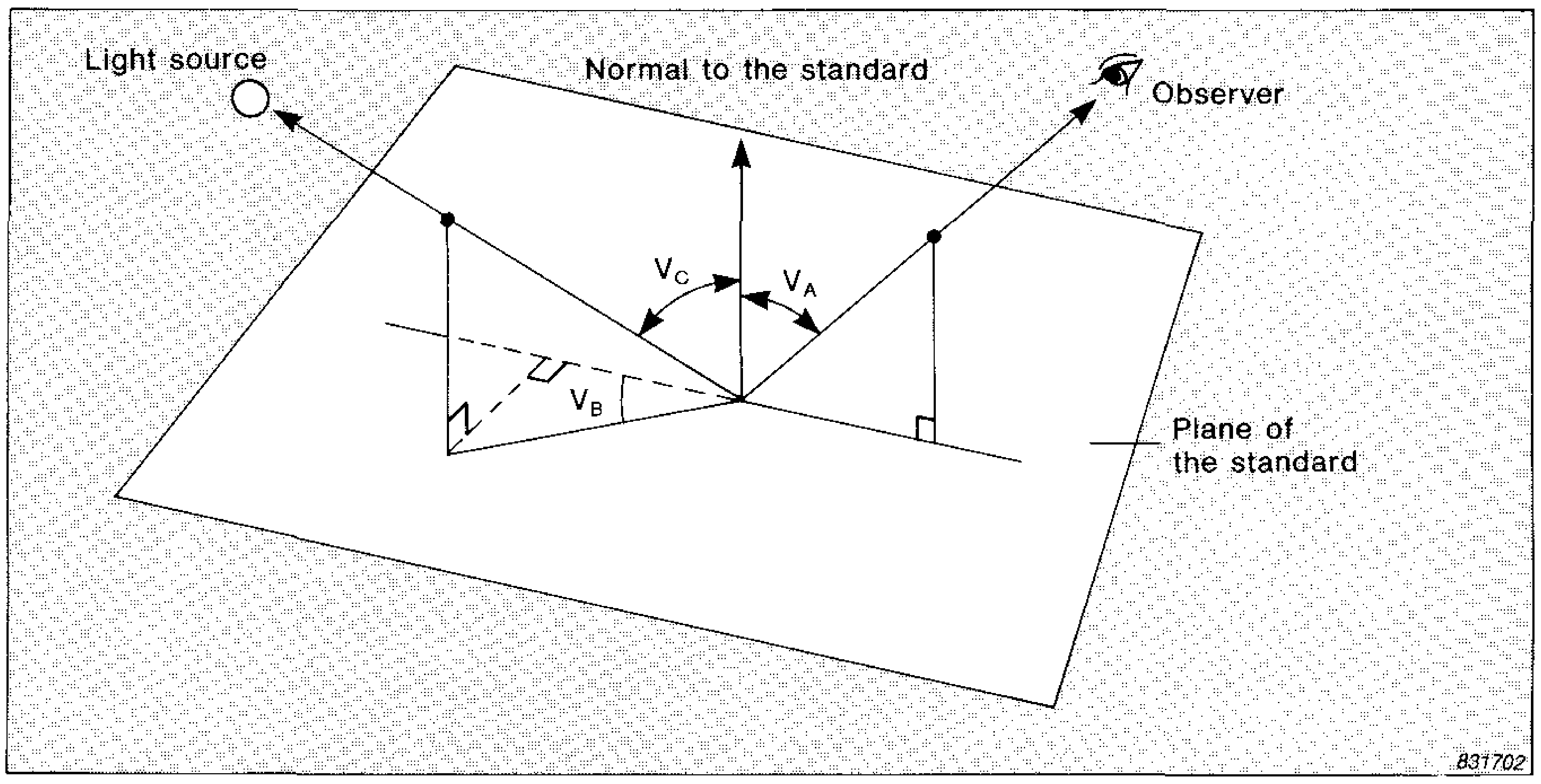

Fig. 5. Angular system for specifying the geometry of illumination and observation

