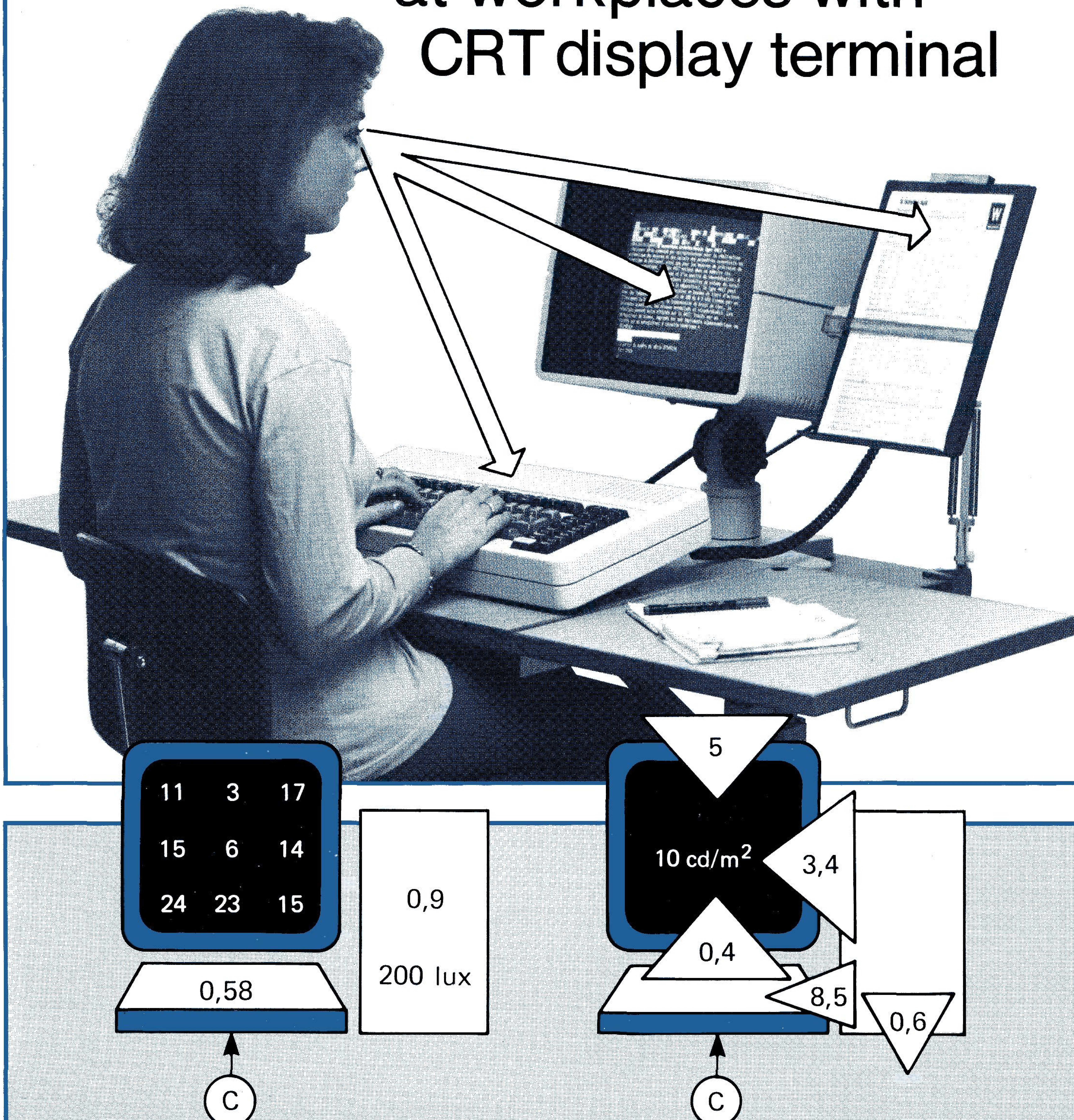
Brüel & Kjær application notes

Ergonomic evaluation of lighting at workplaces with CRT display terminal



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Work on CRT display terminals

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Introduction

The introduction of cathode ray tube (CRT) display terminals into the office is an irreversible phenomenon which has started to arouse the attention of ergonomists and safety officers. How can reflections on the key-board or the screen be avoided? How should the screens be placed relative to the windows, and to artificial lighting? Should the level of illumination at the workplace be increased? How should the brightness of the characters and the background be adjusted? Should the workplaces for CRT display terminals be isolated from other types of workplaces? The questions and problems are many and the people who are confronted by them often have only a short time in which to find lasting solutions. The introduction of modern techniques is a matter of such importance that there can be no question of experimenting since the techniques might have adverse effects on the users.

Without presuming to offer solutions, the aim of this article is to present some measurement methods as well as methods of evaluation referring to ongoing standardization work. It concludes with some practical advice on possible action before or after the installation of the workplaces.

Ergonomic evaluation of lighting at workplaces with CRT display terminals

In the near future, progress in microelectronics and in data handling technology is going to change the vast majority of workmethods of white-collar workers. This evolution is aimed at attaining improved efficiency and consequently an increased productivity in the office sector, by offering the people who perform the traditional office tasks the possibility of using a powerful, amenable and rapid computer system.

However, there is a risk that this aim will not be achieved if the introduction of display terminals meets with the apathy of the users who complain of visual fatigue, eye strain, headaches, and difficulty in concentration. There is also the sensation of alienation when faced with a machine which, by imposing its own routines and delays, compels the user to play the role of an automaton. The terminal is in fact a means of bilateral com-

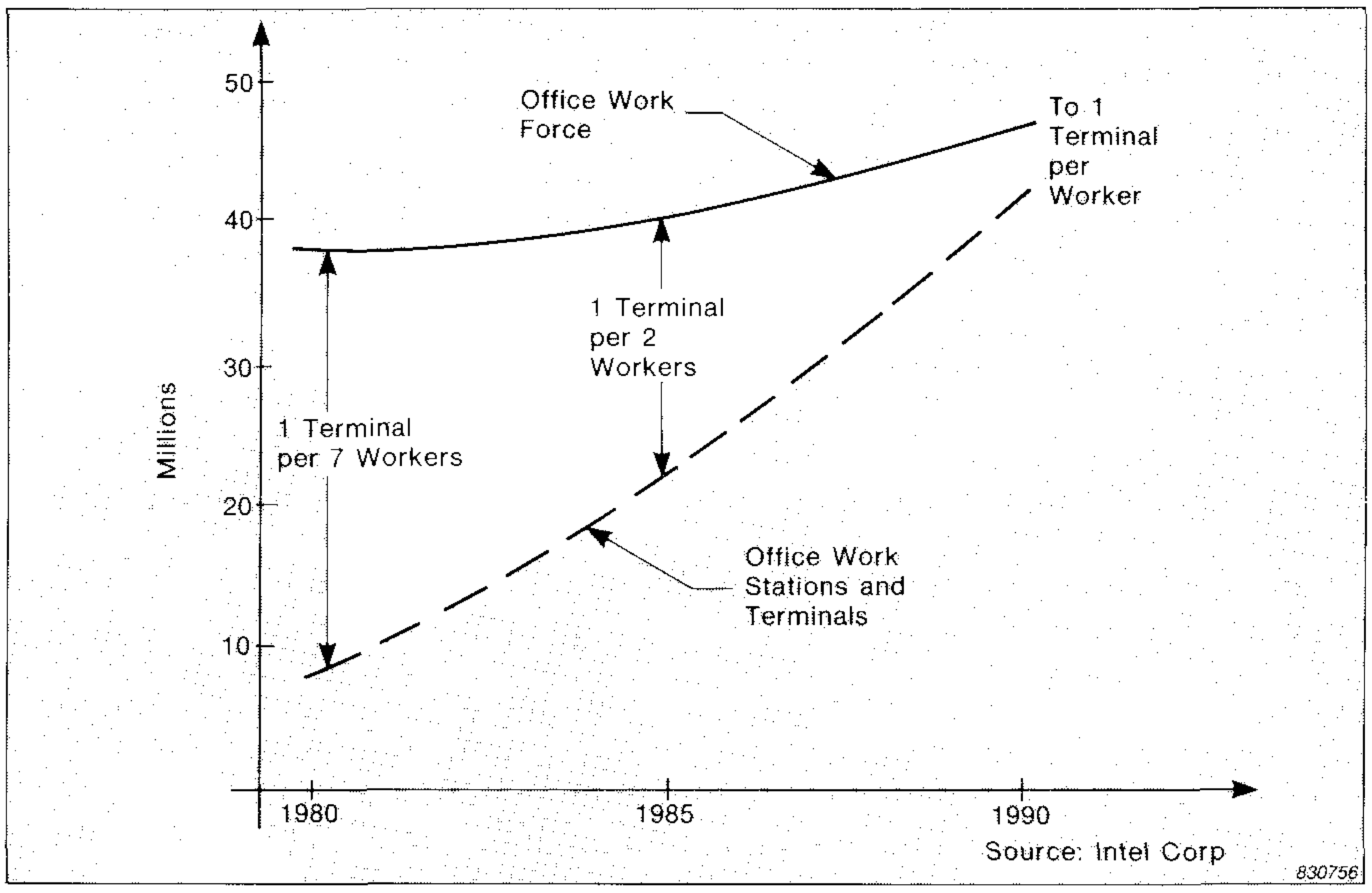


Fig. 1. A terminal for everyone. The number of terminals in use has increased much more rapidly than the number of employees in the office sector in the USA and in Europe. The use of terminals is no longer restricted to special rooms. The planning of ordinary offices should allow for this inevitable "intrusion".

munication between the operator and the computer. This communication is essentially visual; data entered via the keyboard are visualised on the screen and the eventual response of the computer or the system is also shown on the screen. It is not surprising then that the problems posed by CRT terminals are mainly visual, related directly or indirectly to the ambient lighting at the workplace.

It is an important question and it involves an increasing number of people. This is illustrated by the study performed by the American company INTEL which predicts that in the United States the number of terminals will increase to equal the number of office workers by the beginning of the 1990's (Fig.1). A similar growth is predicted in Western Europe and particularly in France. At present there are about 260000 terminals installed in France and it is expected that the number will reach 600000 by 1985 without counting the 800000 terminals which the French Post Office (PTT) envisages installing in coming years.

Fig. 2. The three visual tasks at a workplace with a terminal: the screen, the keyboard and the document. But what type of lighting should be installed so that these three tasks are performed under optimal conditions?

The workplace and its visual problems

Working with a CRT display terminal generally involves 3 visual tasks: the reading of a text on the screen, the recognition of the letters or symbols on the key-board and the reading of a manuscript or document placed beside the screen.

Such a workplace is very different to a traditional office where the visual task generally consists of reading or writing on a horizontal surface. With a terminal, the visual tasks are more complex.

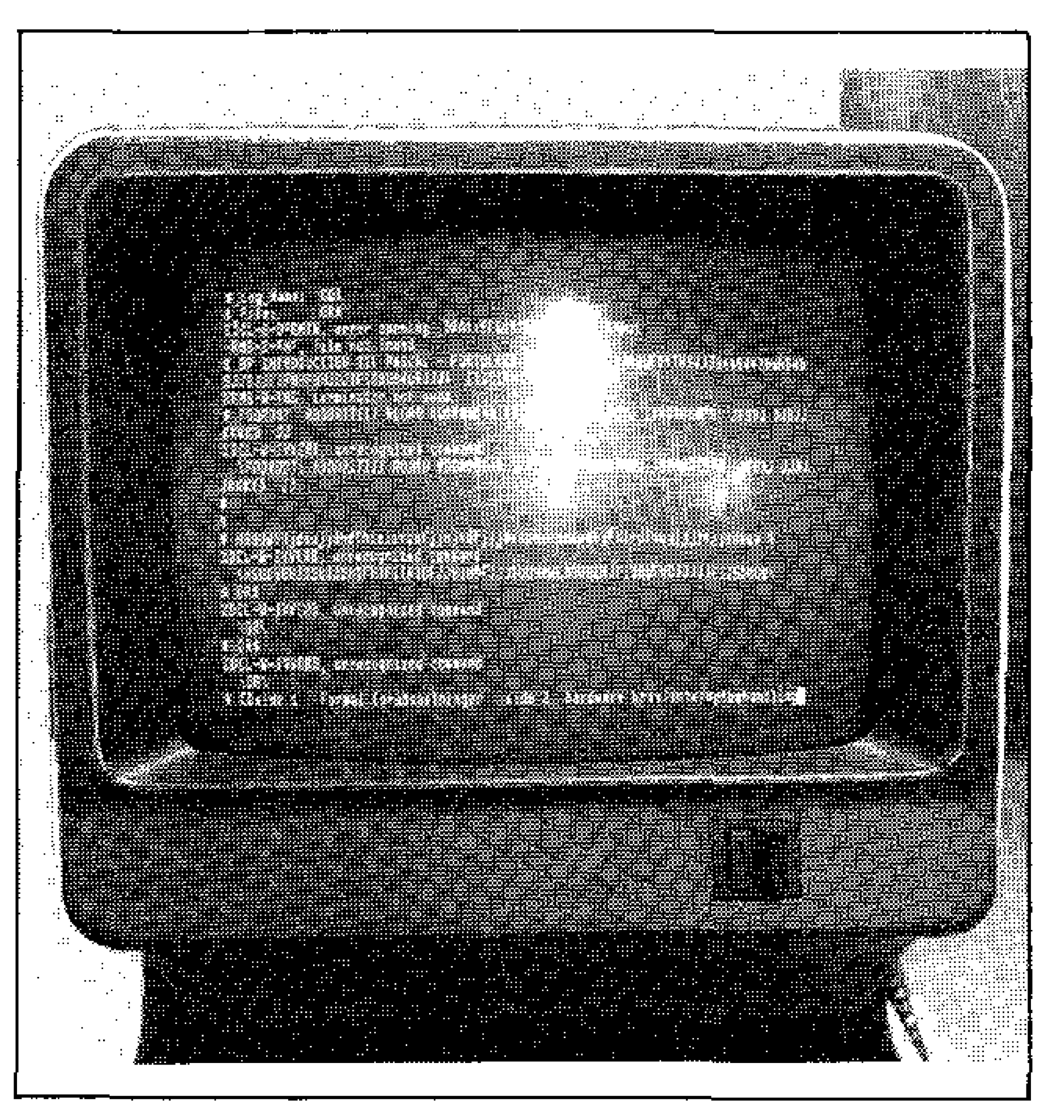


Fig. 3. Veiling reflections on the screen make reading particularly difficult.

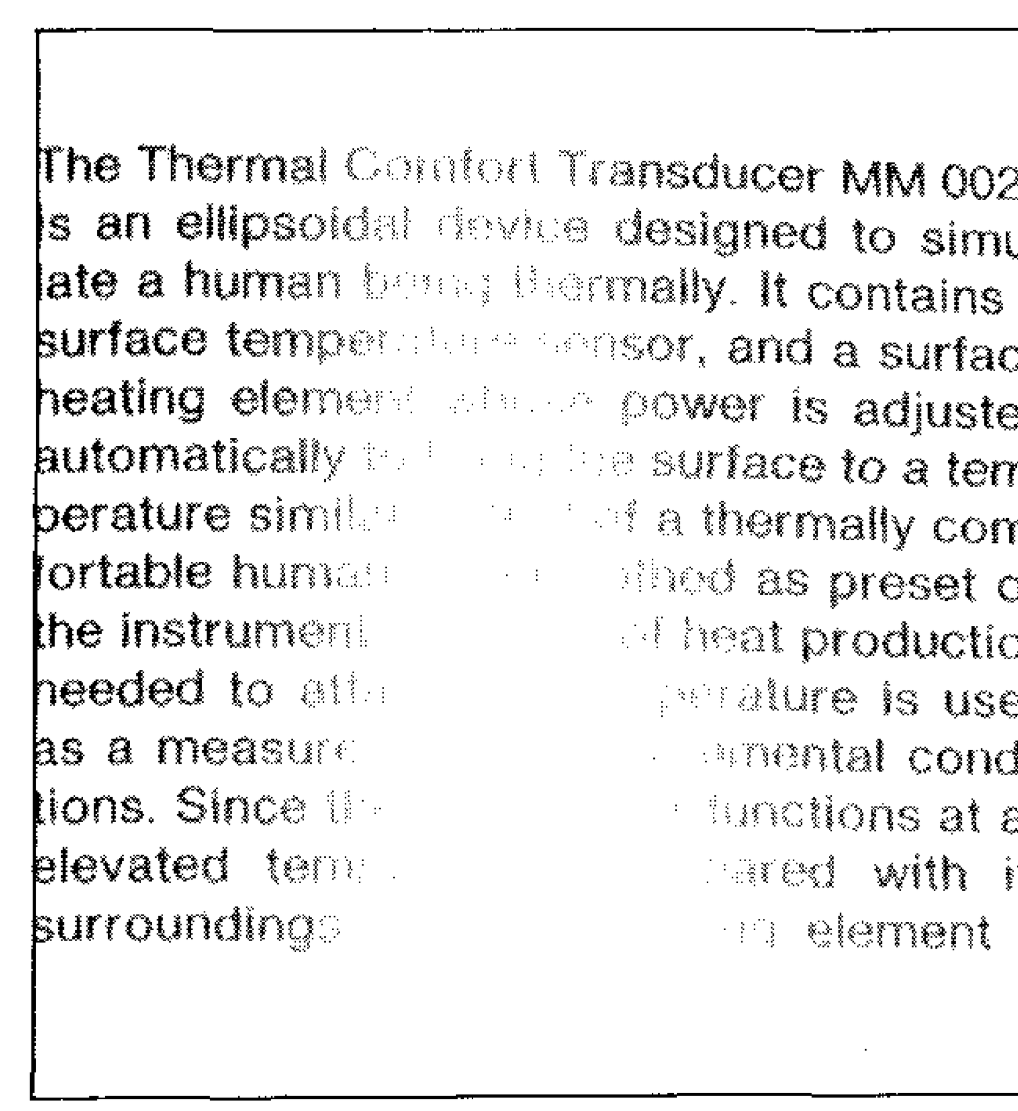


Fig. 5. Light sources also produce veiling reflections on the documents. If the paper is glossy then the text may disappear completely in places.

