# International Standard ISO 4854

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## Personal eye-protectors — Optical test methods

*Protecteurs individuels de l'œil — Méthodes d'essai optiques*

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# Foreword

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International Standard ISO 4854 was developed by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment,* and was circulated to the member bodies in July 1978.

It has been approved by the member bodies of the following countries :

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# Personal eye-protectors — Optical test methods

## 1 Scope and field of application

This International Standard specifies the optical test methods for eye-protectors the requirements for which are given in ISO 4849 to ISO 4853.[1)]

The test methods other than optical test methods are given in ISO 4855.

## 2 References

ISO 4849, *Personal eye-protectors — Specifications.*

ISO 4850, *Personal eye-protectors for welding and related techniques — Filters — Utilisation and transmittance requirements.*

ISO 4851, *Personal eye-protectors — Ultraviolet filters — Utilisation and transmittance requirements.*

ISO 4852, *Personal eye-protectors — Infrared filters — Utilisation and transmittance requirements.*

## 3 Test for refractive, astigmatic and prismatic powers

Any method of examining the required area with an accuracy of ± 0,015 $m^{-1}$ may be used. However, the methods described below are given as reference methods for use in cases of dispute.

### 3.1 Testing unmounted oculars

#### 3.1.1 Apparatus

**3.1.1.1 Telescope,** with a magnification of between 7,5 and 20 (recommended magnification 15) with an aperture of 15 to 20 mm and an adjustable eye-piece fitted with a graticule, for example a theodolite which is adjustable both vertically and laterally.

In the event that the telescope, a large-aperture instrument, shows a doubling of the image or other aberration, the ocular to be tested shall be examined with a 5 mm aperture instrument to locate and quantify the area or areas of aberration in the total area of 20 mm diameter. A focometer may be used for this operation.

**3.1.1.2 Adjustable light source,** with condenser.

**3.1.1.3 Target,** consisting of a black plate with the cut-out pattern shown in figure 1. The bars are 2,0 mm wide. The larger annulus depicted inside the bars has a diameter of 23 mm with an annular aperture of 0,6 mm, and the smaller has a diameter of 11 mm. The diameter of the central aperture is 0,6 mm. The target is mounted on a glass plate.

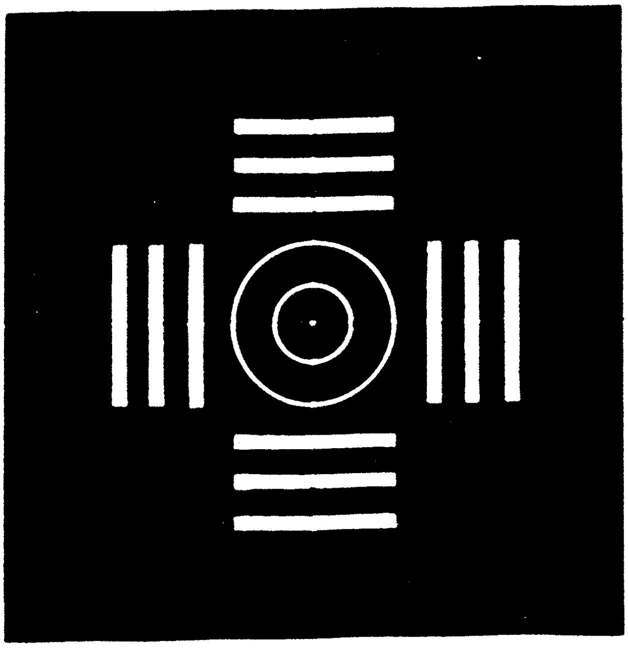


**Figure 1 — Target**

**3.1.1.4 Interference filter,** with λ max. = 555 ± 10 nm and a half-band width of approximately 50 nm.

1) In preparation : ISO 4853, *Personal eye-protectors — Daylight filters, utilisation and transmittance requirements.*

**3.1.1.5 Standard lenses**, with refractive powers of $\pm$ 0,06 $m^{-1}$, $\pm$ 0,12 $m^{-1}$ and $\pm$ 0,25 $m^{-1}$ (tolerance $\pm$ 0,01 $m^{-1}$). Any other method of calibration may be used.