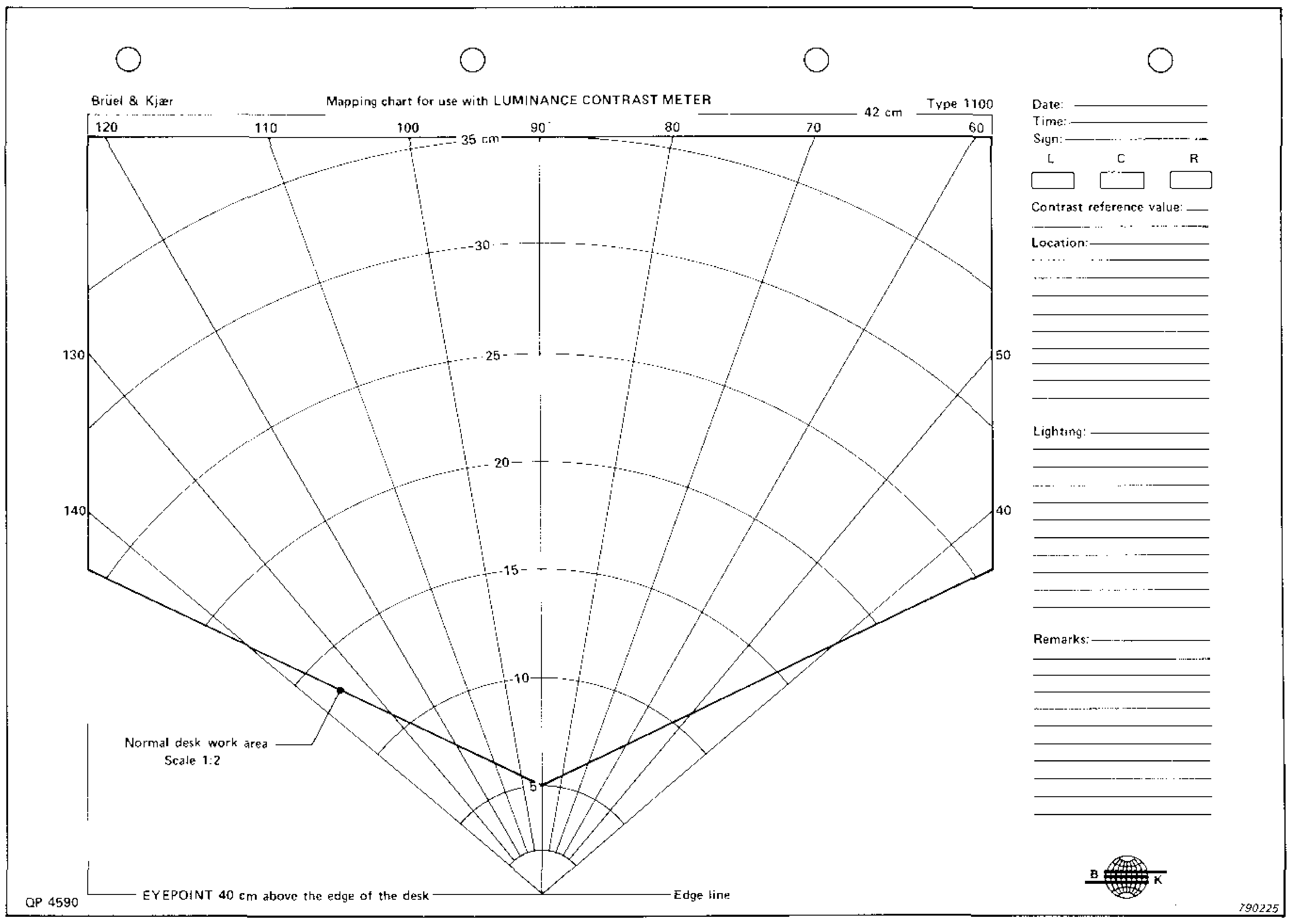

Fig. 7. The proposed standard work field

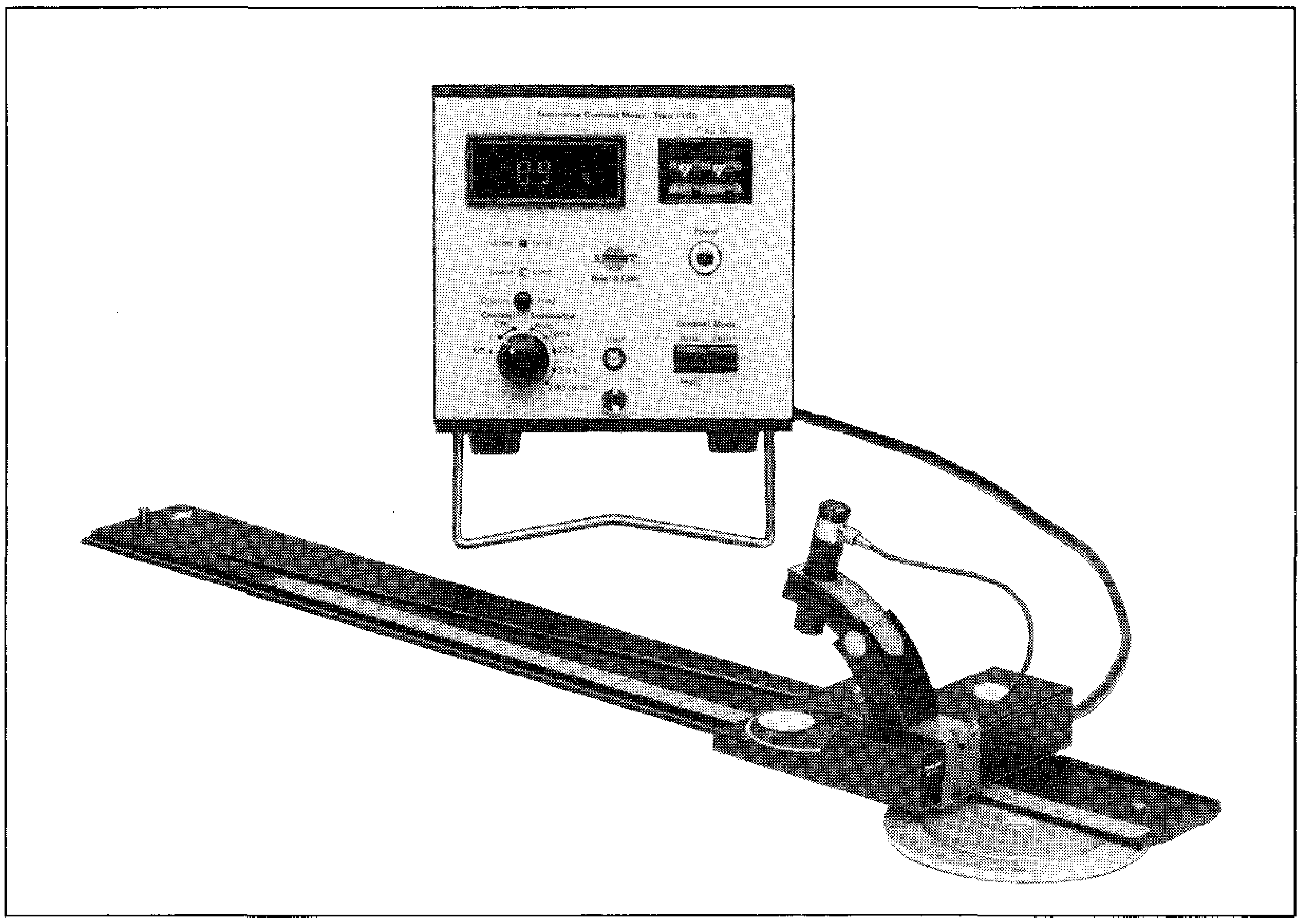

Fig. 8. The B&K Luminance Contrast Meter Type 1100

The diffuse contrast of the B&K standard task is 91% ± 1%.

To standardize a measurement procedure for luminance contrast, apart from standardization of a visual task, standardization of the measurement geometry is also desirable. The CIE *Guide on Interior Lighting* (CIE Publication 29/2) proposes a desk work area based on a DIN A3 format with cut lower left and lower right corners (see Fig. 7). An observer eye position is defined 40 cm above the edge of the desk, resulting in observation angles with the vertical from 7° to 47°, and side angles from −50° to +50° referred to the main direction of view.

To measure contrast rendering, the B&K Luminance Contrast Meter Type 1100, has been developed, which incorporates a mechanism to automatically implement the proposed measuring geometries (Fig.6 and 8). It is intended for use with the Luminance Contrast Standard Type 1104, and it measures the luminance of each of the two surfaces of the Standard, and calculates either the contrast, or the Contrast Rendering Factor.