The screen

On the screen, the letters are usually bright on a dark background and the plane of the screen is vertical. The user may change the aspect of the letters on the screen by adjusting the brightness of the characters by means of the intensity control. The visual task may be termed "active" or "dynamic". The screen may be the origin of reflections due to bright surfaces, such as windows or sources of artificial light situated in the reflecting field of the screen, that is, behind the operator. Such reflections are particularly inconvenient as they are superimposed on the details being viewed. They are in fact seen behind the detail

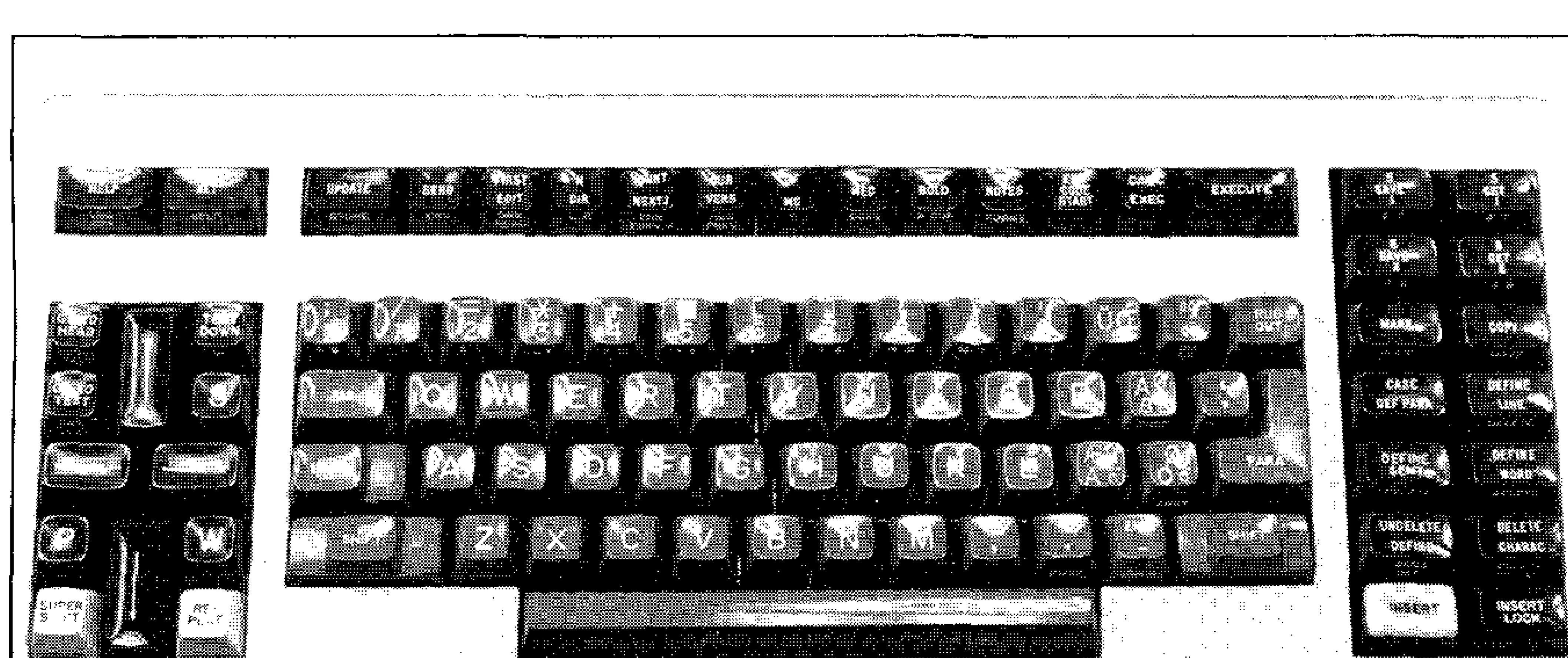


Fig. 4. The keyboard must not be neglected. If there are reflections which hinder the recognition of the symbols on the keys then the operator will make more typing errors than usual.

on the screen, at a distance corresponding to the position of the source of the reflection in the room.

These reflections produce difficulties in visual accommodation which the operators try to solve by reducing or simply switching off the light sources which are the cause of the problem. However, this produces another problem, because they end up in quasi-darkness and reading the document along side the screen becomes practically impossible.

The keyboard

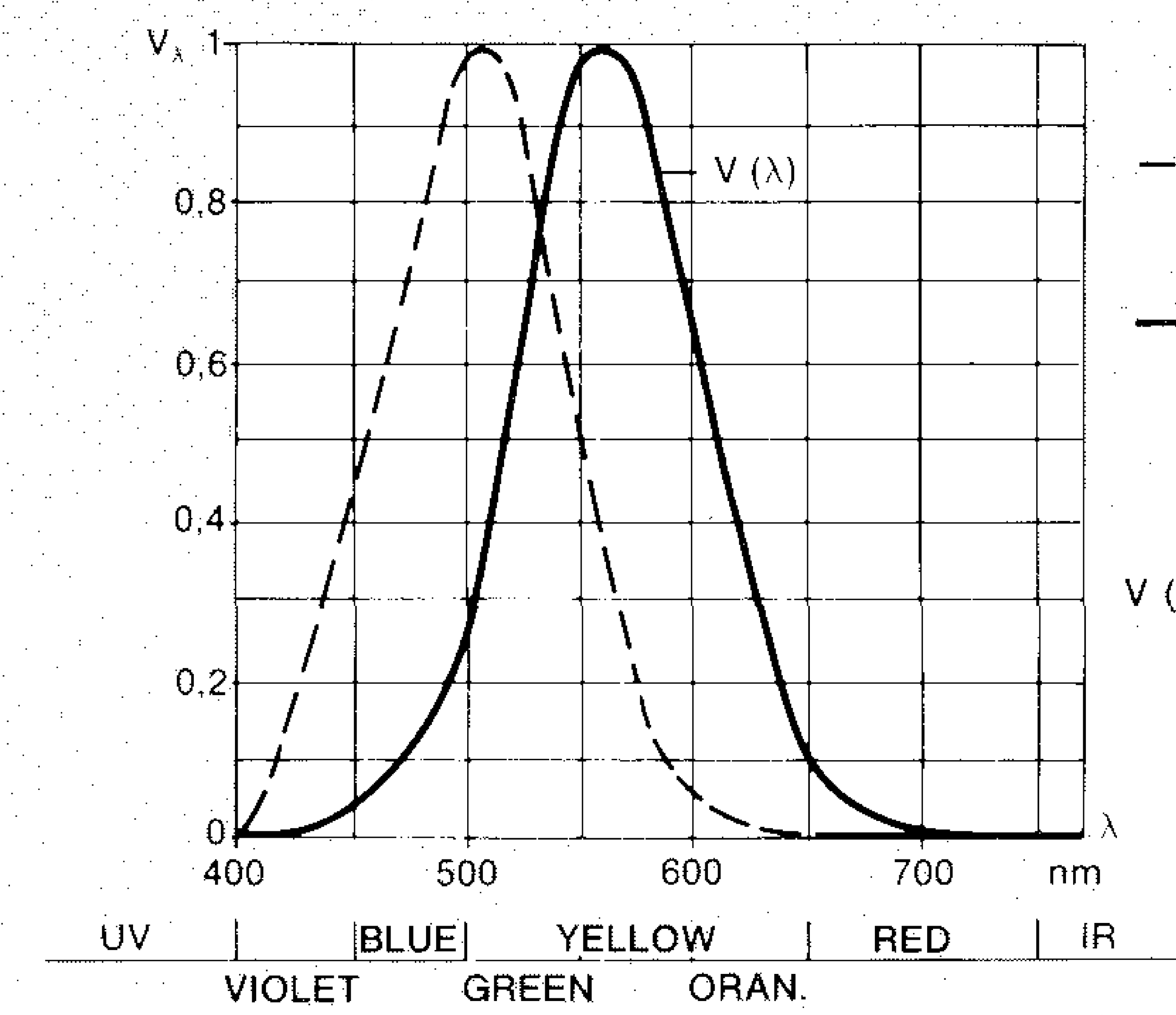
The keyboard poses a visual task which should also not be neglected. Studies show that operators who can touch-type, glance frequently at the keyboard. It is thus necessary that they can recognize the symbols on the keyboard without difficulty. Furthermore, the keyboards of computers or text-handling systems have a number of special keys corresponding to special functions which have no relation whatever to the keys on an ordinary typewriter. The keys can be the source of reflections which are difficult to avoid because of their concave form, they reflect sources of light in an extended zone above the terminal. Even if the keys are initially matt, their surfaces become polished with use.

The language of the lighting engineers

To characterise light there are at least 4 essential parameters. **The luminous flux** enables the visible energy emitted by a source to be described; by comparing this to the energy consumed, sources can be classified according to their luminous efficacy (quotient of the luminous flux to the energy consumed). **The luminous intensity** characterises the emission of light as a function of direction. This enables light sources to be classified according to the distribution of intensity in different regions of space (the photometric classes of luminaires). The **illumination** enables a luminous environment to be evaluated in a quantitative manner (mean illumination recommended as a function of the type of activity, for instance). **The luminance**, on the other hand, expresses the real luminous sensation as received by the eye. This will be the key parameter in all ergonomic estimations of a luminous environment. Luminance occurs in the definition of the **quality** of the visual performance (contrast, glare, etc.).

Lighting Terminology

1. Spectral sensitivity of the eye

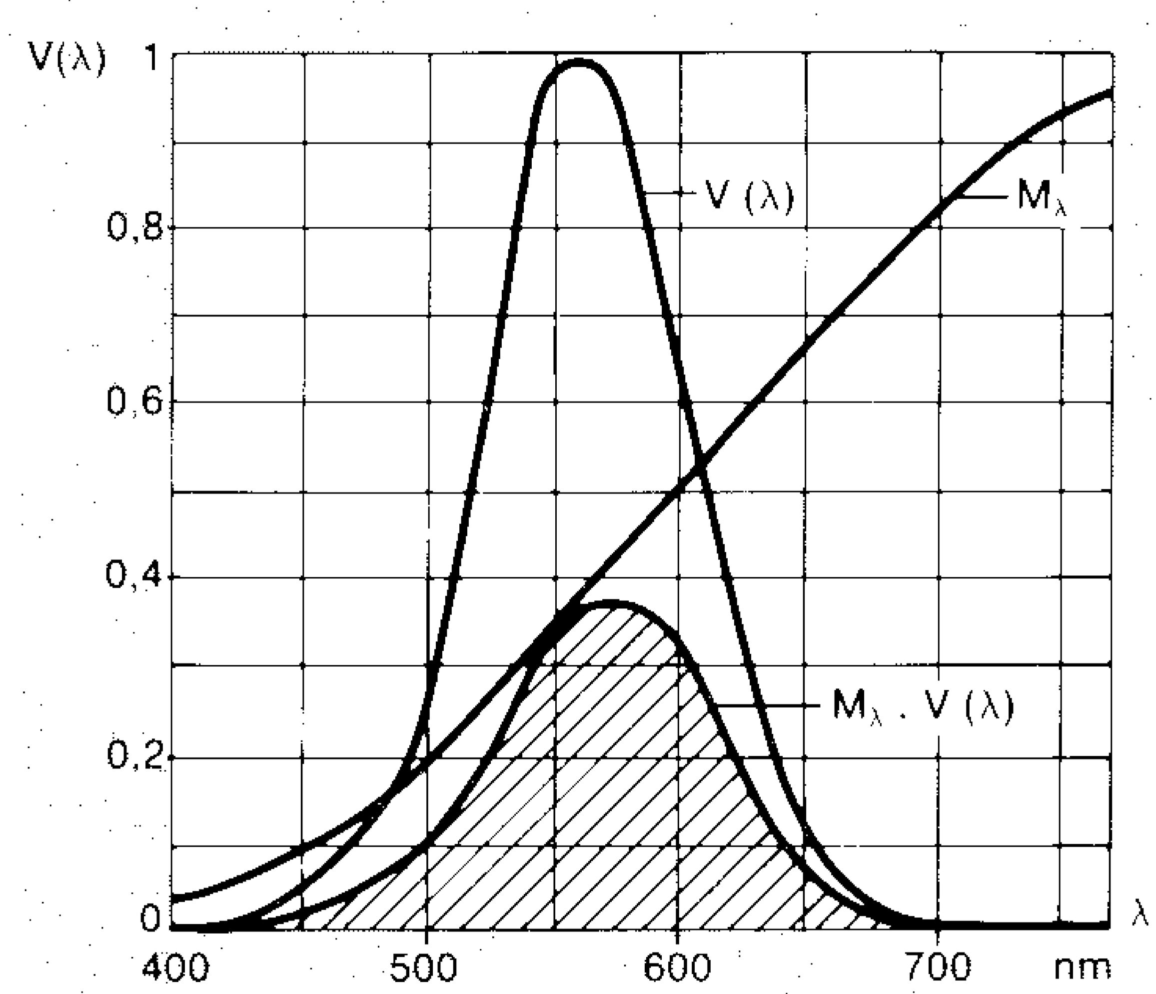


- - - - Scotopic vision (vision at low light levels)

——— photopic vision (vision at higher light levels)

V (λ): Spectral luminous efficiency curve adopted by the "Commission Internationale de l'Eclairage" (CIE)

2. Luminous flux



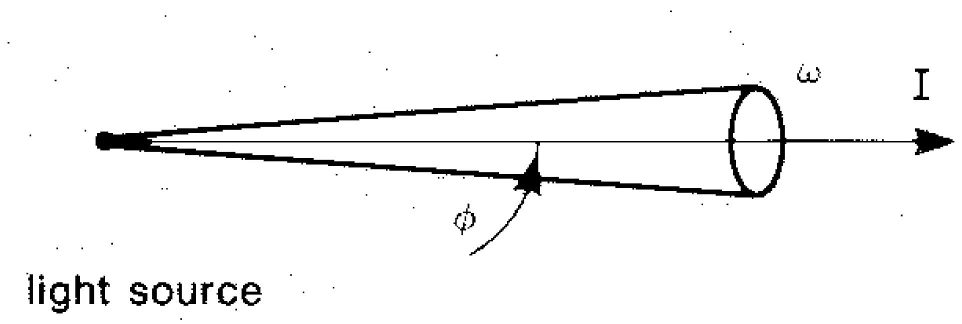
M_λ: spectral emission of a light source

$\phi = M_\lambda \cdot V(\lambda)$

ϕ = spectral energy of a source, received by the eye or luminous flux
= quantity of light emitted per second

Unit: **lumen**

3. Luminous intensity



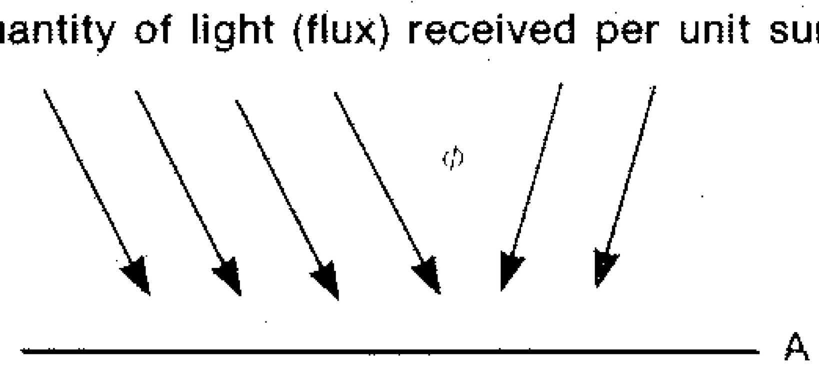
$$I = \frac{\phi}{\omega}$$

ω = solid angle in steradians

Unit: **candela** or lumen/steradian

4. Illuminance

Quantity of light (flux) received per unit surface area

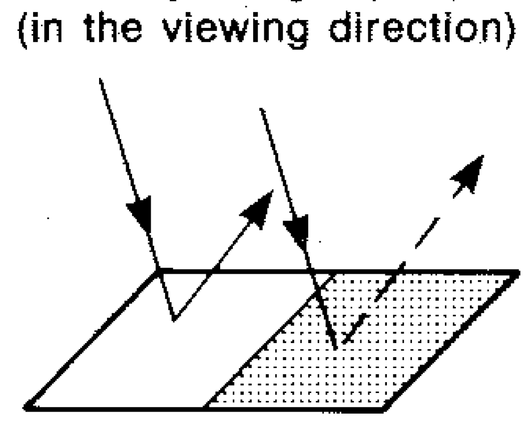


$$E = \frac{\phi}{A}$$

Unit: **lux** (lumen/m²)

5. Luminance

Intensity of light (flux) received per unit surface area (in the viewing direction)



$$L = \frac{I}{A_{proj}}$$

Unit. **candela/m²**

The luminance is a function of both the illuminance on the surface, **and** its reflectance

I = Intensity of reflected light

$A_{proj.}$ = Area of the surface projected onto the plane normal to the viewing direction

In a wider sense, one can define the luminance of a light source, of a window, etc. (I is then the intensity of the observed light)

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The document

The visual task of the operator becomes more complicated when it is necessary to read a document. Moreover, it is most rare that work on a terminal does not involve reading a manuscript, a list or some other form of document. To ensure its legibility, it might be necessary to adopt a level of illumination which is not necessarily compatible with legibility conditions on the screen. One must also ensure that the source of a nearby lamp does not produce reflections from the document.