### 3.1.2 Procedure

The target shall be trans-illuminated by means of a parallel beam of monochromatic light of adjustable intensity. The telescope and the optical system of the target shall be on the same axis.

The interference filter is used to reduce chromatic aberration.

The focusing adjustment of the telescope shall be calibrated so that a power of 0,01 $m^{-1}$ can be measured.

The distance between the telescope and the target shall be 4,6 $\pm$ 0,1 m. Focus the graticule and the target and align the telescope to obtain a clear image of the target. This setting shall be regarded as the zero point of the scale of the telescope.

Calibrate the equipment using standard lenses of known refractive powers or any other equivalent method.

Position the ocular normal to the telescope axis. Make measurements at the test points defined in sub-clause 7.1.2.1.1 of ISO 4849.

To determine the refractive power, adjust the telescope until the image of the target is perfectly resolved. Then read the refractive power of the eye-protector from the scale of the telescope.

The astigmatism of the ocular is the maximum refractive power difference between two perpendicular meridians observed during rotation of the ocular axis. Record this maximum difference obtained in resolving the horizontal and vertical bars during rotation as the astigmatism.

To determine the prismatic power, position the ocular to be tested in front of the telescope and, if the point of intersection of the lines of the graticule falls outside the image of the bigger annulus, the prismatic power exceeds 0,25 cm/m. If the permitted limit is 0,12 cm/m, the point of intersection of the lines of the graticule shall fall inside the image of the smaller annulus of the target.

The values obtained for the refractive, astigmatic and prismatic powers shall be within the limits defined in table 2, sub-clause 7.1.2.1.1, of ISO 4849.

Oculars may be also tested with a device using a laser beam. This optional method, allowing the measurement of small refractive and astigmatic powers, is described in annex A.

## 3.2 Control methods for mounted oculars

### 3.2.1 Apparatus

**3.2.1.1 Standard support for spectacles**, constructed in metal or other rigid material according to figure 2, to reproduce the position of the spectacles in front of the eyes of the wearer. Protectors without side pieces shall be positioned on the support as they are normally placed before the eyes when worn.

**3.2.1.2 Two telescopes**, similar to the one described in 3.1.1.1, fitted with 6 mm diameter circular diaphragms and fixed with 2 axes 66 mm apart and parallel to within 1′.

A single telescope may also be used which can be displaced, its axis remaining parallel to within 1′ of its original direction; alternatively, the protector may be displaced relative to the single telescope and target, these remaining fixed. The distance between ocular and telescope shall be reduced to a minimum.

In the event that the telescope, a large-aperture instrument, shows a doubling of the image or other aberration, the ocular to be tested shall be examined with a 5 mm aperture instrument to locate and quantify the area or areas of aberration in the total area of 20 mm diameter. A focometer may be used for this operation.

**3.2.1.3 Double target**, conforming to the design shown in figure 3, or **single target**, as the case may be, on which the reading is made. The target is brightly illuminated and placed 4,6 $\pm$ 0,1 m from the telescope(s).

### 3.2.2 Procedure

Place the protector to be tested on the support (3.2.1.1). Using both telescopes, one for each ocular in the case of spectacles (the arms of those must be horizontal) and two-piece goggles, or at each visual centre in the case of face-shields and one-piece goggles, measure the horizontal and vertical prismatic powers by counting the number of circles across which the vertical and horizontal cross-wires of the graticule are displaced and by interpolating between two circles if necessary. Since each circle represents 0,05 cm/m, the reading may be made to the nearest $\pm$ 0,025 cm/m.

Deviations measured for each ocular or each visual centre are added when they are in opposite directions and subtracted when they are in the same direction.

Measure the refractive power for each ocular or each visual centre by opening the telescope diaphragm to 20 mm. Determine the astigmatism by the difference of refractive powers measured by resolving 2 circular arcs on the target. Spherical effect is the average of refractive powers measured by resolving 2 circular arcs on the target.

In this way a value for the horizontal prismatic power and a value for the vertical prismatic power are obtained, as well as values for the spherical effect and astigmatism. These values shall be within the limits defined in table 3 of sub-clause 7.1.2.1.2 of ISO 4849.