Classification

In the Annex B of the CIE *"Guide to Interior Lighting"*, three quality classes of contrast rendering are proposed (Table 2).

Class I should only be applied to rooms for very special applications, like composing rooms, where very specular materials are used. Since CRF = 1 is found in a totally diffuse environment the criterion roughly says that no luminaire can be allowed to reflect itself anywhere in the working plane.

Class II is meant for "normal" offices, where all sorts of material may be used.

Class III is applied in particular to classrooms, where presumably matt materials are predominantly used.

Evaluation

Specifying a measurement procedure and some quality classes do not by themselves solve the evaluation problem.

How many or which points of the work area or work plane should fulfil the requirements? All points? Some of them? Selected points for each work area? An average of all points?

Contrast rendering class	CRF	Recommended application areas for reading and writing tasks
I	⩾ 1,0	interiors where predominantly glossy materials are used. e.g. composing rooms
II	⩾ 0,9	interiors where glossy materials are used only occasionally, e.g. normal offices and schools
III	⩾ 0,75	interiors where materials are usually matt, e.g. schools and certain offices

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Table 2. The three CRF-classes proposed by the CIE

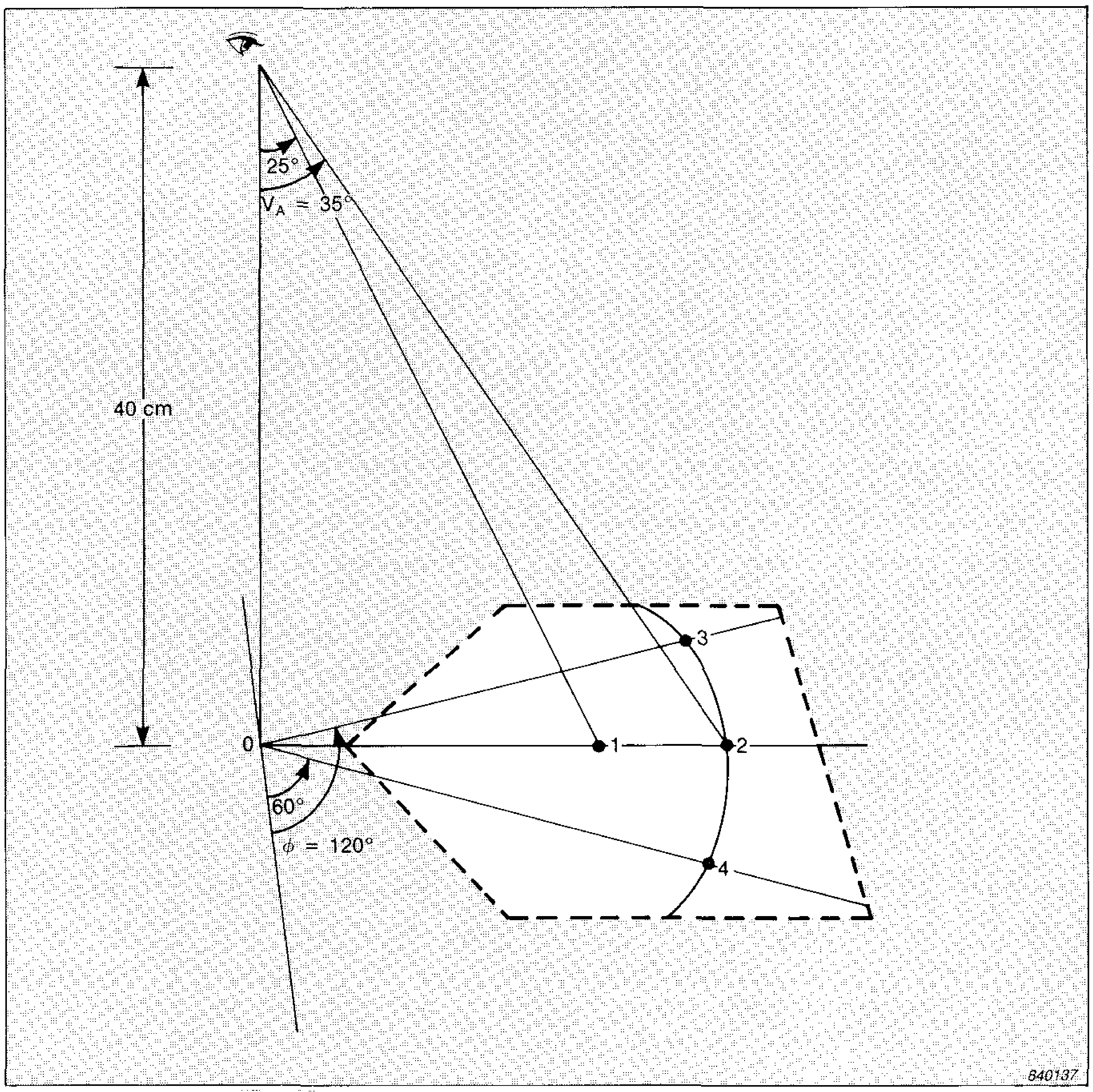

Fig. 9. The four reference points of the West German stadardization proposed (Ref.9)

There have been several proposals about this. In West Germany an evaluation based on four reference points on the work area has been proposed as a standard method. (See Fig. 9).

Dr. R. Pusch, Siemens AG, Leuchtenwerk, West Germany, has proposed a supplementary evaluation, called "contrast gradient", defined:

$$C_g = \frac{C_c - C_{min}}{\Delta \phi}$$

where C_c is the contrast of the central point of the work area, C_{min} is the minimum contrast for the whole area, and $\Delta \phi$ is the angular difference in the horizontal plane between the observation lines for the two points. Ref. 8 This expression is a measure of the contrast **uniformity** of the work area.

In the United States, the contrast is usually defined at only one reference point, the same as C_c, mentioned above. This point is defined by an observation angle of $V_A = 25$, side angle $= 0°$ (point no. 1 of Fig.9).

A reference point of vertical observation angle $V_A = 20°$ has been proposed by Lynes (ref. 6).