The most arduous problem however, is without doubt the adaptation difficulty between the screen and the document; the operator glances continually back and forth between these two visual tasks which correspond to two completely different levels of luminance as the screen is basically dark whereas the paper is light.

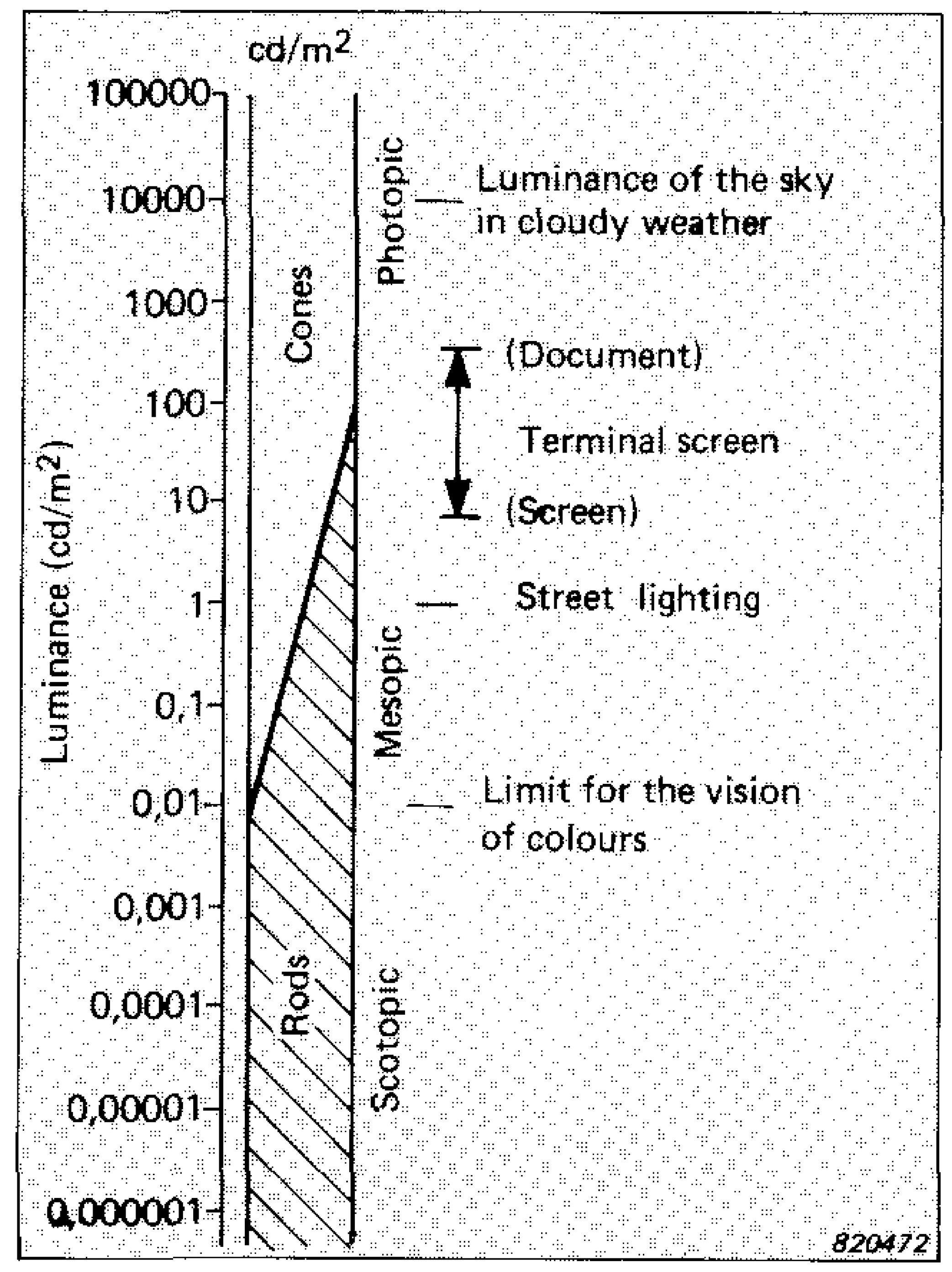


Fig. 6. The luminance scale showing the extent of the range of sensibility of the human eye. The eye adapts to a luminance level corresponding to the mean luminance in the visual field.

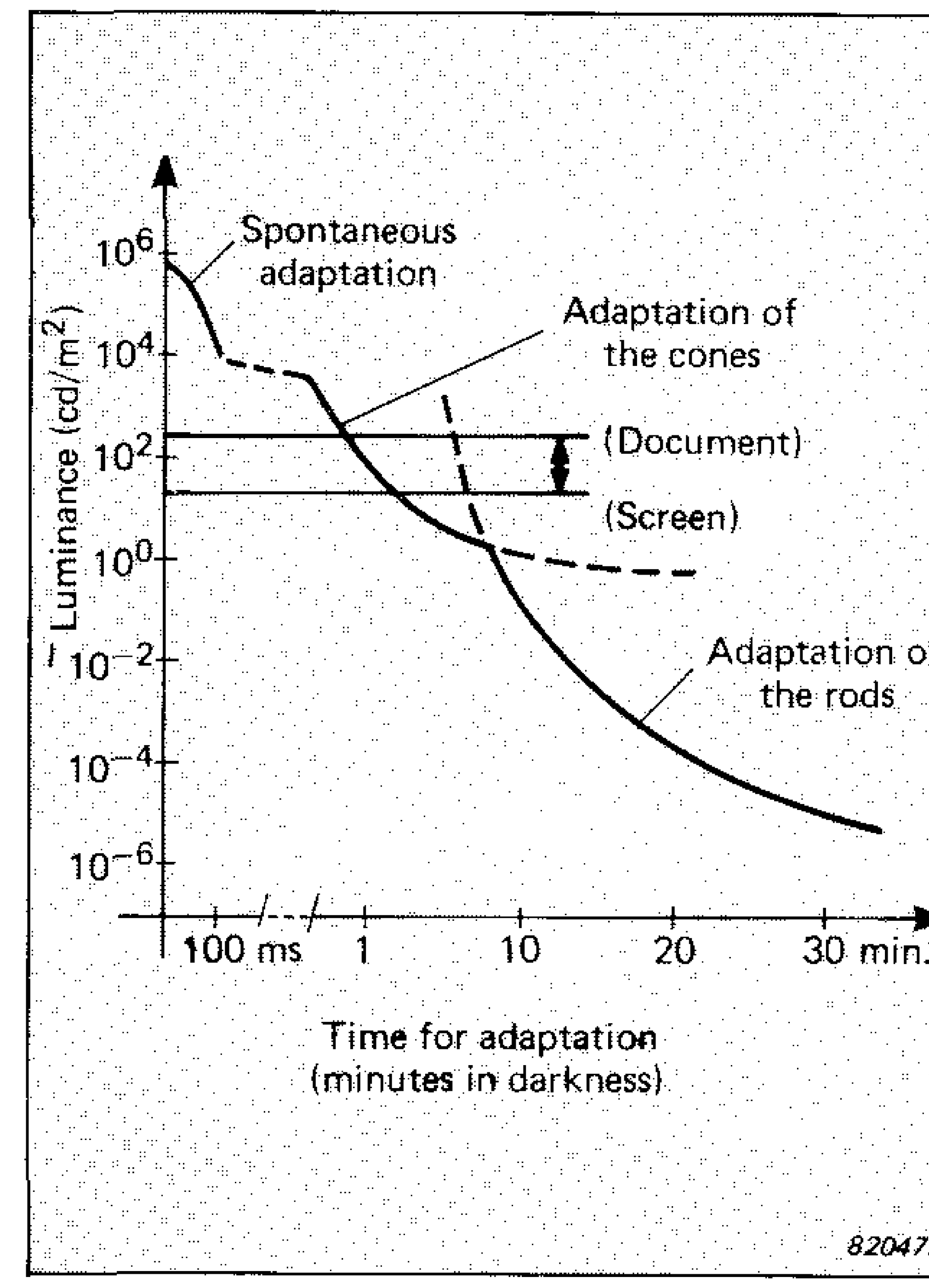


Fig. 7. If the document is too luminous, the eye takes a certain time to completely adapt when moving from the document to the screen.

The risks of glare

The eye of the operator adapts to a level of luminance corresponding to the average luminance in the field of vision. If the operator looks at the screen, this level of adaptation will be relatively feeble situated in the intermediate zone between diurnal vision (photopic vision) and nocturnal vision (scotopic vision).

A window or a light source, a luminaire for example situated in the field of vision behind the screen will possess a luminance far superior to the adaptation luminance of the operator and could produce glare. Glare may be defined as a disorder of the adaptation process of the eye; the cells on various parts of the retina being excited simultaneously by luminance levels too far removed from one another.

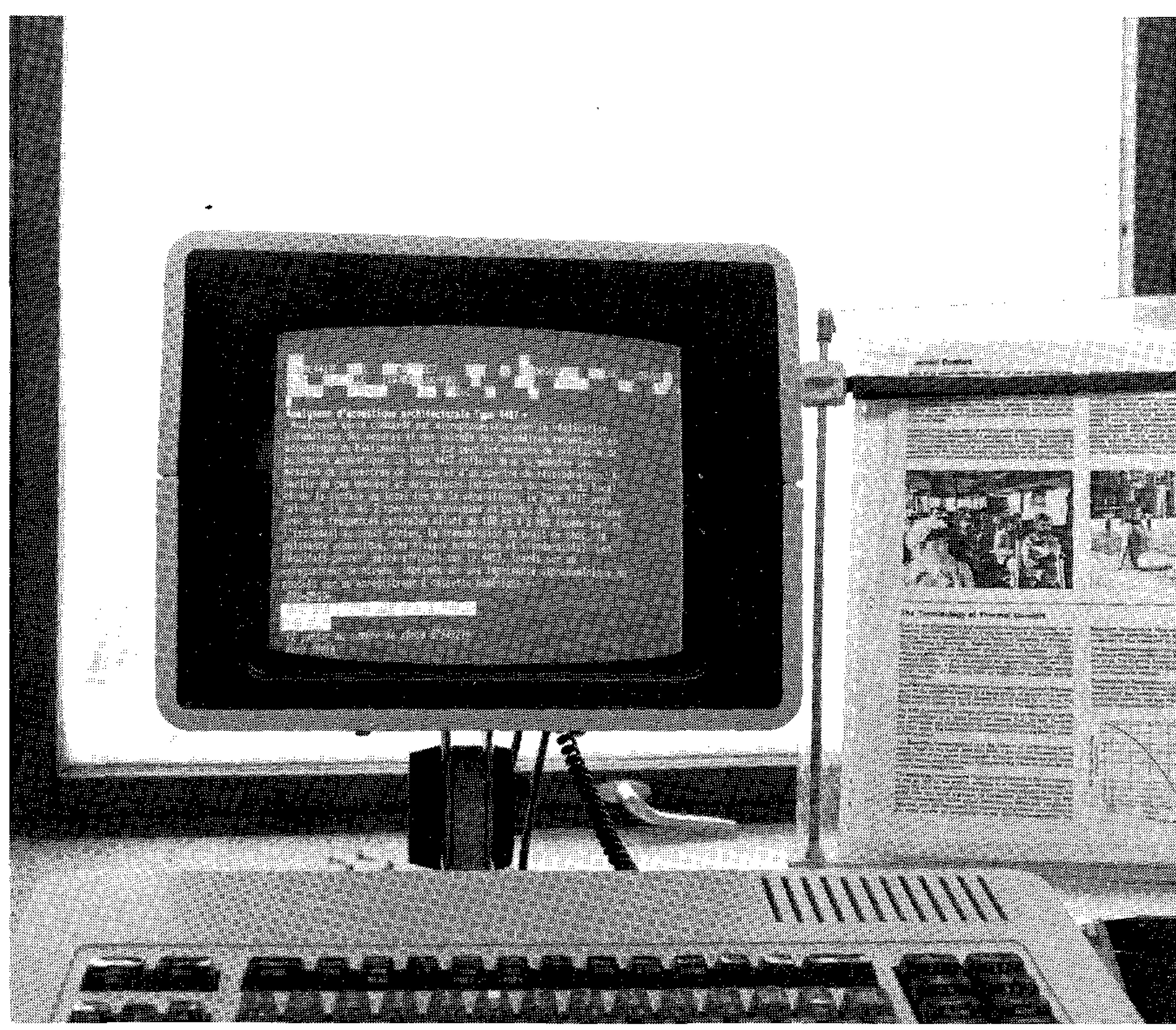


Fig. 8. The disability glare effect from a window in the visual field of an operator.

Generally, two types of glare are distinguished:

"Disability" glare which is due to the presence of a surface whose luminance is far superior to that of the observed object. This provokes a type of veil which is interposed between the eye and the detail observed and diminishes the visual acuity. This type of glare is very frequent when the operator of a terminal faces towards a window, or even a bright wall or when a bright ceiling is in the field of vision.

"Discomfort" glare is caused by the presence of a source of very strong luminance (relative to the adaptation luminance of the eye) in the field of vision as for example a luminaire or the desk lamp of a colleague. In this case, there is no visual incapacity but only an annoyance which could lead to fatigue in the long term. This annoyance is a function of the luminance of the source, on the perceived dimensions and the angle subtended with the line of vision. One should, therefore, avoid placing sources of high luminance within the angle of glare. The vertical angle of glare is defined as 30° or 45° depending on the recommendations to which one refers.

The angle of vision at the workplace for a terminal is elevated by about 20°, relative to the workplace at a traditional writing desk. This increases the risk of glare as the ceiling and its associated light sources are now situated in the angle of glare.

A supplementary difficulty – flicker

To overcome the problem of adaptation difficulty caused by the alternation of the eye from dark screen to light document, one could envisage screens with a light background and dark characters, that's to say with a contrast which would be of the same sign as the document. But here one encounters another phenomenon, which is perhaps even more annoying – flicker. This is due to the emission of light from the screen being intermittent and at a repetition rate which is just inferior to the critical fusion frequency of the eye (this is the frequency above which the observed image appears stable). Flicker increases with luminance and also when the surface on which it is produced covers a greater portion of the field of vision. This is just what happens when one has a bright background and dark characters. The solution would evidently be to increase the frequency of the image but this would entail the use of completely different techniques for forming the image which up to now have proved to be very onerous and complex.

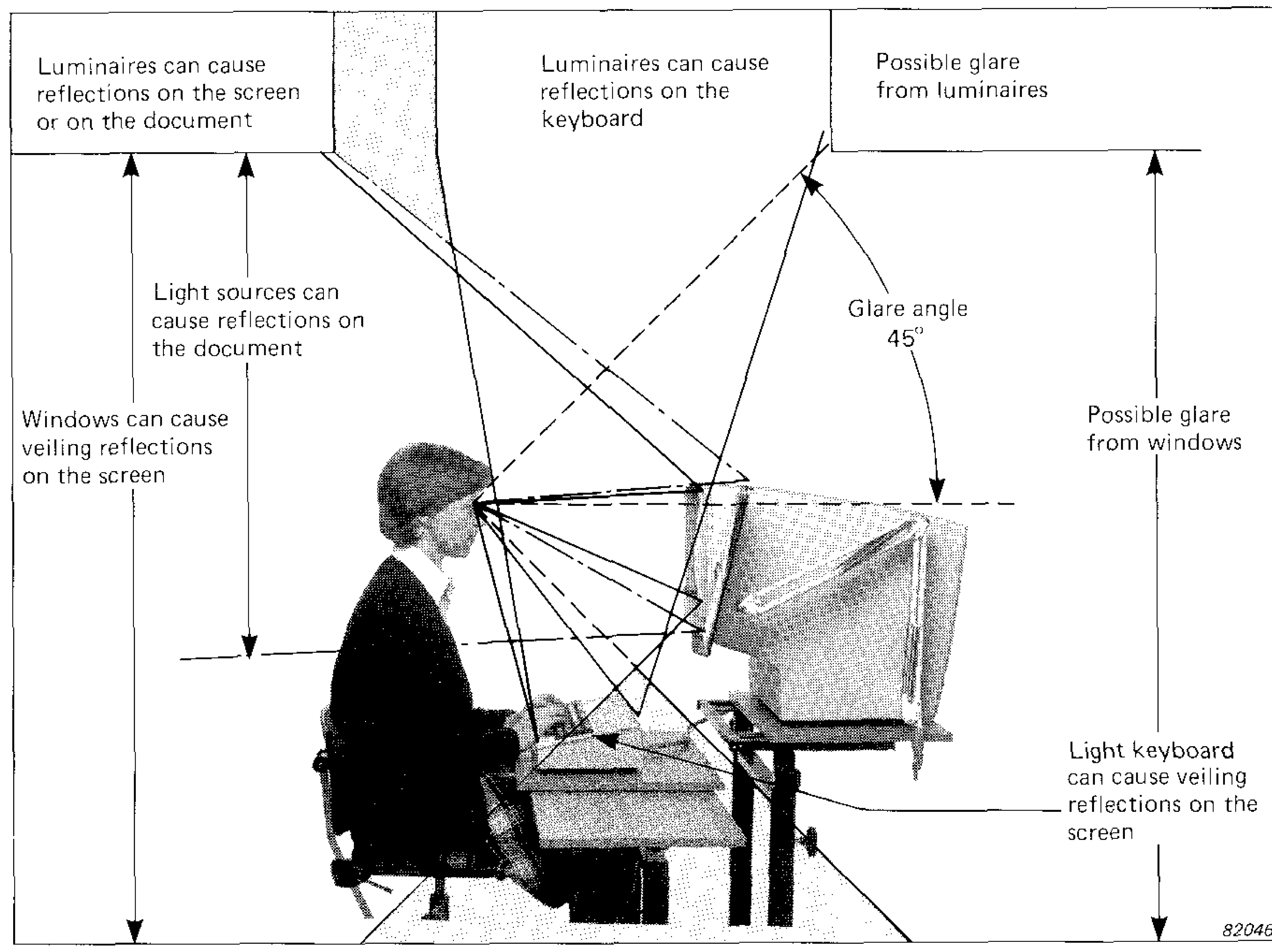


Fig. 9. There are many zones around a terminal where light sources can cause reflections or glare effects.

Measurements and evaluation of lighting at workplaces with CRT terminals

It has been demonstrated that if one considers only the visual problems of terminal operators, there are certain parameters which have conflicting effects and which are difficult to master. To obtain even lighting in an office requires a large number of light sources, and this leads to the need to avoid reflections from the screens and from the keyboards. How can one meet the requirement for an average illumination of 500 lux on documents (as recommended for office lighting in most countries), and at the same time obtain a balance of suitable luminances between the screen, the keyboard and the document? An illumination of 500 lux on white paper corresponds to a luminance exceeding 130 cd/m²(1) whereas the mean luminance of a screen rarely exceeds 20 to 30 cd/m².

It is evident that a compromise must be adopted and that certain rules and priorities must be laid down which enable optimal visual comfort to be attained. Hence the necessity to perform ergonomic measurements at the workplace itself, and to compare a given situation with the recommended limits.

In several countries, research and standardization work has already resulted in precise recommendations.

Contrast of characters on the screen

The German Standard DIN 66 234 [1] states that the contrast of characters, defined as the simple ratio of the mean luminances of the characters to that of the background, should be between 6:1 (luminance of the characters 6 times that of the background) and 10:1. The quotient must not exceed 15:1 nor fall below 3:1. Furthermore the standard recommends that the background luminance of the screen should not be less than to 10 cd/m². It is necessary here to distinguish between the "intrinsic" contrast of the characters on the screen and the actual contrast of the characters in the luminous environment of the terminal, in order to account for eventual veiling reflections. Naturally it is important to control the latter contrast, as it expresses the real state of legibility of the text on the screen, as seen by the operator. The elements of the characters usually have very small dimensions (luminous points of tenths of a mm). It is, therefore, often practical to perform contrast measurements on a pattern consisting of several areas, each having the luminance of the characters, spread evenly over the surface of the screen. When the luminances are measured, the direction of observation of the operator's eye must be taken into account.

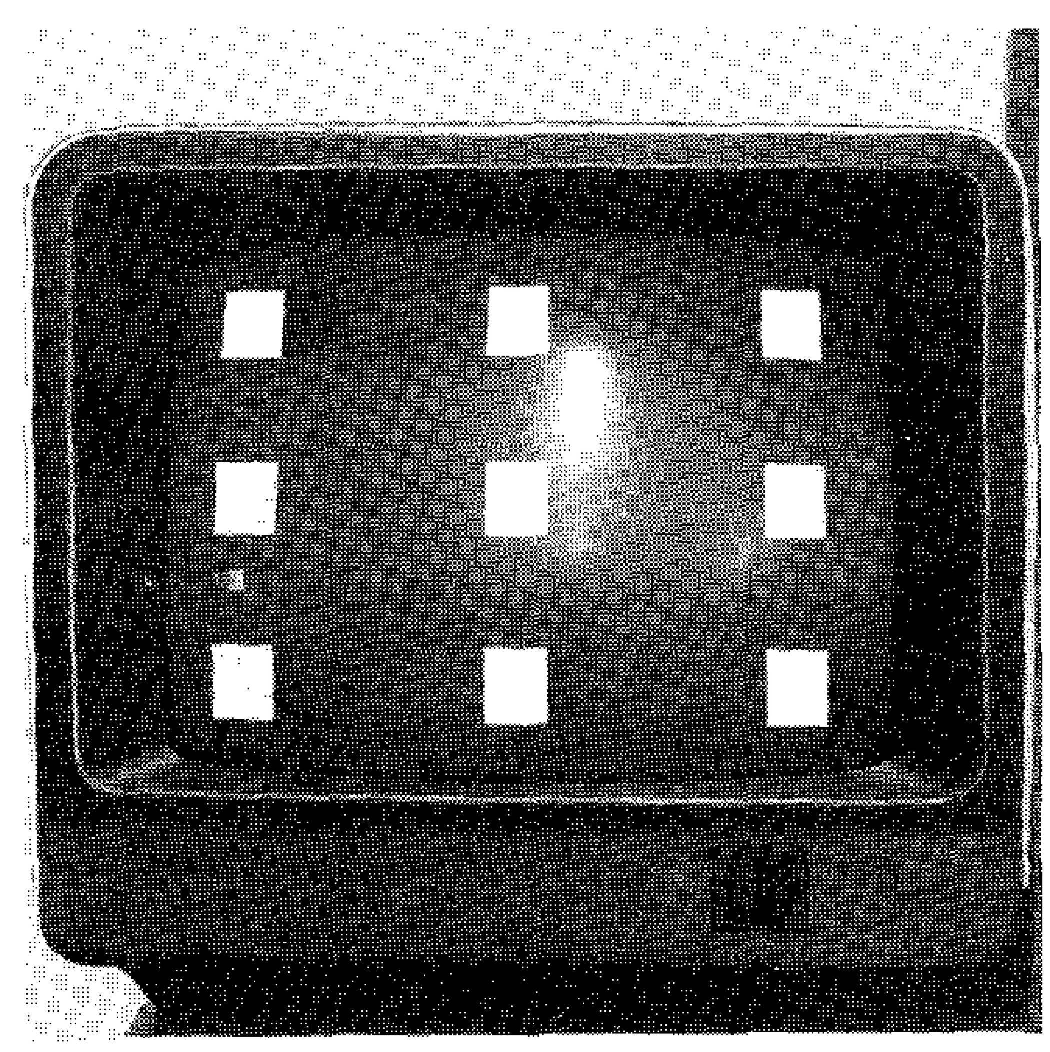


Fig. 10. The contrast measurement of characters may be performed on a pattern of small areas on the screen such as the one shown here. The luminance of each small area is compared with the background luminance in the proximity including eventual reflections

1. The luminance of a diffuse surface (a matt surface which has the same luminance in all directions) may be calculated as being equal to $0{,}32\rho E$ where ρ is the diffuse reflection coefficient (in this case ρ is taken to be 0,8) and E the illumination in lux.

Contrast on the document

The contrast of a detail on a document is defined [2] by the relationship:

$$C = (L_d - L_b)/L_b$$

where L_d is the luminance of the detail (the letter for example) and L_b is the luminance of the paper. It will be noticed that this definition, adopted by the majority of lighting engineers, leads to a negative value for contrast when the detail is dark and the background is light, while typographers talk of positive contrast in this case. The sign of the contrast is in itself of limited importance, as it is purely a matter of convention. However, it is essential, that the manner in which this contrast varies in the luminous environment is given. The reflection of luminous sources on the document, can in certain cases, have an effect which effaces certain parts of the text. This phenomenon is not easy to evaluate as it depends not only on the type of document (paper which reflects to a greater or lesser degree) but also on the details which are written or printed on the paper (ink or pencil writing; a typed or printed document).

Fig. 11. The instrument memorises the two luminances and gives the value of the contrast. The measuring cell, which incorporates a normalised CIE filter and a narrow acceptance angle, is installed on a sighting mount at the position of the operator's eye and simply pointed towards one of the areas on the screen

Rather than defining a contrast model for each type of document, standardization work in Europe and on an international level is oriented towards the definition of a single contrast sample, capable of yielding reproducible measurements in all situations and the adoption of different criteria for use with this common contrast standard as a function of different visual tasks. The International Commission on Illumination (CIE) intends to propose in the revision of Publication CIE 29 "Guide on interior lighting" classes of quality for lighting systems introducing the parameter "Contrast Rendering Factor" (CRF). The parameter CRF had already been proposed in Publication CIE 19A (1972) and is widely used in the USA.

The CRF is defined as the ratio of the contrast of a standard visual task in the lighting to be evaluated to the contrast of this standard in a reference lighting environment i.e.:

$$CRF = C/C_{ref}$$

The reference lighting is the lighting of a totally diffuse sphere illumination.

The standard visual task consists of a light surface and a dark surface the characteristics of which are well defined and which permit the simulation of practically all contrast types of all the usual visual tasks performed in offices, schools and libraries. One observes that the luminance of the dark surface can surpass that of the bright surface when the angle of observation is exactly symmetrical to the angle of incidence of a point light source relative to the vertical. This yields a correct simulation of cases where the text is printed on glossy paper and where an inversion of contrast can occur.

Three classes of quality for the contrast rendering of lighting systems have been proposed by the CIE according to the degree of "glossiness" of the visual task [3]. In the case of documents used in conjunction with work on a terminal, one should allow for the fact that the visual work of the operator is already sufficiently complex so that no compromise can be accepted on the legibility of the document. If the documents are not too glossy (computer print-out for example), it is reasonable to adopt class II corresponding to a CRF greater than or equal to 0,90.

In practice, it might be sufficient to locate the point where the CRF is a minimum, that is the point where the dark surface of the contrast standard attains a luminance maximum over the surface of the document.

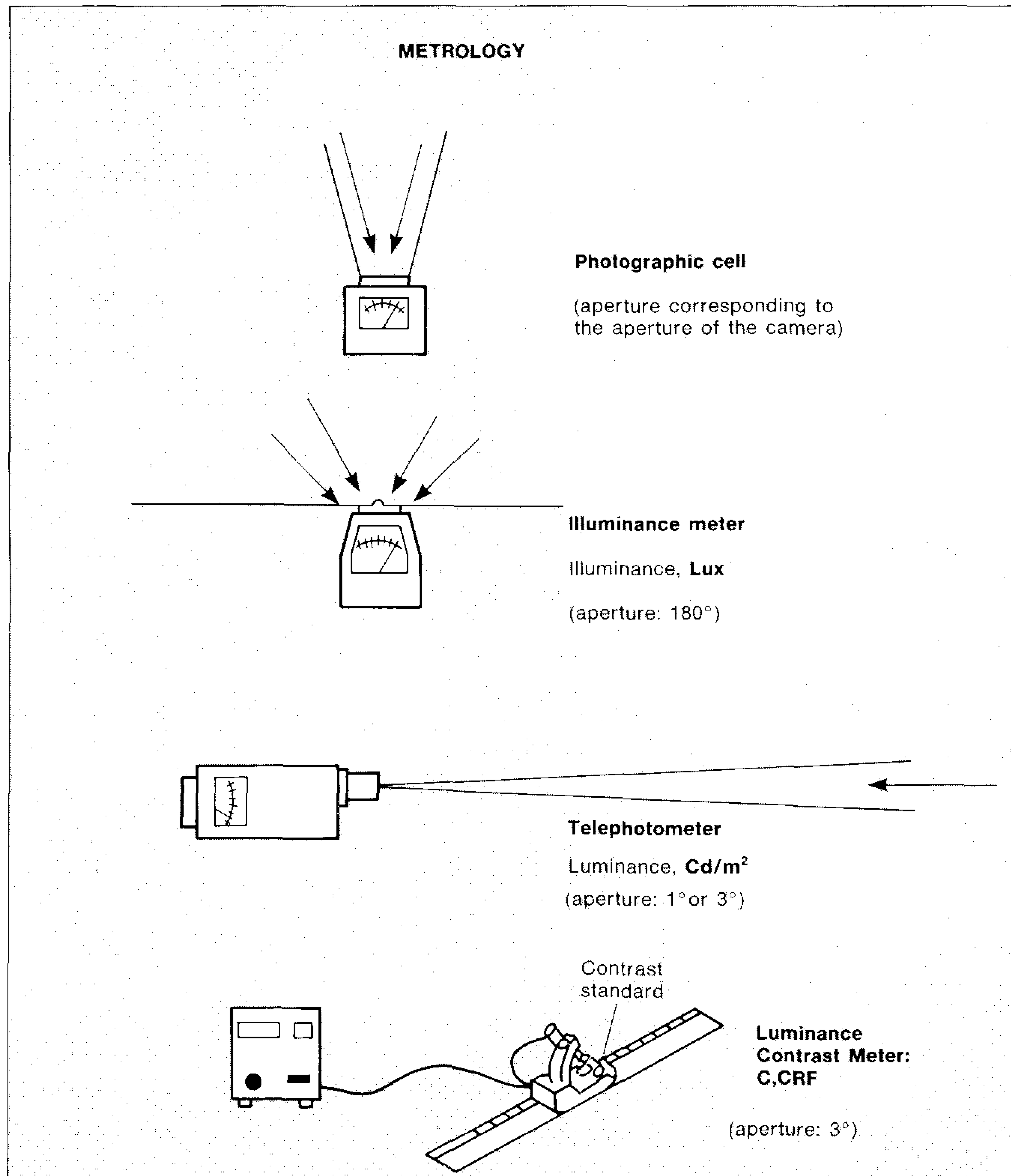
On the other hand, if it is necessary to evaluate the contrast on the surface of a table or a desk, one can define a nominal work area [4] corresponding to about 2 pages of A4 format. The eye of the observer being at 40 cm above the work plane. A map of the contrast rendering on this normal surface can be drawn by plotting contours with equal CRF (ISO–CRF contours)

Contrast on the Keyboard

The same method may be applied to the keyboard if one can represent the contrast of the keyboard with that of a document whose surface is particularly glossy. In practice, one locates the point where the contrast is a minimum (CRF minimum) allowing for the eventual concavity of the keys. That means that at critical points, the measurement is made several times while trying to locate the angle of inclination of the contrast standard which yields a CRF minimum as seen by the observer.

Balance of luminance conditions

In general a distinction is made between the balance of luminance conditions in the near visual field (that's to say between the three visual tasks: screen, keyboard and document) and the balance of luminance conditions between near field and far field. The ratio of the luminance between any two of the three visual tasks of the near field must not be greater than 3. Furthermore, the ratio of the luminance between the far field behind the screen and the screen itself must not



Contrast

$$C = \frac{L_d - L_b}{L_b}$$

Contrast Rendering Factor (CRF)

$$CRF = \frac{C}{C_{ref}}$$

where: L_d = luminance of detail
L_b = luminance of background
C_{ref} = Contrast obtained in an Equivalent Sphere Illumination (ESI), (CIE Publication No. 19)

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Measurement of light. The influence of the aperture angle.