The existence of several evaluation methods for the contrast rendering on a work field, introduced in various countries, is mentioned in the CIE *Guide on Interior Lighting*. However, it is emphazised that to be representative of the contrast rendering of the entire standard work area, the evaluation should include the point of this area with minimum CRF value. If measurements are made at a number of desk-top work areas, mapping all the points of the proposed work area, it soon becomes apparent that high contrasts, say higher than 90%, are found as soon as no luminaire is itself reflected in the work area. Only where a luminaire is itself reflected, will a poorer contrast occur.

In fact, a reduction of contrast, which is experienced by the observer as a nuisance or a decline in working proficiency, will take place where a luminaire is reflected in the work area or its close vicinity. At all other positions no problems with contrast will exist.

Where a luminaire is reflected, a (local) minimum contrast point is found.

Since a minimum contrast is by definition produced where the luminance of the black standard surface has a maximum, a maximum luminance of this surface can be used to trace a point of (local) minimum constrast. Setting the Luminance Contrast Meter Type 1100 in its Auto-Luminance mode, and turning the dark surface into focus of the luminance detector enables a maximum luminance point to be quickly found by simple trial and error, combined with watching the display of the instrument. As soon as a maximum is found, the instrument is switched back to one of the contrast modes, and the (local) minimum contrast is found.

II Desk Top Study

An elementary study of a desk top problem is described below (Ref. 7):

A desk top is positioned in an office with four luminaires mounted in the ceiling as shown in Fig. (10a). The desk top is shown in the middle, a little bit to the left, and different desk lamp positions are suggested. (Fig. 10 d).

Fig. 10 (b) shows the illuminance level on the desk resulting from the use of the ceiling lighting alone. A 300 lux iso-curve traverses the table.

Fig. 10 (c) shows the contrast rendering resulting from the use of the ceiling system alone. It is seen that the worst contrast rendering position is found in the upper left-hand corner of the work area, where a reflection of the luminaire L_1 courses a CRF = 0,66. In addition, a minor reduction of contrast is seen in the upper right-hand corner, but in this case the lumi-

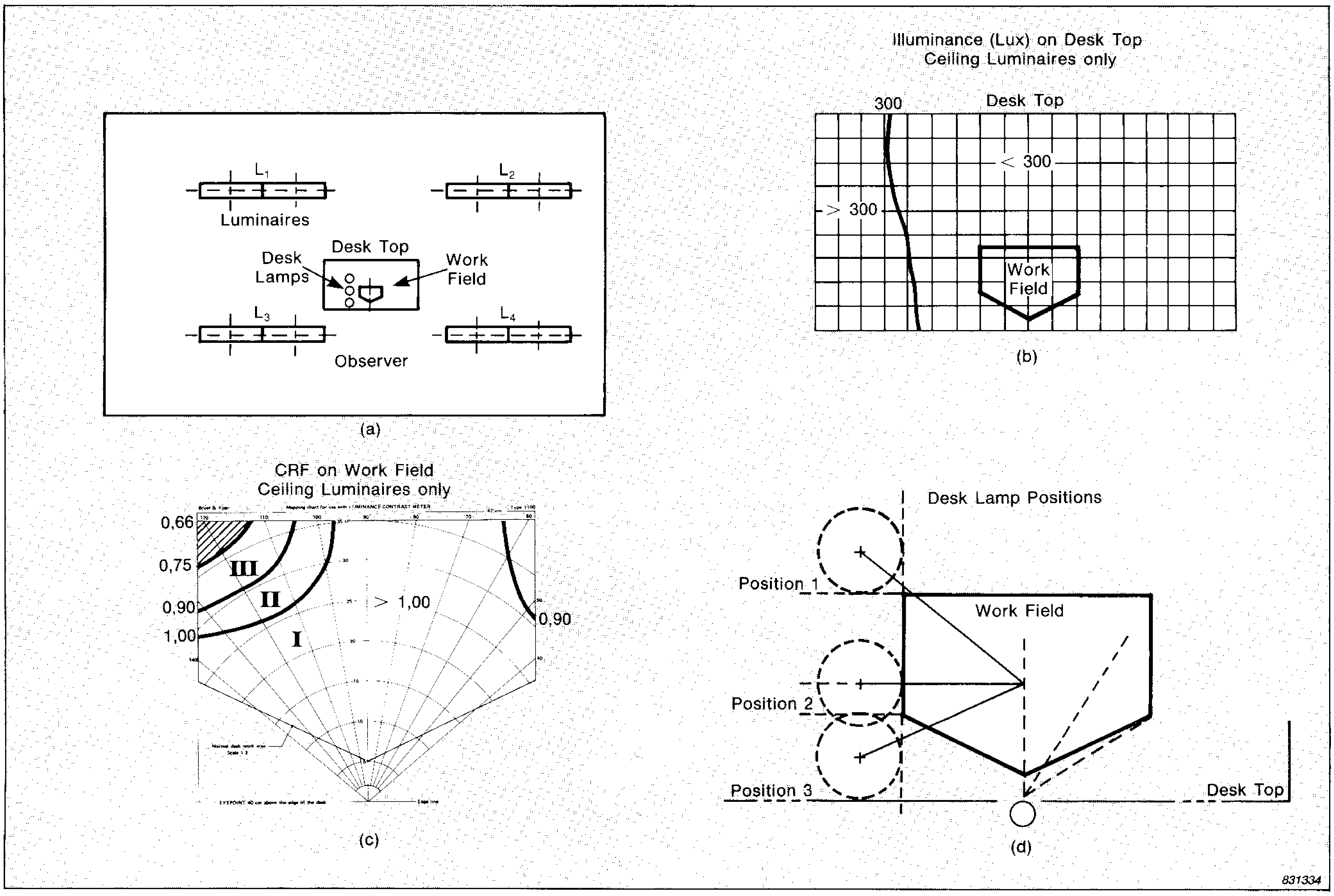

Fig. 10. a-d. Desk top study

naire L_2 is too far away to cause any real trouble.

Fig. 10 (d) shows an attempt to improve the CRF of the upper left corner — by the addition of a supplementary desk lamp. Three positions of the lamp are shown.

The resultant contrast pattern is shown in Fig. 10 (e) for lamp position 1. A marked worsening of the contrast conditions has taken place, owing to the fact that the "improving" luminaire has unfortunately been placed in the same direction as the "offending" luminaire and thereby only making bad conditions worse.

Fig. 10 (f) shows a much better desk lamp position (2). The "bad" upper left corner is now quite all right, because the offending light from the luminaire L_1 is being improved by light from the desk lamp, now falling from the side on the upper left corner (referred to the line of observation). Light coming in from the side will be reflected much more by the light standard surface than by the dark surface (see reflectance tables in table 1, angular system in Fig. 5), thus improving contrast rendering. However, position (2) is not entirely satisfactory either: it improves contrast in the upper left-hand corner, but it produces another bad area in the lower left-hand corner, where a reflection can be seen by the observer.

Thus only position (3), Fig. 10 (g) is good: It improves the upper left-hand corner, without reducing the contrast elsewhere.

This study thus shows that the best work lamp position is somewhere close to the edge of the desk top. Whether this position is also optimal from other points of view is another matter. It might be impractical to have a lamp so close to the edge of the table, and shadows from a finger or other items used to mark a line or a position might cause problems. Consequently, in our comparative measurements of six desk lamps (Fig. 12), we have chosen a medium position for the lamps, and a little more to the left.

Fig. 10 (h) shows how much illuminance is produced by the ceiling and desk lamps together (pos. 3). If you compare the values of the upper left work area, fig. 10 (b) and 10 (h), you will find that the illuminance contribution there from the desk lamp is something like 800–300 lux = 500 lux, that is to say an increase of 170% in illuminance coming from the side.

The improvement of CRF for this corner is from 0,66 to 0,88 (fig. 10 (c) and 10 (g)).

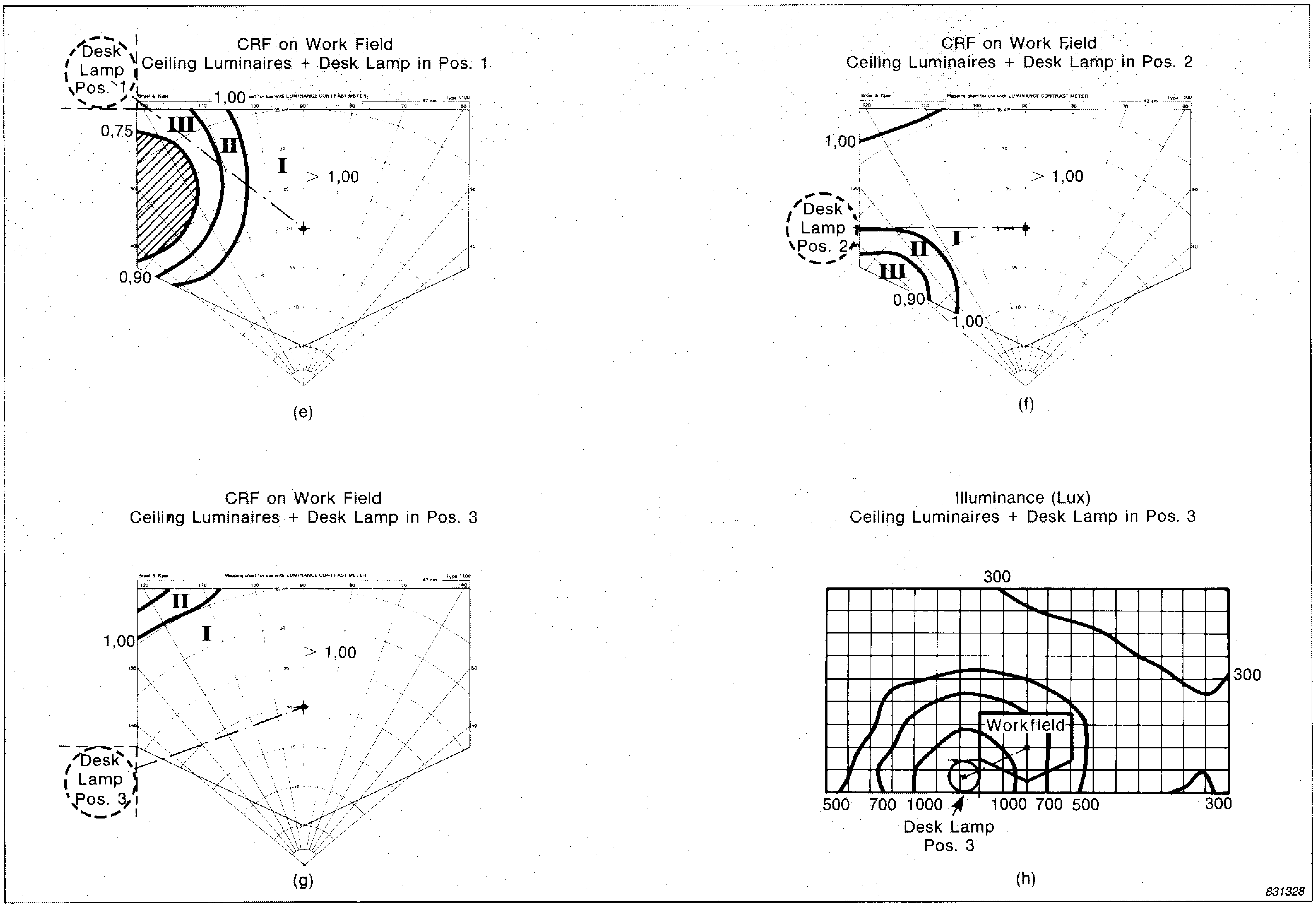

Fig. 10. e-h. Desk top study

III Interaction between General and Localized Illumination

Fig. 11 shows a set of curves displaying how much improvement in CRF will result from a given amount of "supporting" illuminance.

The example above — an improvement in CRF from 0,66 to 0,88 with an increase of 170% in the illuminance — can be confirmed from the figure. Enter the horizontal axis at CRF = 0,66, go vertically up until the line representing a CRF of 0,88 is intersected, project a horizontal line to the left of this intersection and read off on the vertical axis the corresponding percentage increase produced by the supporting light, i.e. about 170%.

Fig. 11 shows, as special cases, the curves for CRF — Class I, II and III. Thus the system will indicate how much additional light should be applied to improve a lighting installation into class III, II or I from a given initial value.

The exact direction of the contrast-supporting light is not critical — provided it does not come from the front hemi-sphere referred to the direction of observation. But of course, this diagram will provide only a rough indication.