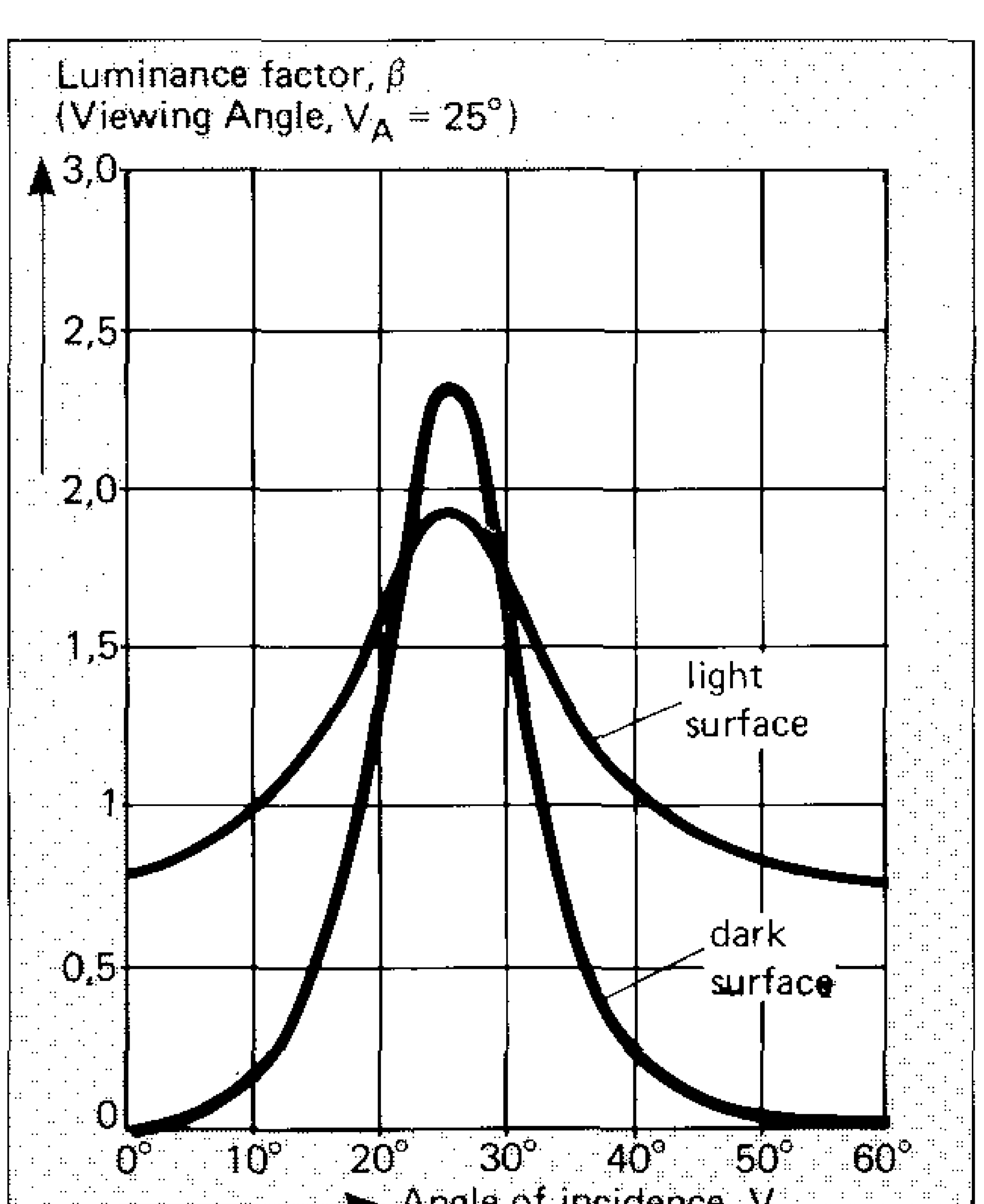

Fig. 12. Reflection characteristics of the contrast standard recommended by CIE (TC 4.1), in point source lighting.

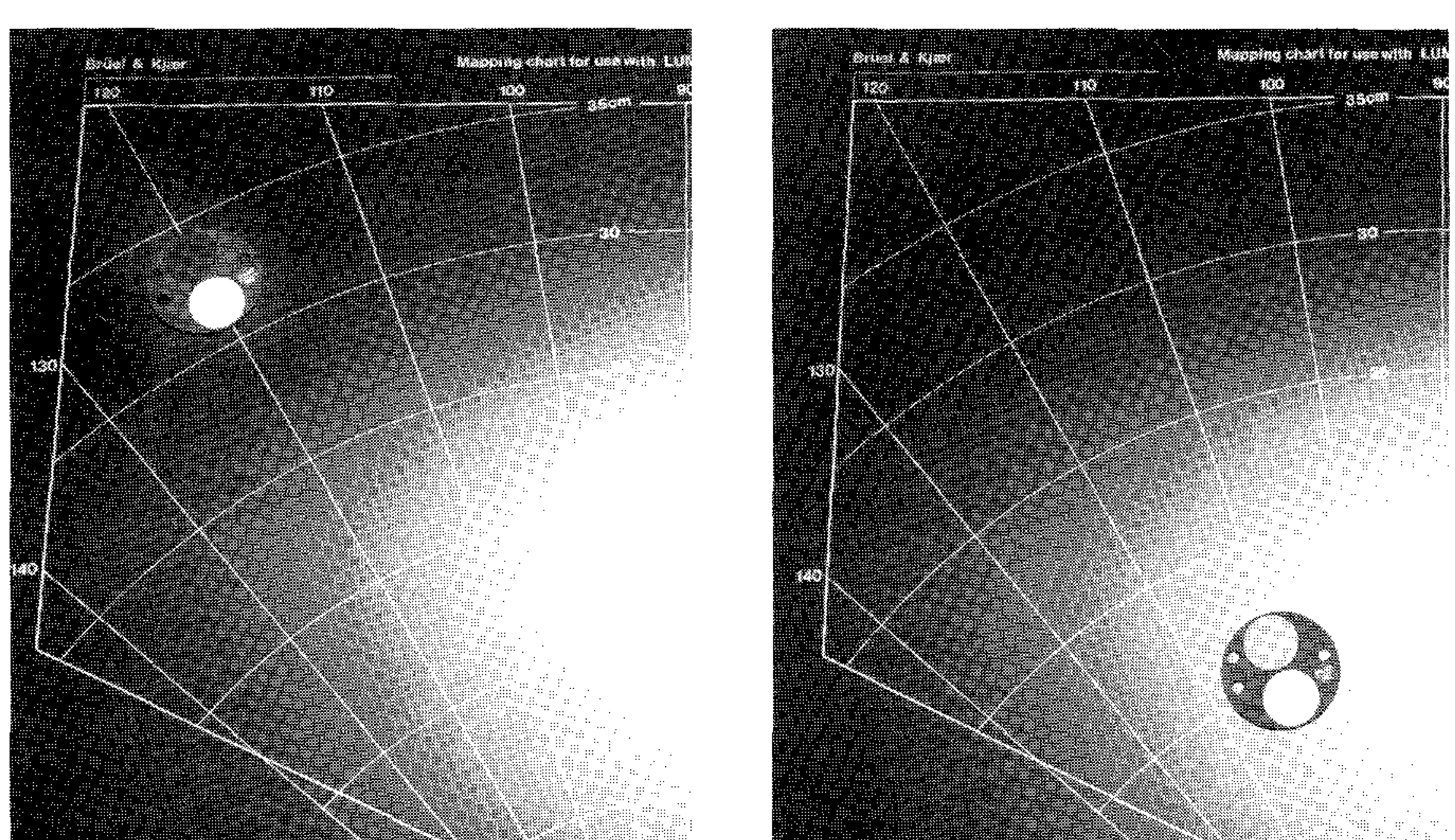

Fig. 13. Contrast Standard placed at two points on the surface of the proposed standard work surface. At the place where the reflection occurs, the luminance of the dark contrast task practically becomes equal to that of the light contrast task. The contrast disappears.

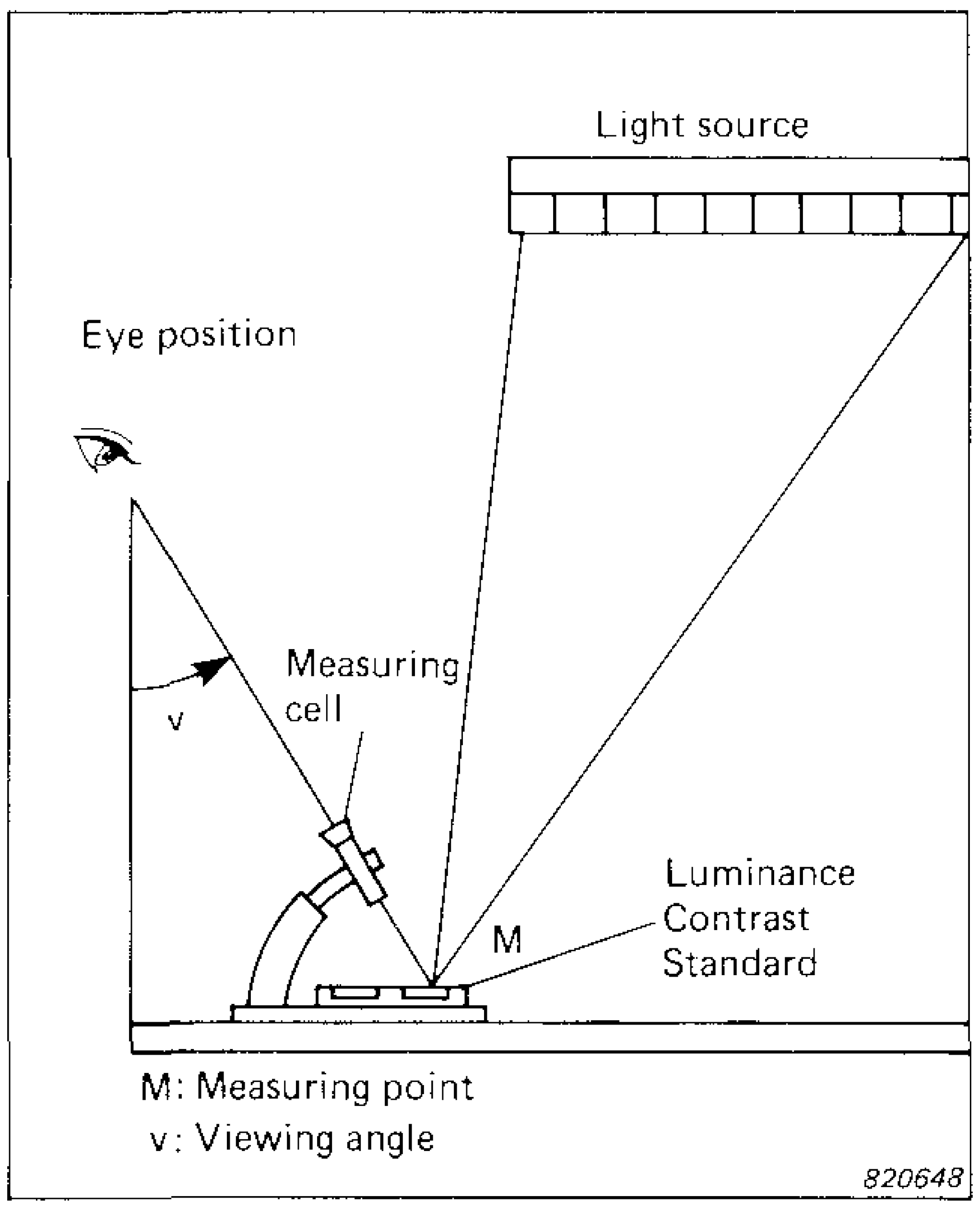

Fig. 14. Principle of contrast rendering measurement enabling the quality class of the luminous source to be defined.

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 1. Contrast rendering classes for CRF and recommended application areas for reading and writing tasks.

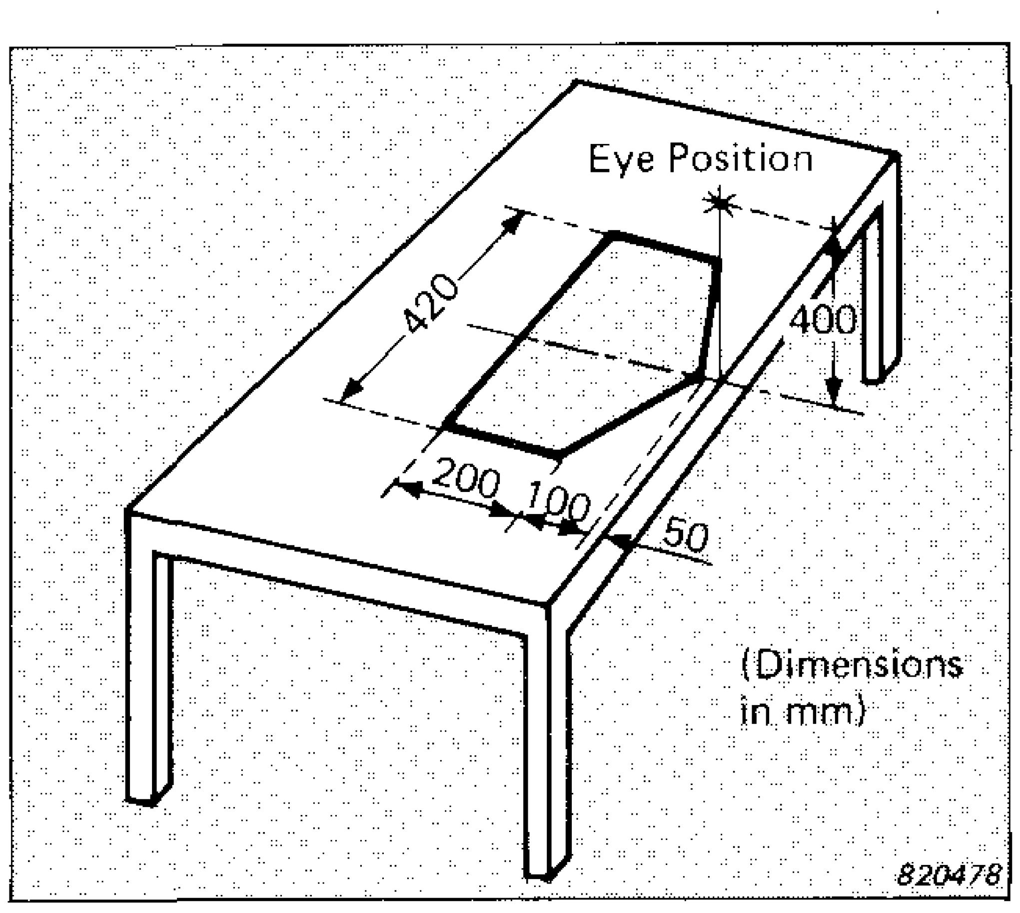

Fig. 15. Standard area for measuring the contrast rendering on a worktop (desk, table, etc.).

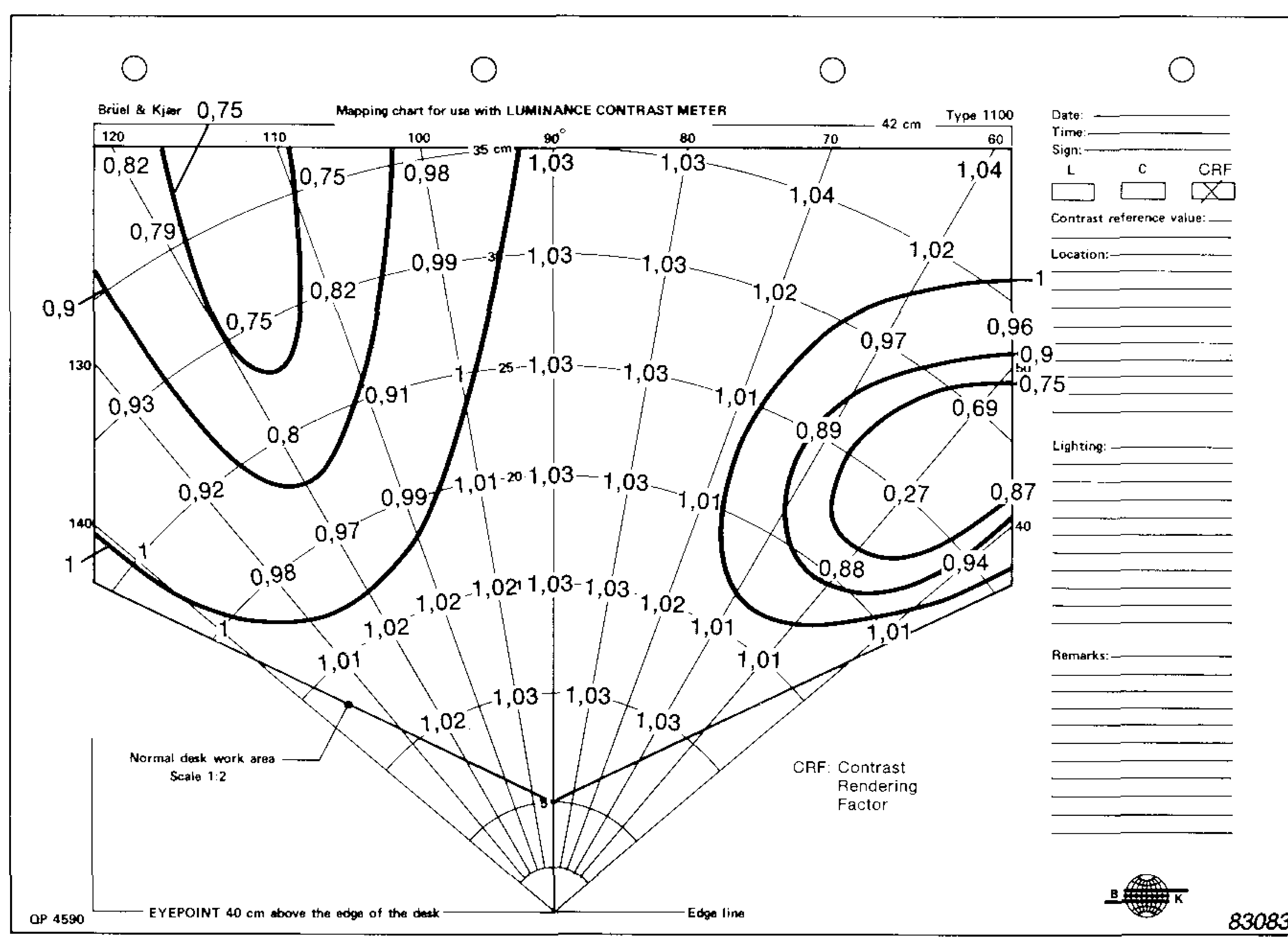

Fig. 16. Mapping of the contrast rendering on a desk. The reflection at the left is due to a direct luminaire (2 fluorescent tubes each of 40 W) corresponding to Class III (CRF ⩾ 0,75). The office lamp (with a clear bulb of 60 W) which is the cause of the reflection on the right yields a minimum CRF of 0,27. This is an example of poor quality lighting.

be greater than 10. This excludes therefore, an orientation of the screens in front of windows or other very bright sources (e.g. luminaires).