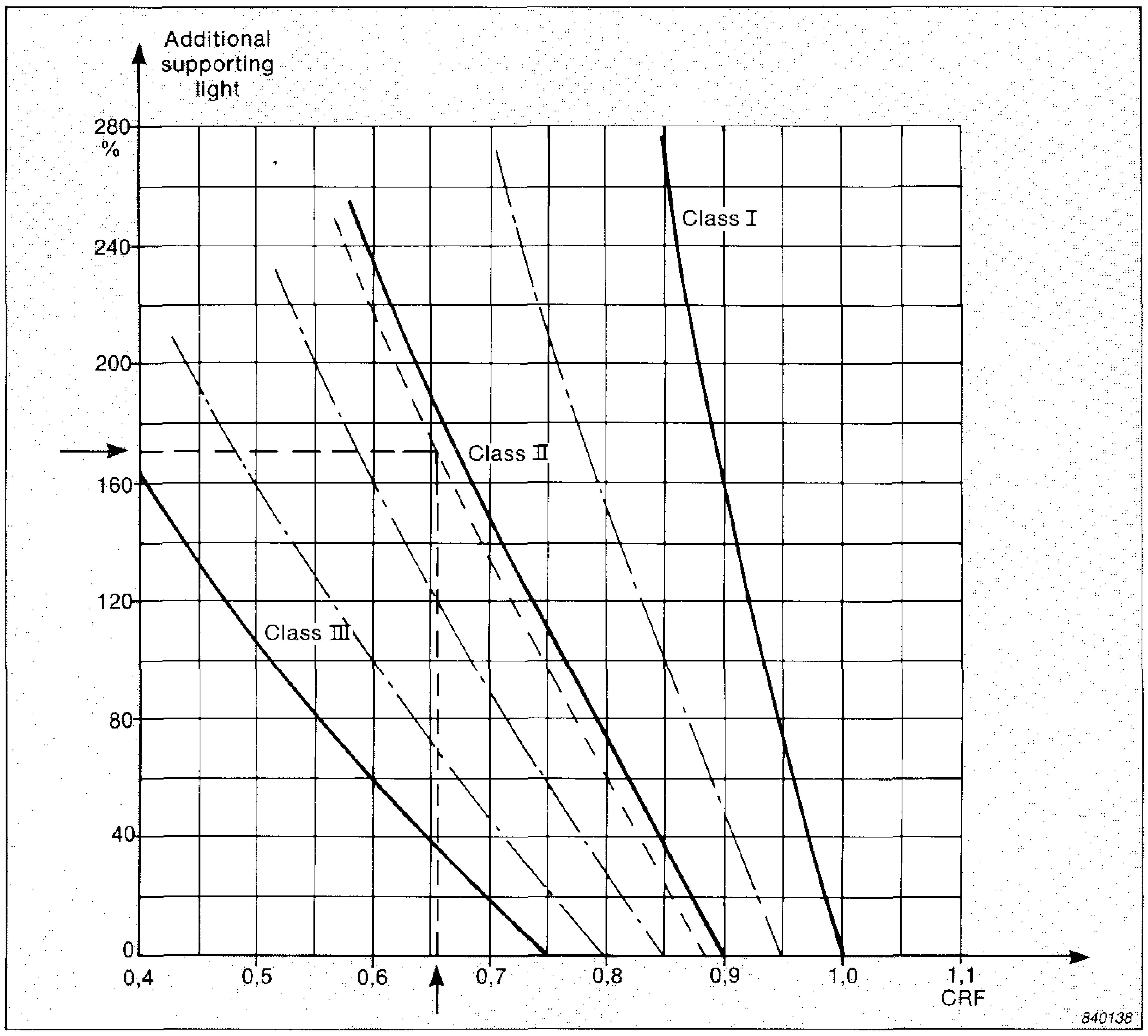

Fig. 11. Curves showing the amount of additional light from a desk lamp necessary to bring resultant contrast up into a wanted class

An exact determination of the result of applying a desk lamp can be calculated, provided both contrast, and luminance measured via the light standard surface are known for both illuminating sources. The general formula is:

$$C_{1,2} = \frac{C_1L_1 + C_2L_2}{L_1 + L_2} \qquad (1)$$

where $C_{1,2}$ is the resulting contrast, C_1 and L_1 are contrast and (light-surface) luminance for source 1, C_2 and L_2 contrast and light-surface luminance for source no. 2.

The formula applies to any point in the work area, and it can be extended to an arbitrary number of light sources. It applies to CRF's as well as to C's.

Thus if, in a large office, the minimum contrasts, plus the light surface luminances, for the minimum contrast points are known, it is possible to define the specifications for a desk lamp in terms of C and L — to bring the system into a given quality class.

Fig. 12 shows a mapping for siz different types of desk lamps. The mappings are "7-point" mappings, showing for each point the couple C/L.

The positioning of the desk lamps is chosen as 20 cm from the table edge to the centre of the lamp. The distance of each lamp from the work area is chosen so as to ensure the minimum CRF acceptable within class II: 0,90 for the critical lower left-hand corner of the work area.

The height of the lamp is in cases 1 to 4 and 6 just below 40 cm. Case 5 is 60 cm.

It is seen that only the CRF of the lower left-hand corner is below unity (0,90). All other CRF values in these 7-point measurements are above unity.

The luminances exhibit quite substantial variations. In other words: The luminance **uniformity** is rather poor. Furthermore, most of the lamps will be of little help if a specular reflection from a ceiling luminaire occurs in the right-hand side of the work area.

Of course, it is a problem to get enough illuminance on the right part of the area from a height of less than 40 cm above the table and at the same time to avoid glare. If uniform luminance were obtained, deep shadows would be thrown by objects or fingers in the central area.

The answer to this must be to increase the mounting height of the lamp (as, e.g., lamp 5), but then special shielding against glare must be provided.

The office of Fig.13 is a large office with localized luminaires mounted in the ceiling with parabolic louvres giving a cut-off angle at 50°. Minimum contrast is shown for all the desks, plus (light-surface) luminances for these points. One of the "bad" points in this installation is found on the desk in the middle of the room, with a minimum contrast of 0,42 combined with a light surface luminance of 85 cd/m^2.