Level of illumination at a workplace with a terminal

The first condition for the balance of the luminance conditions can only be fulfilled in the usual situation where a screen has a "positive" contrast (light characters on a dark background) if the level of illumination on the document is not too great. The level of illumination recommended for office activities is usually 500 lux. However, in most cases this level cannot be respected at least where there is the possibility of using coloured documents, that is, documents having a reflection coefficient well below 0,8. In such cases, it is advantageous to choose a colour complementary to the background colour of the screen in order to compensate for the chromatic phenomenon of after-image due to the alternation of the operator's glance between screen and document. An extended and intense exposure of the eye to a particular colour provokes the appearance of the complementary colour on a sheet of blank paper. If the paper is already this complementary colour, annoyance will be reduced. Apart from this particular case, it appears that an illumination of 300 lux is a good compromise; giving a sufficient legibility of the document if the contrast rendering is sufficient and a luminance balance which is acceptable for screens whose mean luminance is of the order of 20 cd/m^2. One should normally not accept illumination levels below 200 lux.

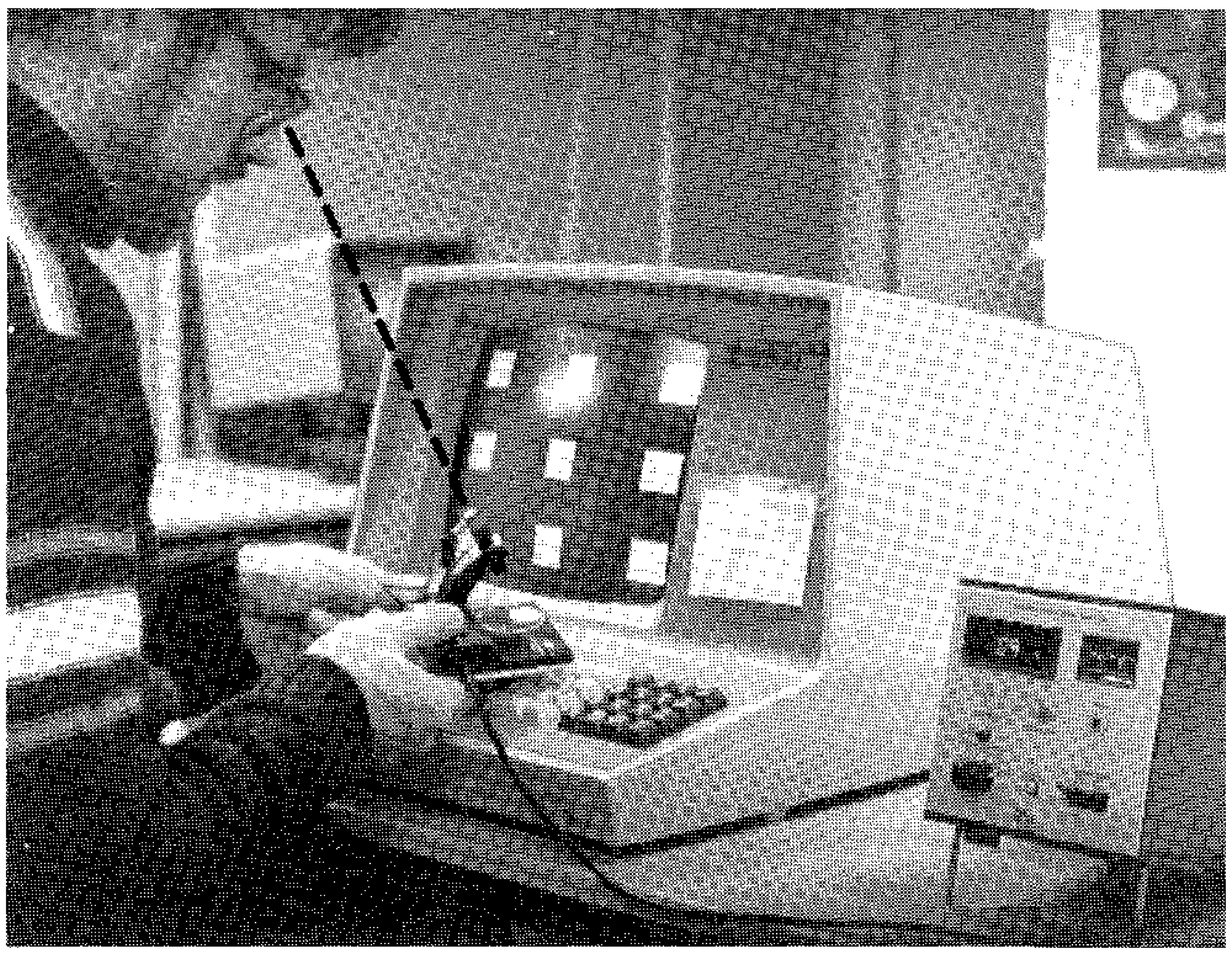

Fig. 17. Measurement of contrast rendering on a keyboard.

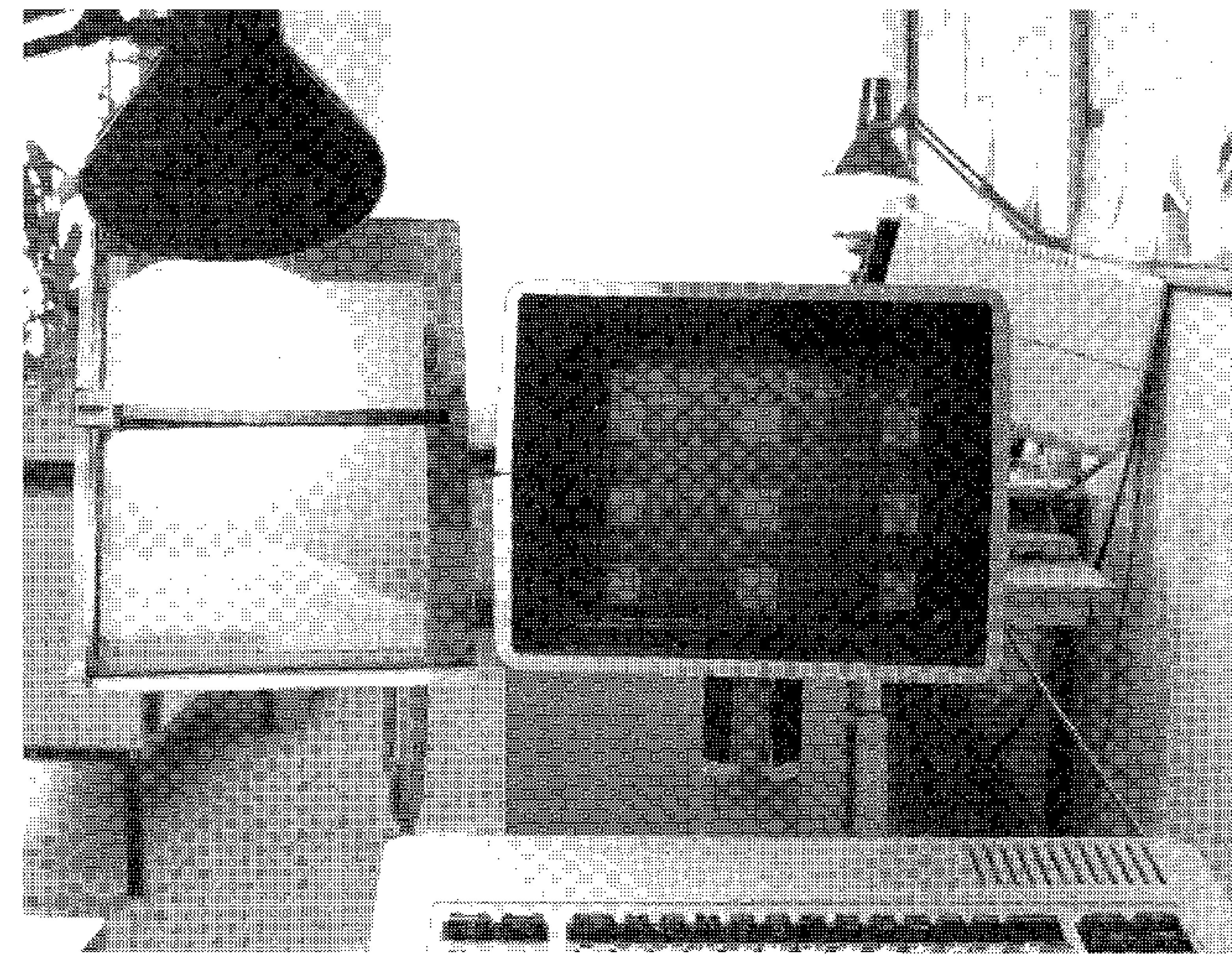

Fig. 18. An example of a workplace where the contrast conditions leave something to be desired!

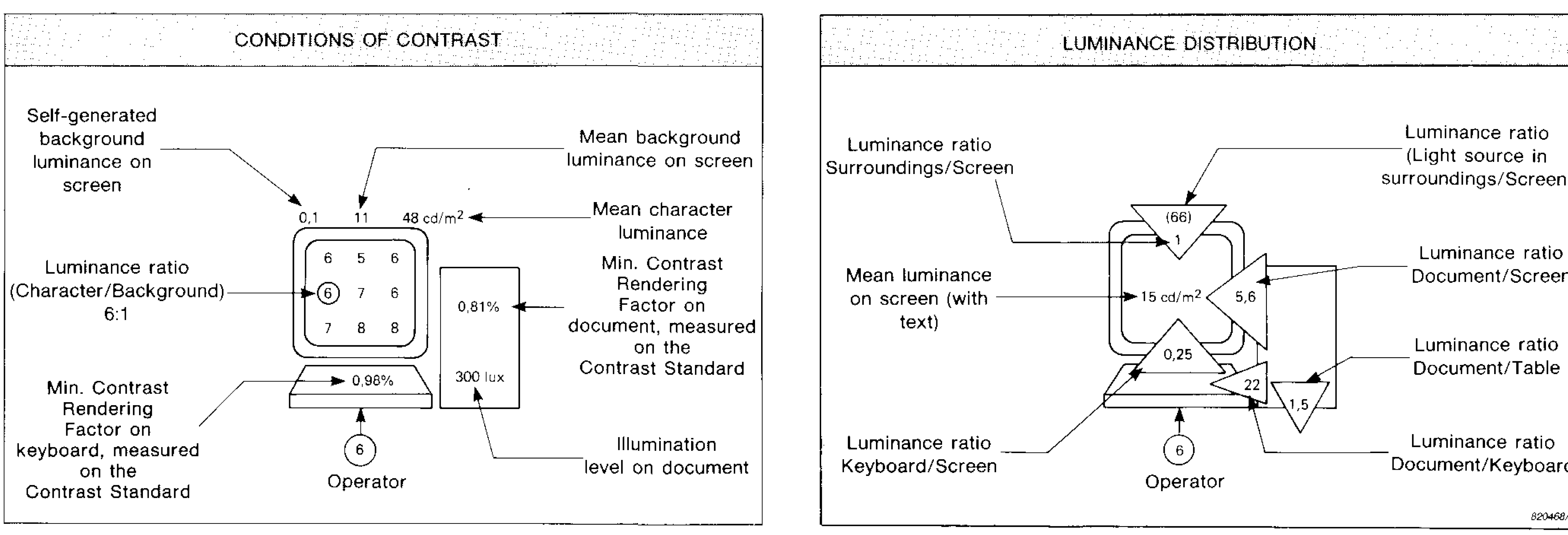

Fig. 19. Two groups of parameters for evaluating the visual conditions on a CRT terminal: the contrast conditions on the 3 visual tasks and the mutual luminance balance between the 3 tasks and between the screen and the far visual field.

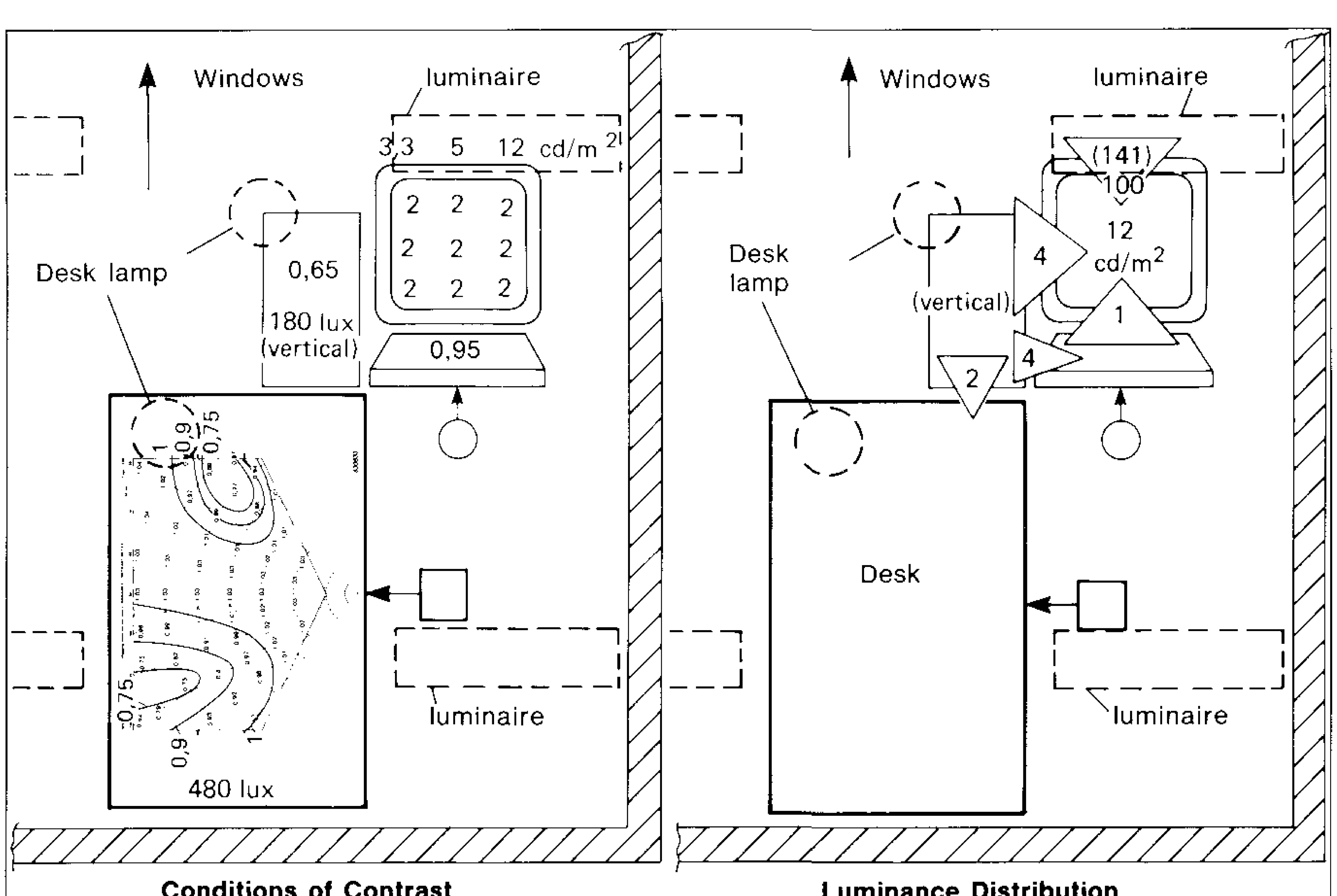

Fig. 20. Measurements performed on the workplace: the contrast on the screen is particularly deficient (2:1), the reflections on the manuscript and on the desk are too strong, and finally the screen should not be placed facing the windows even though the curtains are drawn. (See Fig.18).

Envisaged Action; Possible Remedies

Artifical lighting and daylight

Windows and glazed partitions should be equipped with relatively thick curtains which are capable of excluding practically all light. Fabrics with a low percentage of absorption are not recommended as their luminance in bright sunlight would probably be excessive. Venetian blinds may be employed with vertical slats which are easily regulated according to the external lighting conditions. Half opened venetian blinds with horizontal slats may allow the sunlight directly into the room producing bright bands inside the room which can be reflected onto the wall, floor or on the workplace. This is not the case for blinds with vertical slats which may be positioned obliquely such that the sunlight cannot pass directly into the room.

Artificial light sources should be placed so that there is no risk of glare for the operators nor of producing veiling reflections on the screens or on the keyboards. Naked fluorescent tubes in the angle of glare of the operator should be totally prohibited, as their luminance is of the order of 5000 to 6000 cd/m^2.

Luminaires should be furnished with low luminance grilles. To improve the uniformity of the contrast rendering and the illumination throughout the room, one could eventually supplement this general lighting with indirect lighting of the ceiling with a rather bright hue. A good contrast rendering factor (Class I) could also be obtained by luminaires yielding direct lighting but oriented with lateral lobes at 45° [5]. Placed between the rows of terminals, such luminaires yield their maximum light on the workplaces themselves without producing reflections on the keyboards.