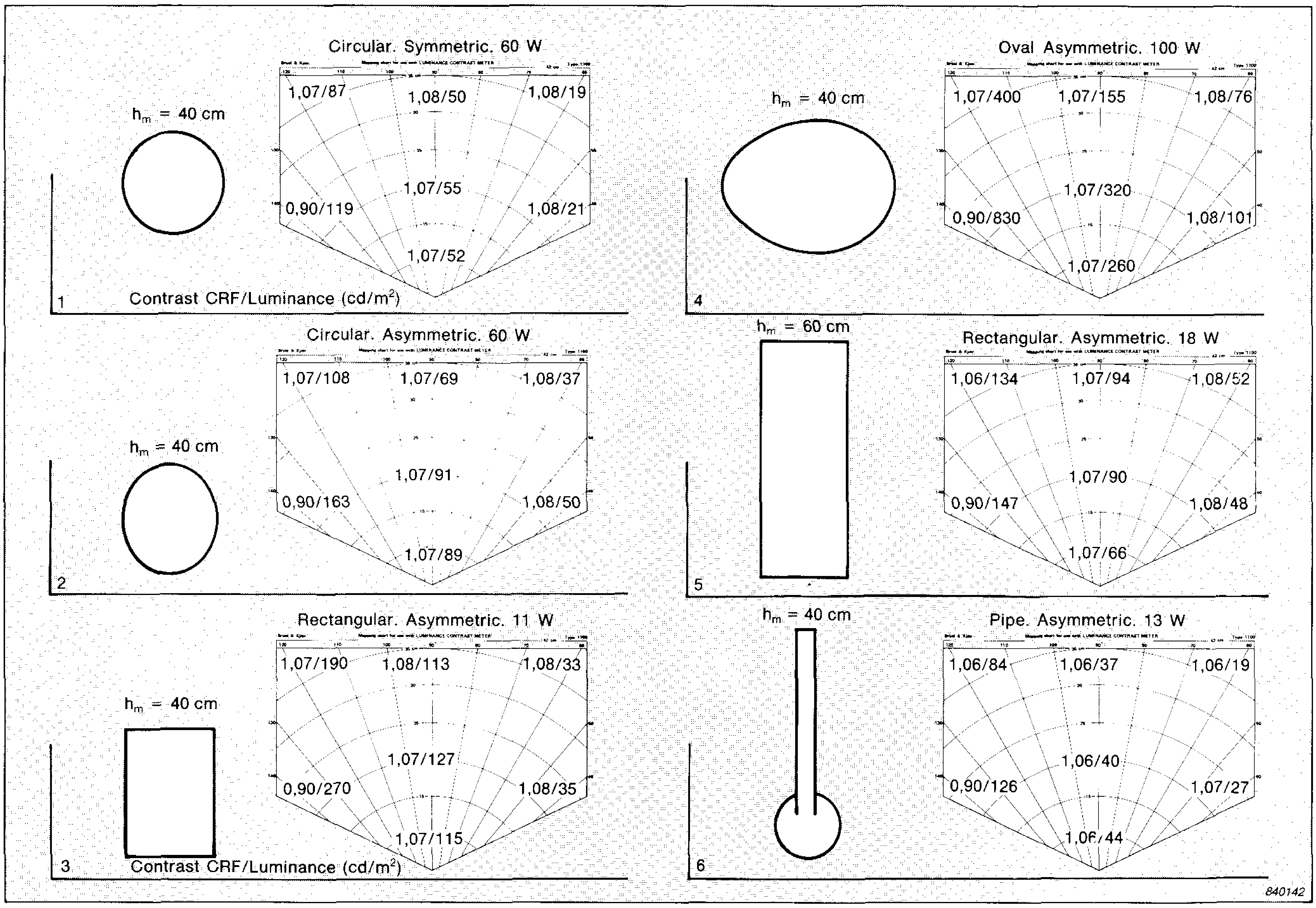

Fig. 12. CRF's and light-surface luminances for 6 types of desk lamps

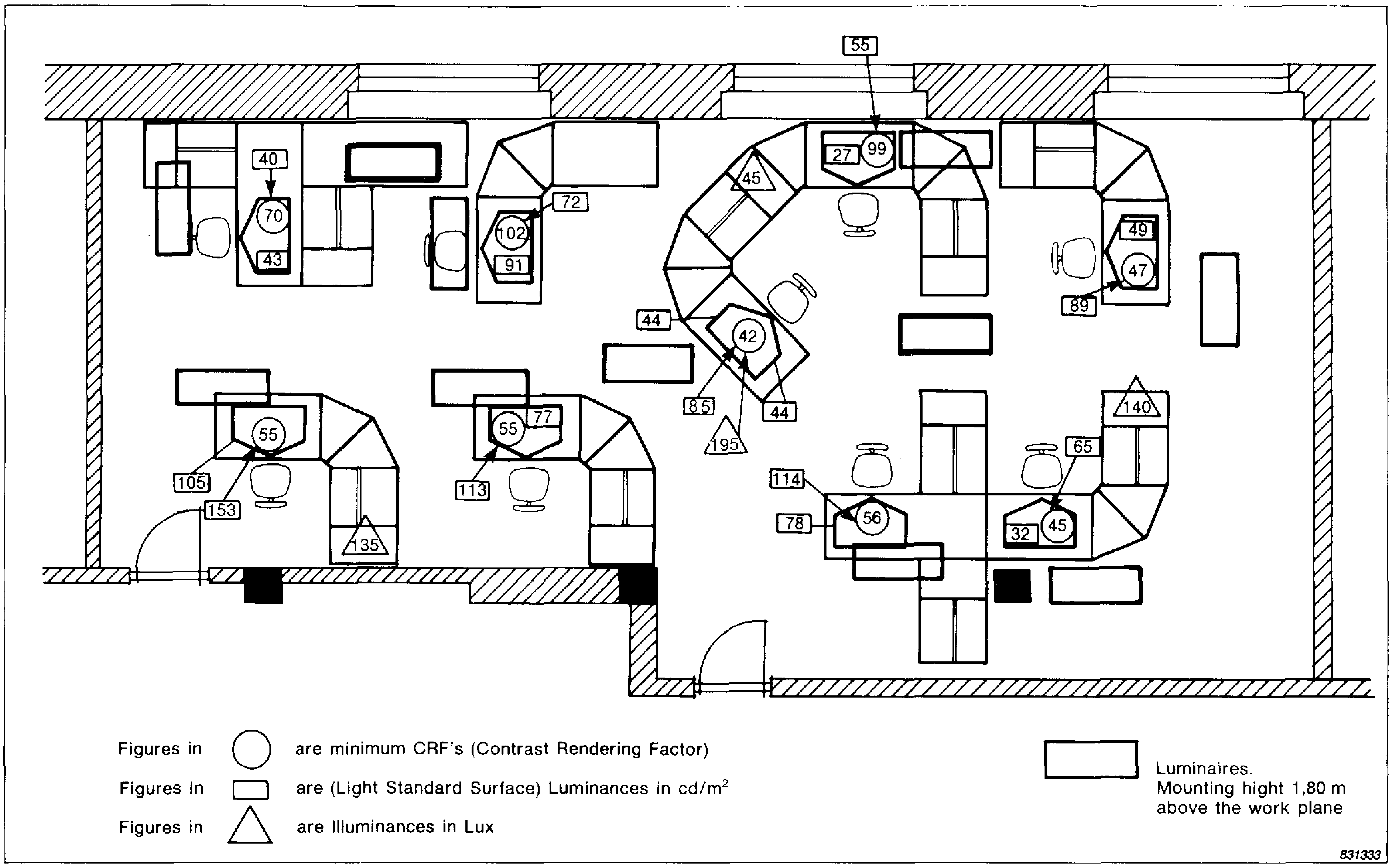

Fig. 13. Minimum CRF's, light-surface luminances and illuminances for office with localized ceiling luminaires

To bring this point into CRF-class II, only the desk lamp no. 4 with a 100 watt lamp bulb will be sufficient:

$$\mathrm{CRF}_{1,2} = \frac{0{,}42 \times 85 + 1{,}07 \times 320}{85 + 320}$$

$$= 0{,}93, \text{ i.e. class II.}$$

With a 60 W bult in the same lamp, assuming slightly decreased lamp efficacy for the smaller wattage i.e. a light-surface luminance of $\approx 175\,\mathrm{cd/m^2}$, resultant CRF would be:

$$\mathrm{CRF}_{1,2} = \frac{0{,}42 \times 85 + 1{,}07 \times 175}{85 + 175}$$

$$= 0{,}86$$

thus only class III.

Another point of low contrast is found at the right hand-side of the desk in the fare right of the room, CRF = 0,47 and L = 89 cd/m^2.

Desk lamp no. 4 again is the one throing most light on this part of the work area, light-surface luminance = 76 cd/m^2 for the upper right corner.

The resultant CRF is:

$$\mathrm{CRF} = \frac{0{,}47 \times 89 + 1{,}08 \times 76}{89 + 76}$$

$$= 0{,}75, \text{ i.e. just class III.}$$

The contrast combination formula can be modified to be based on illuminances in stead of light-surface luminances. Then the following formula applies approximately:

$$C_{1,2} \approx \frac{C_1 \times E_1 + C_2 \times E_2}{E_1 + E_2} \qquad (2)$$

where E means illuminance.

A Swedish luminaire manufacturer [Ref. 10] is in a brochure for its desk lamps stating data like those shown in Fig. 14.

The desk lamp of Fig. 14 used to improve the middle desk of Fig. 13, which has an illumination of 195 lux at its center, produces the following result, — using the approximate formula:

$$\mathrm{CRF}_{1,2} \approx \frac{0{,}42 \times 195 + 1{,}07 \times 1000}{195 + 1000}$$

$$= 0{,}96$$

thus again CRF class II is obtained.

Thus 'combined' CRF's may be calculated in three different ways: Using the curves of Fig. 11 or the approximate formula (2), both based on illuminances, — or using the exact formula (1), based on light-surface luminances.

In any case it is possible to estimate resulting CRF, knowing the CRF and illuminance or light-surface luminance data of the general installation, and getting the corresponding desk lamp data from a catalogue.

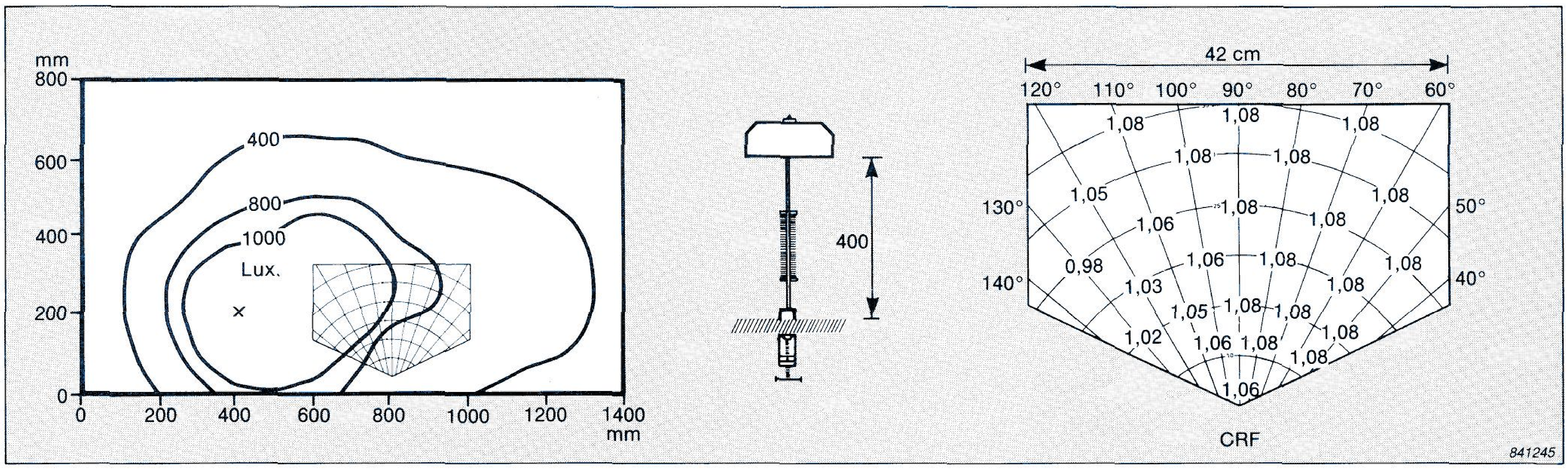

Fig. 14. Iso-lux curves for the desk lamp situated at the point x (left) and corresponding CRF values (right)

Data screen measurements
See Appl. Note: Ergonomic evaluation of lighting at workplaces with CRT display terminal.

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    Habo, Sweden

Brüel & Kjær
DK-2850 Nærum · Denmark · Telephone: +45 2 80 05 00 · Telex: 37316 bruka dk · Fax.: 02 80 14 05

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