Positioning of the terminals

It is desirable to place terminals far from sources of daylight and to orient them if possible parallel to these sources. If there is glazing on two sides of a room thus forming a right angle, then partitions should be placed in one of the directions to avoid reflections and the effects of glare. If possible the screens should be placed between the rows of luminaires, but in certain cases a luminaire may be placed directly above the operator, perpendicular to the axis of the terminal. This exploits the free zone between the two critical regions, corresponding to the risk of reflections on the keyboard and on the screen (Regions I and II respectively, see Fig.24). The dimensions of this free zone depend on the type of terminal and the type of luminaire. Measurements should be made to control the contrast at the workplace and to adjust the position of the luminaires.

In an office with mixed visual tasks (terminals and ordinary office work), one should strive to group the terminals together and to isolate them from the other workplaces by means of partitions. One can thus adopt different types of lighting for the different workzones. If this is not possible, for example, if the operators do not like being "segregated", then provision should be made to enable the general sources of lighting to be individually turned off above the terminal, and to

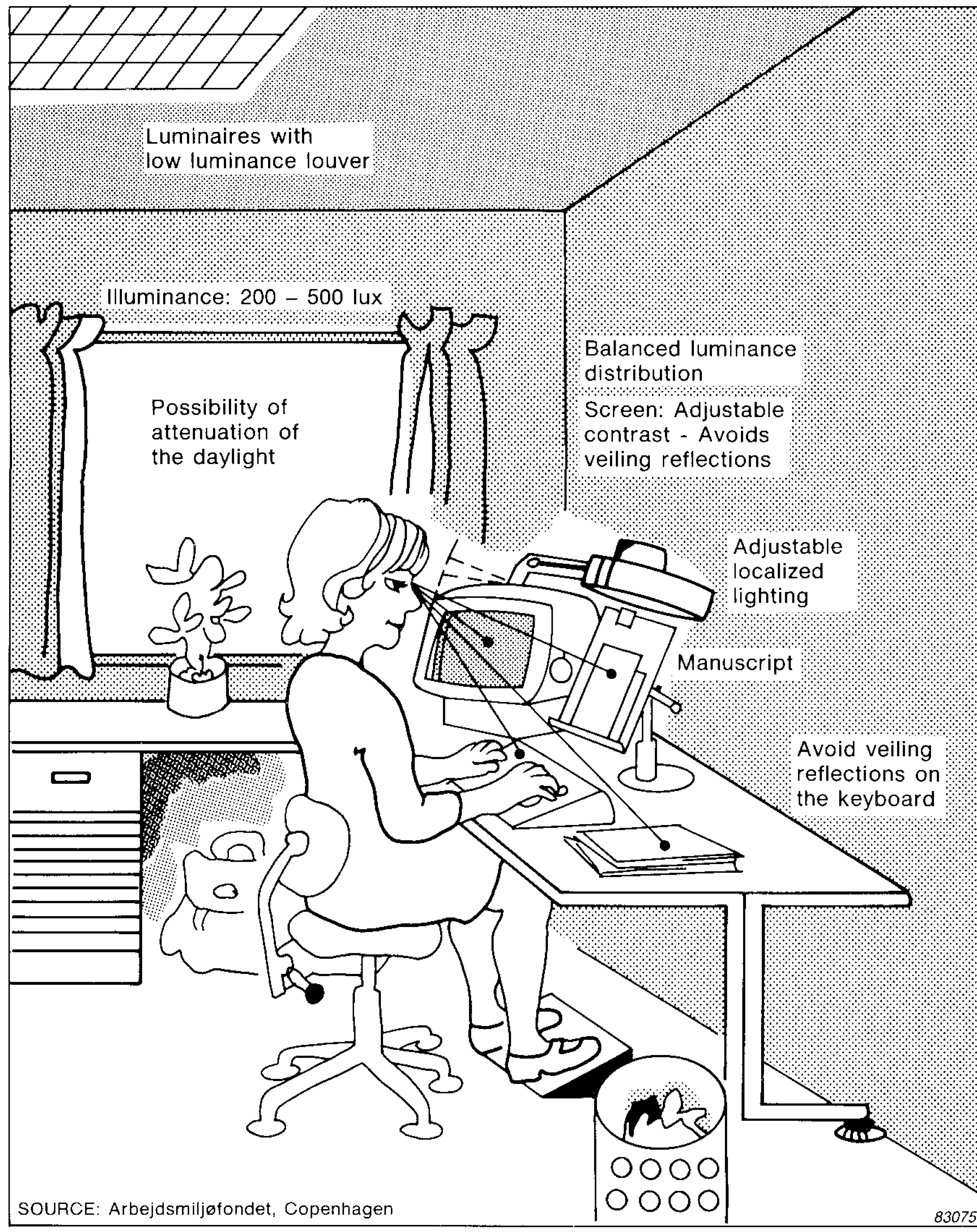

Fig. 21. Some general rules for the installation of a terminal in an office.

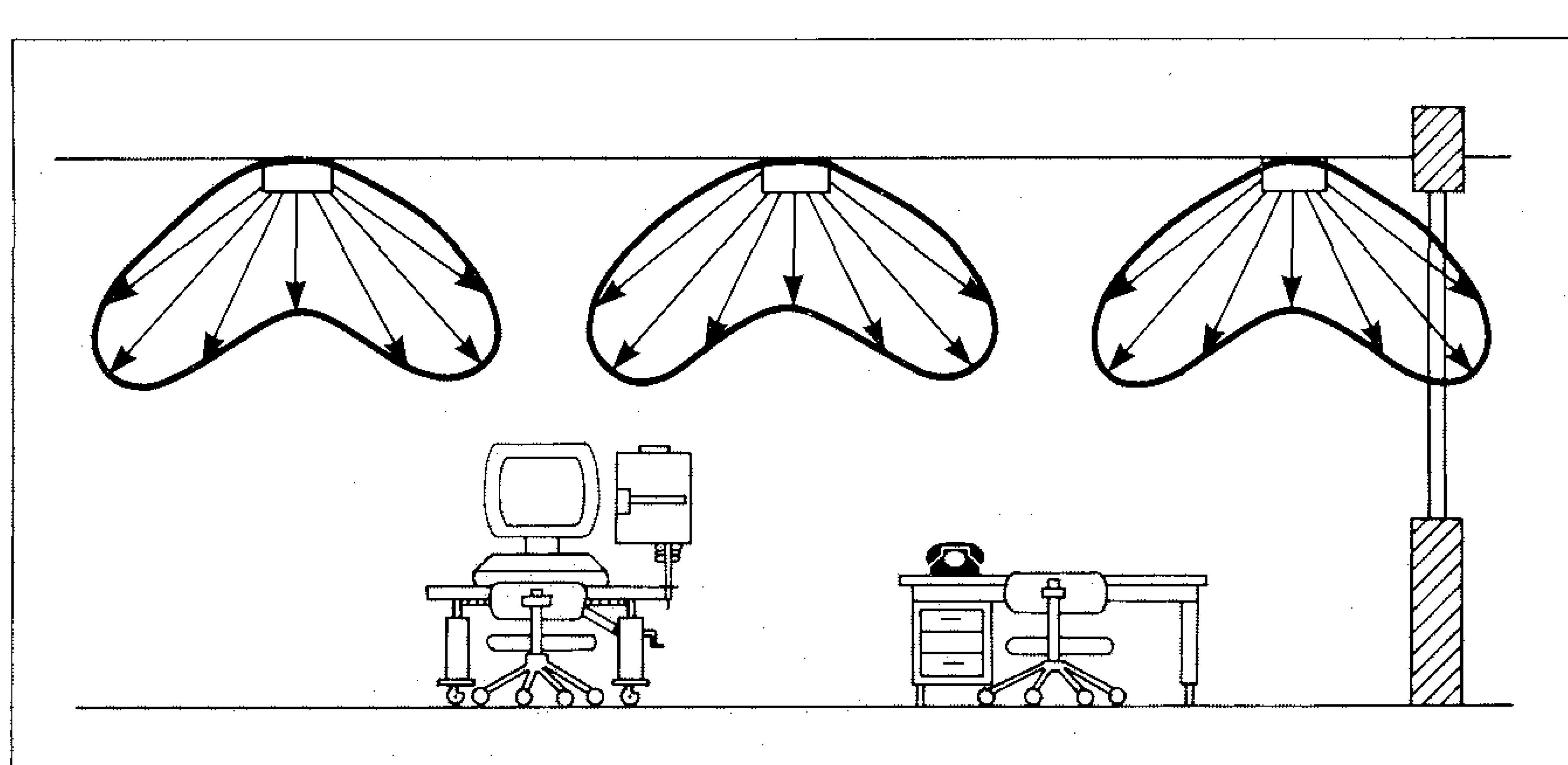

Fig. 22. An example of lighting with sidelobes oriented at 45° (cutoff angle 60°) capable of giving a contrast of Class I (CRF $\geq$ 1) and installed so as to avoid reflections on the screen, the keyboard and the desk.

Fig. 23. An example of luminaires with low luminance louvres enabling the effects of reflections and glare on the screens to be avoided. On the other hand, the luminaires are too widely spaced to give a good contrast rendering on the desks: a localised lighting at each workplace is necessary.

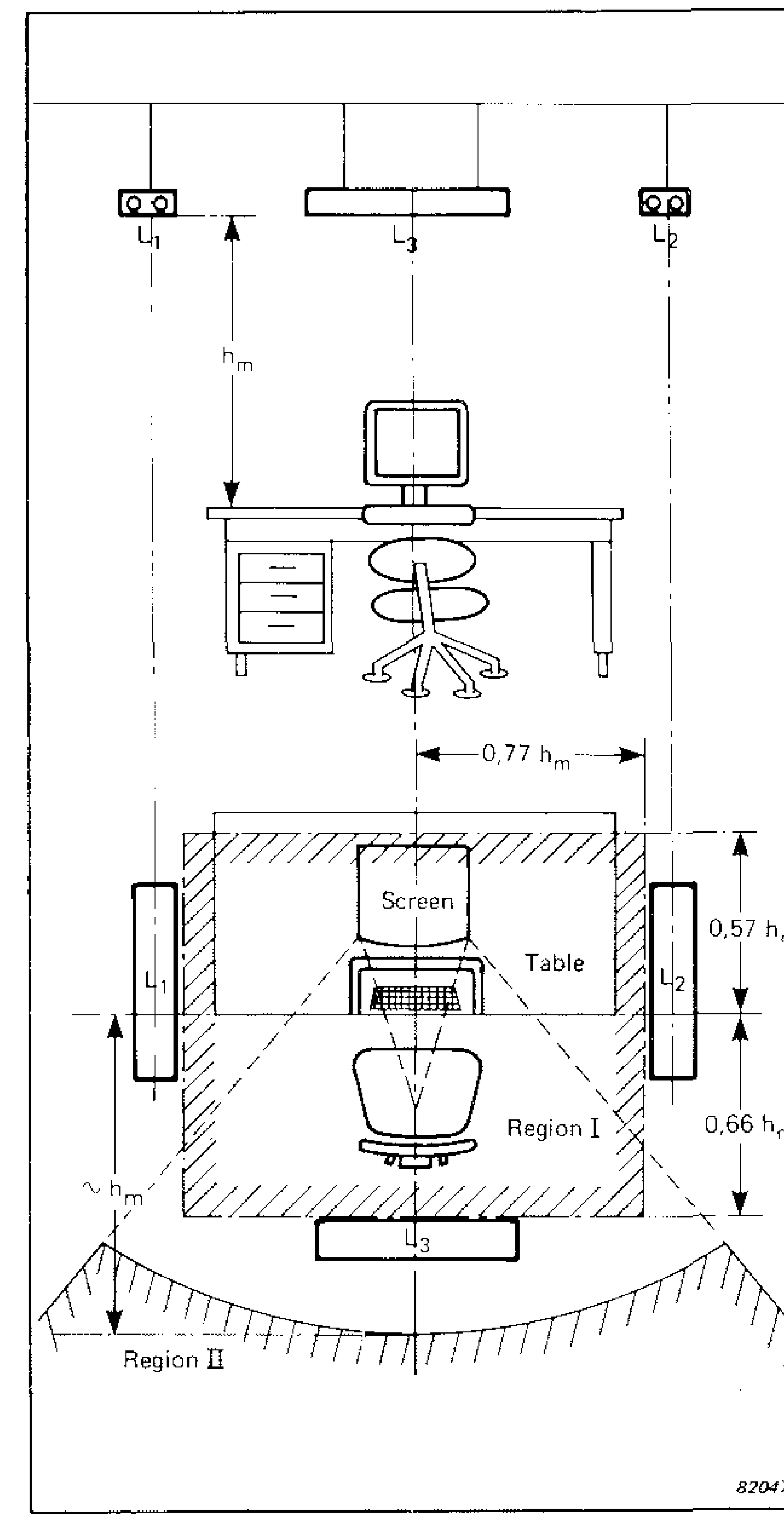

Fig. 24. Possible positions for luminaires above a terminal.

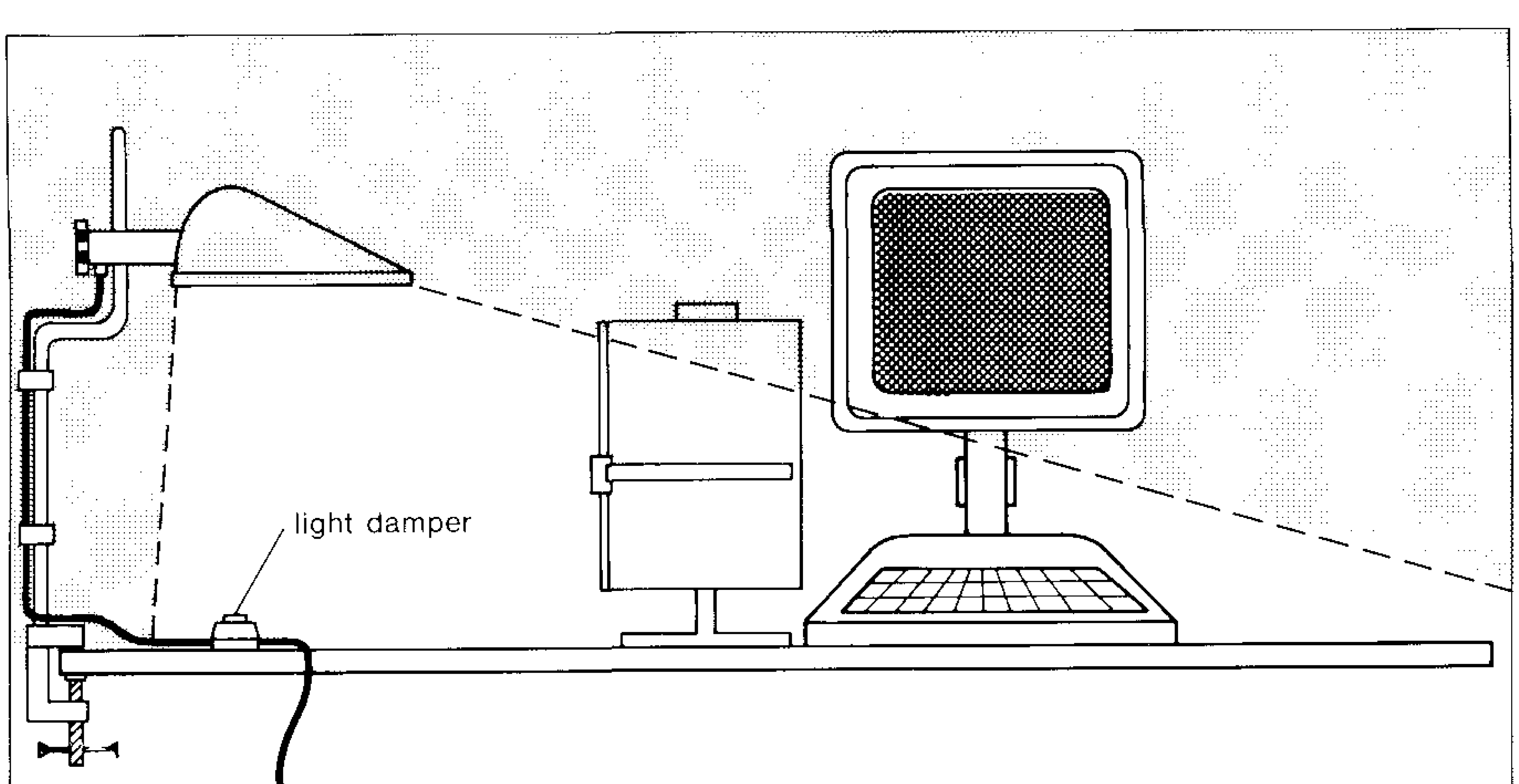

Fig. 25. Example of localized lighting using asymmetrical light beam in order to avoid veiling reflections on the document and on the keyboard.

be replaced by a localized lighting of the document. The preferred localized lighting is obtained from an office lamp with either an asymmetrical beam oriented to the document or very directive lighting which can be concentrated on the document itself. In both cases the operator should have the possibility of regulating the intensity of the light by means of a potentiometer or a variable transformer in order to try to obtain a balance of luminances.

The terminals themselves

Reflections on the screens can be attenuated by employing filters with fine meshes made of synthetic fibres, placed directly on the screens. They have the further advantage of increasing the contrast between the characters and the background as well as the resolution of the characters.

Sheets of tinted plastic material or coloured varnish applied to the screen are, however, not to be recommended. Their job is to make the contours of the reflections less distinct by increasing the diffuse reflection of the screen. However, at the same time they decrease the sharpness of the characters.

To reduce the reflections on the keyboard, it can be advantageous to replace black keys by keys of a light colour (not necessarily white). Nevertheless, to obtain a progressive change in luminance from the screen to the keyboard, the casing of the latter should be of an intermediate colour.

Finally, if the screen is furnished with a rectangular hood, this should be removable, in situations where a light source produces shadows on a part of the screen.

In conclusion, it should be recognised that visual problems at workplaces equipped with terminals are probably not perceived in the same manner by all operators. The relationship between each individual and "his machine" can vary enormously. Furthermore individual factors must also be taken into account, for example, the use of spectacles, the diminution of visual acuity with age, the time spent in front of the terminal each day. This means that the ergonomist or the lighting engineer should be very prudent when he formulates a solution. Ready made receipes, even when applied using the criteria for optimal visual comfort, will not necessarily be accepted by everyone if for example they involve modifications to the positioning of the workplaces relative to the windows or relative to one another. The ergonomist will have a greater chance of success in the adoption of solutions acceptable to all, if some people from the group concerned are involved in the search for a solution.

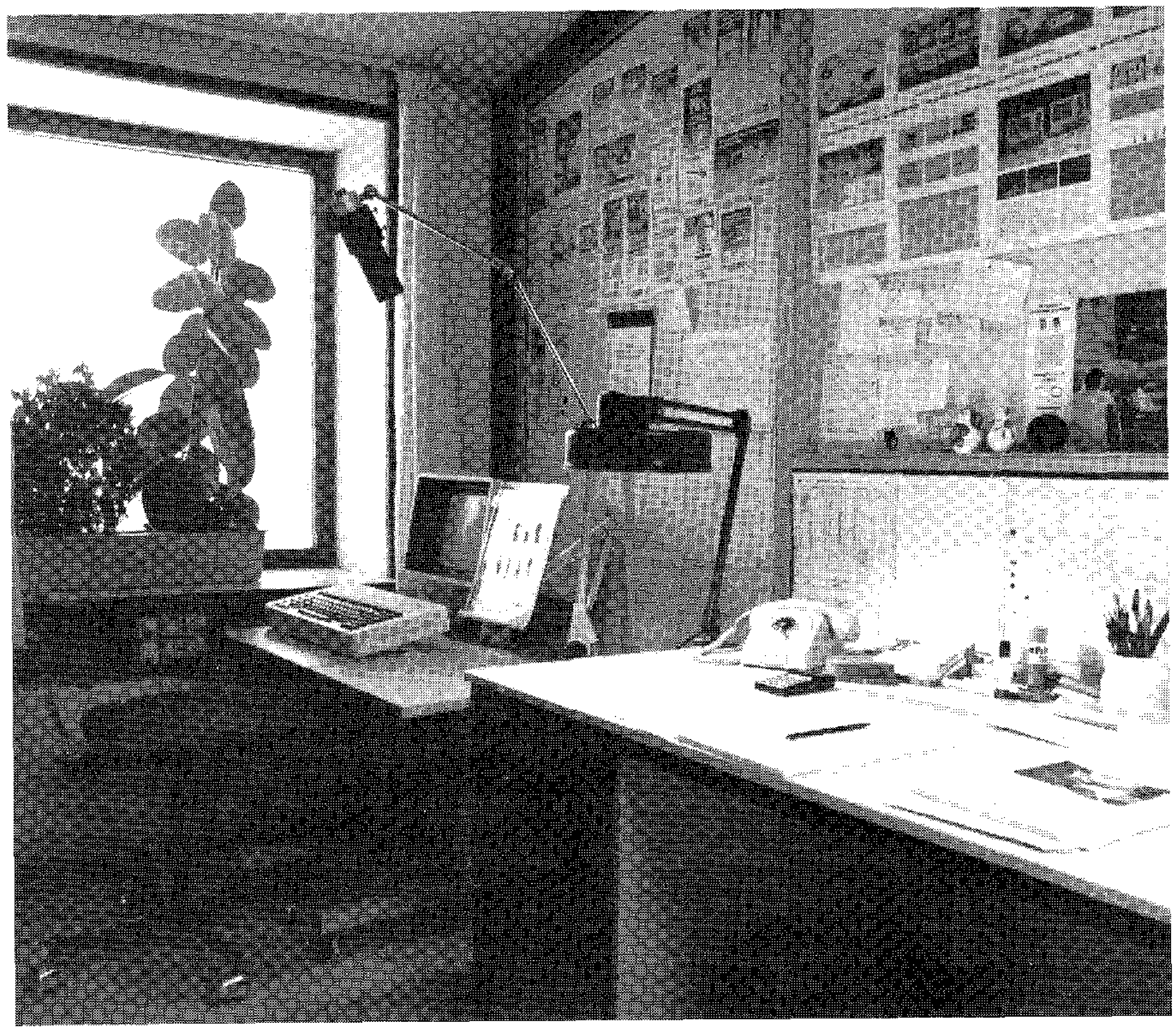

Fig. 26. Localized lighting of the document with a halogen lamp using a very directive beam. Lighting of the desk with a lamp using an asymmetrically oriented beam (CRF ⩾ 1). The intensity of the localized lighting is adjustable by a potentiometer, to enable the balance of luminances to be found.

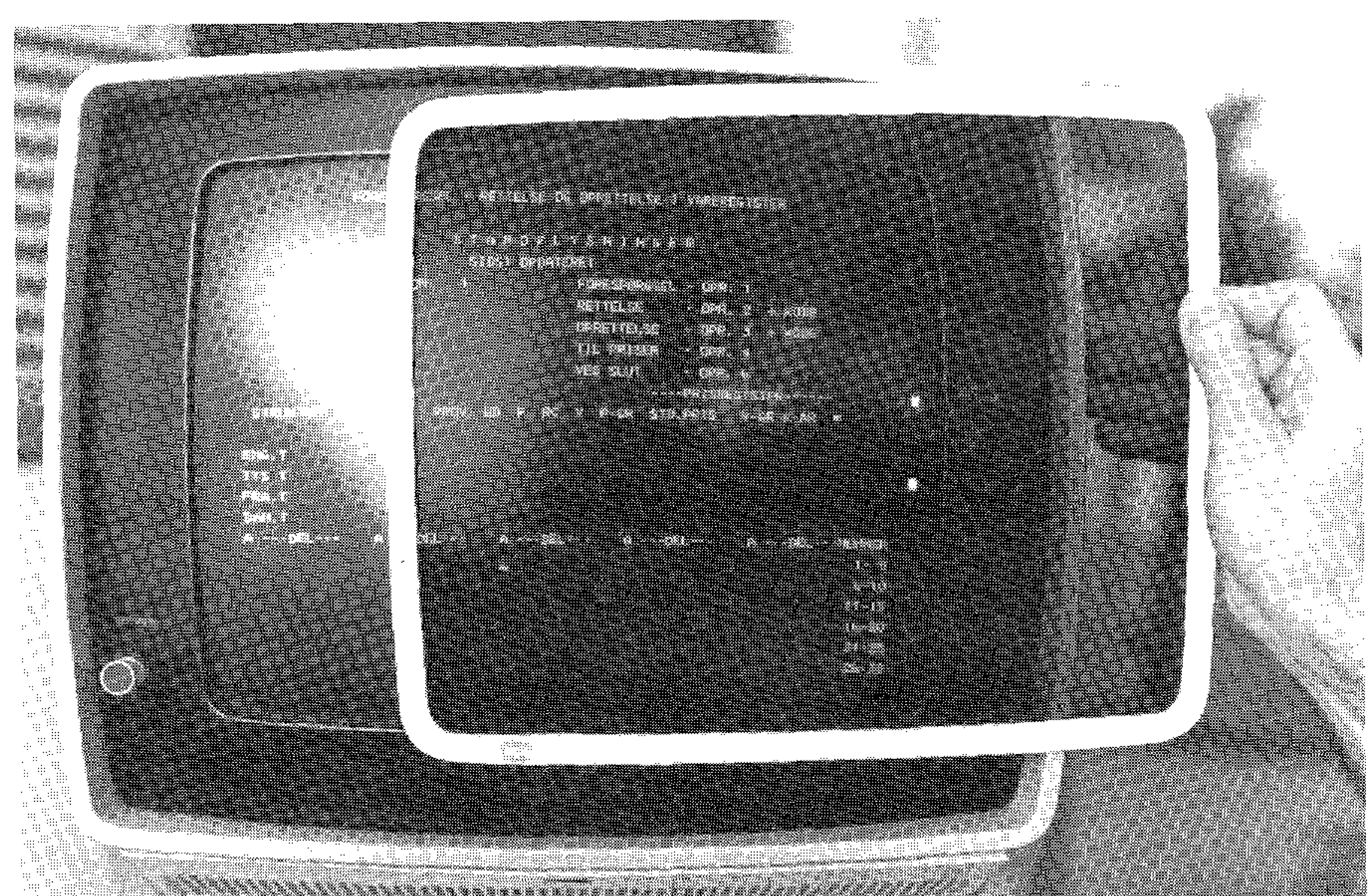

Fig.27. Filter of synthetic fibres enabling some of the reflections on the screen to be absorbed.

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MEASUREMENT REPORT

Type of terminal: ....

Operator: ....

Time spent at screen/day:

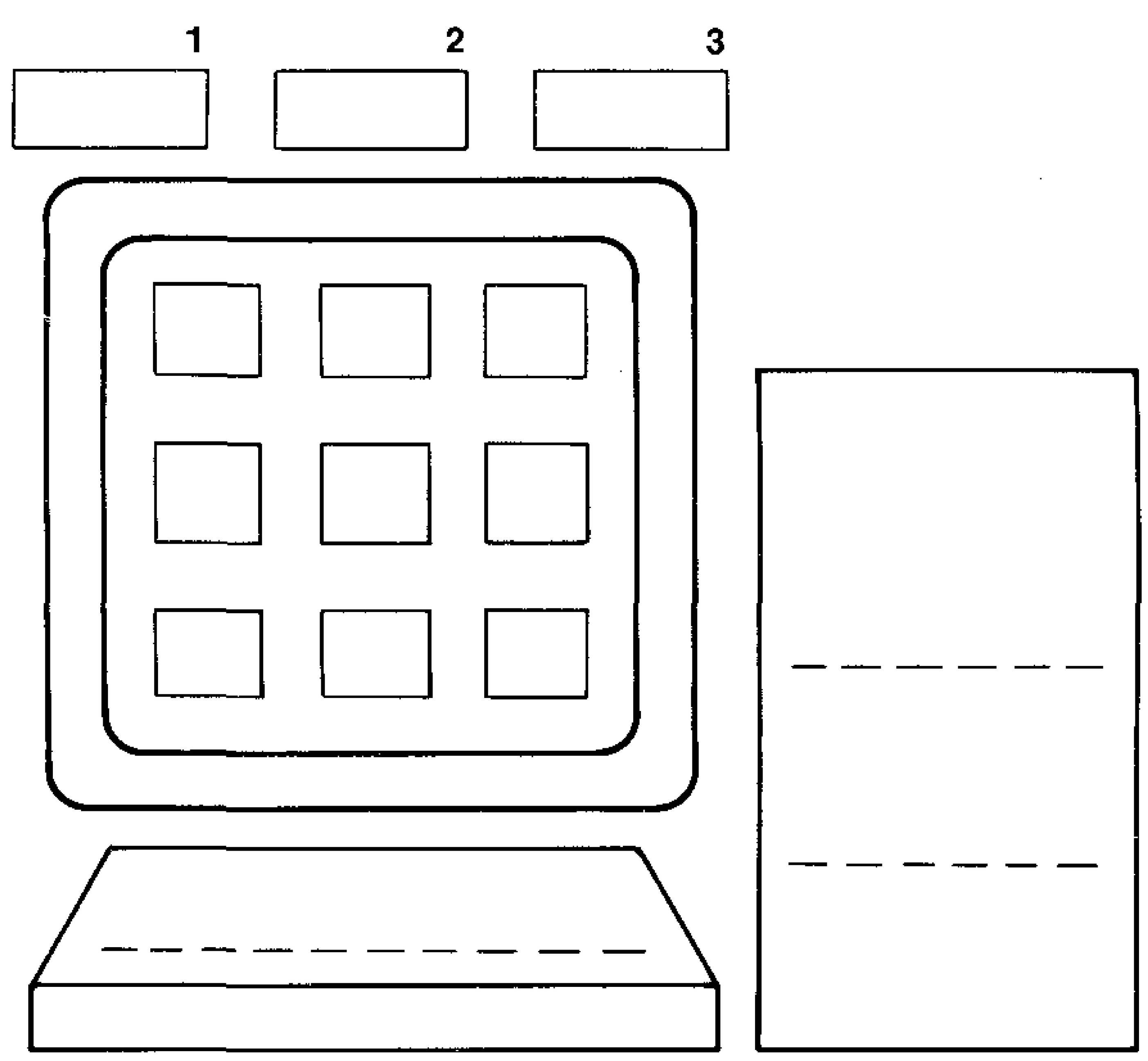
....

Type of work: Interactive: .... ☐

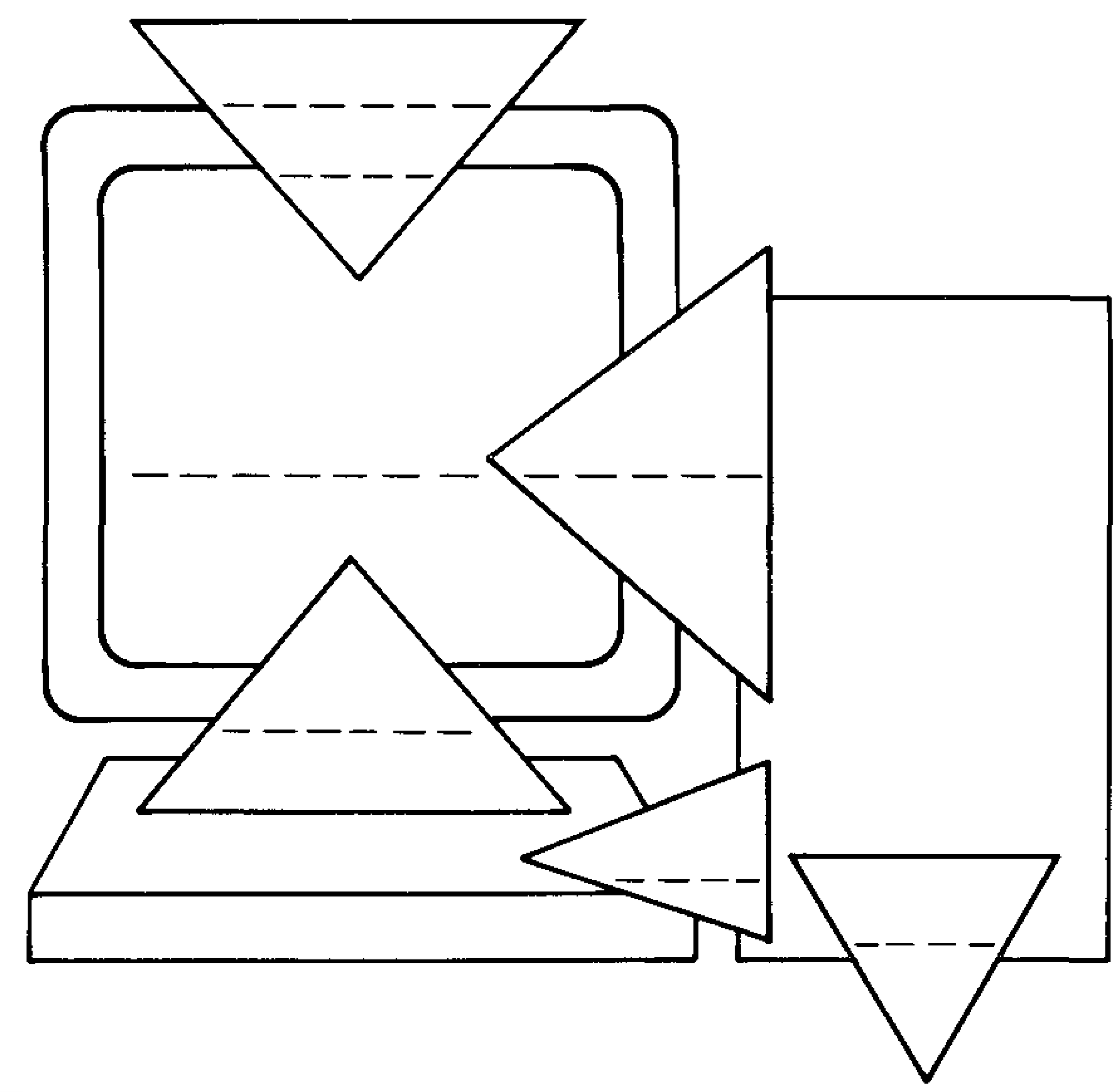
Data entry/reading: .... ☐

other: ....

CONDITIONS OF CONTRAST



LUMINANCE DISTRIBUTION



Sketch of terminal position (incl. windows, lighting)

Screen:

dark: ☐
light: ☐

backgnd. colour: ....
char. colour: ....
veiling reflections: Yes ☐
No ☐

Keyboard:

dark: ☐
light: ☐

veiling reflections: Yes ☐
No ☐

Manuscript:

position ....
localized lighting: ....

General lighting:

....
....

Observations: ....

Date: ....   **Sign.:** ....

840359

1: Self generated character luminance

2: Self generated background luminance   3: Resulting background luminance

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