Two other optional methods for prismatic power measurement are presented in annexes B and C.

Dimensions in millimetres

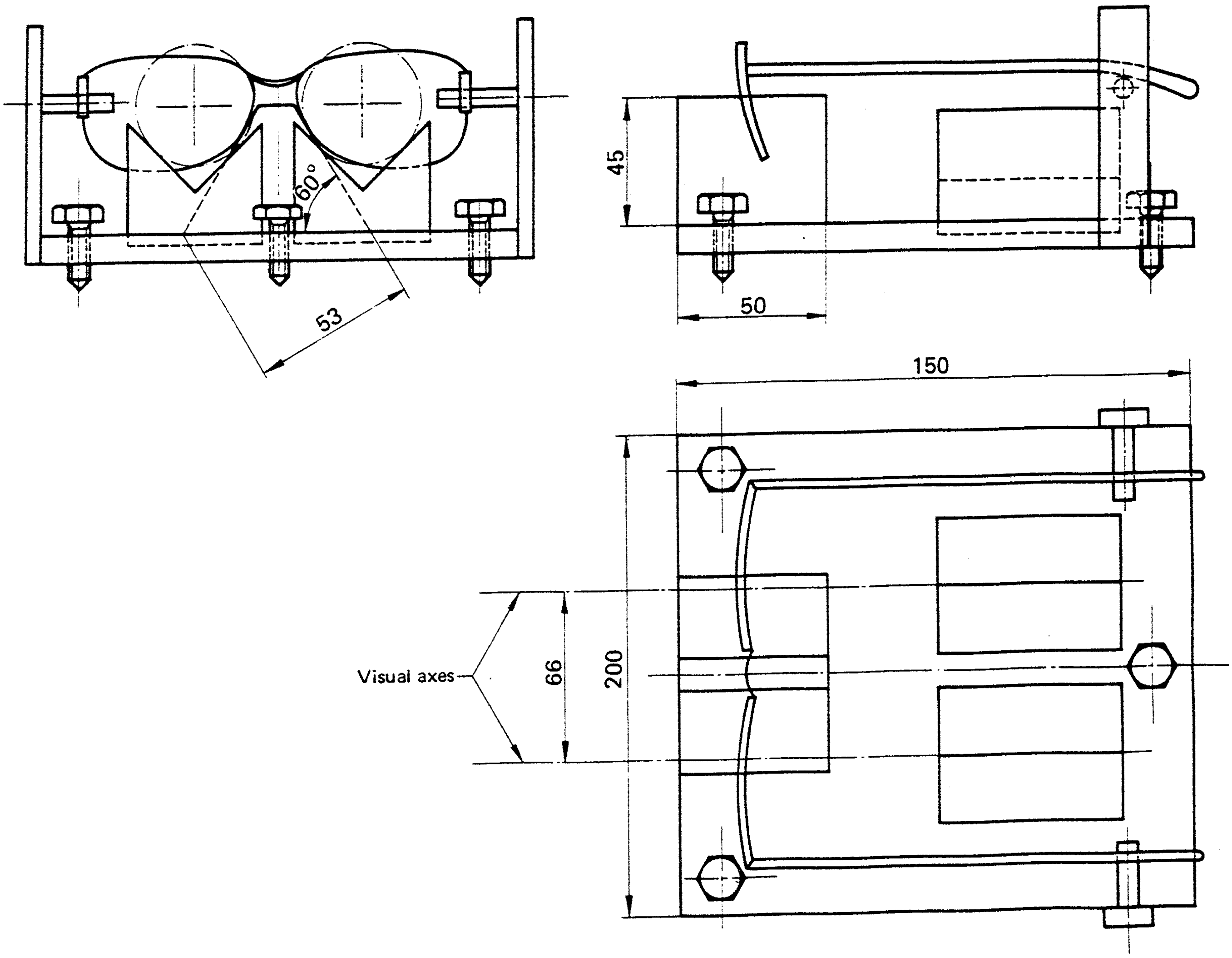



Figure 2 — Standard support for spectacles

Dimensions in millimetres

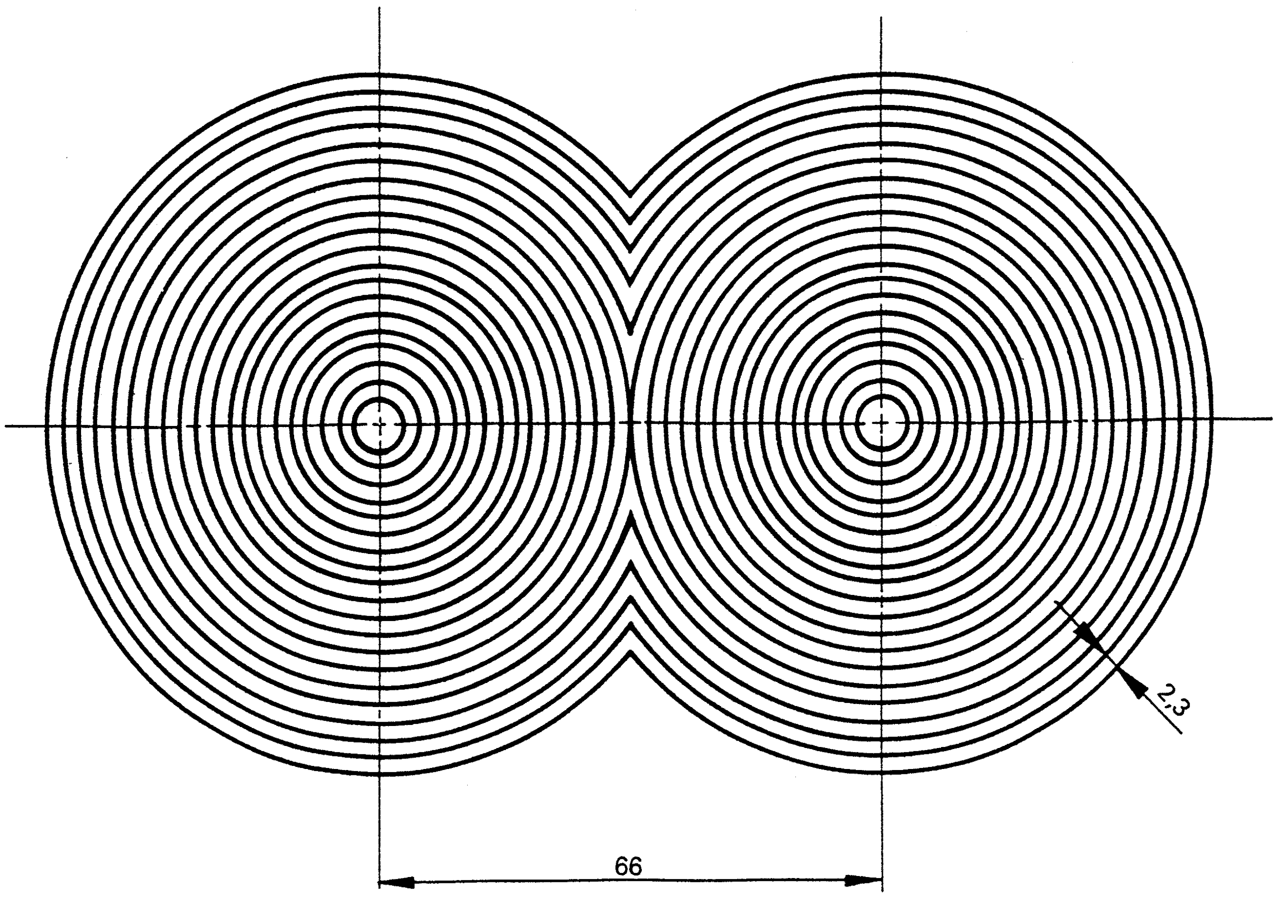



Figure 3 — Double target

## 4 Diffusion test

The test method described in 4.3 is given as a reference method. Alternative methods for filters having a transmittance value ($\tau_v$) in excess of 10 % may be used, as for example a hazemeter or visual inspection, provided that correlation has been established for the material under test.

### 4.1 Basic notions

#### 4.1.1 Reduced luminance factor

The degree of diffusion of light produced by a filter is proportional to the illuminance $E$. Luminance is a measure of the diffusion of light by the filter, and the value $L_s$ is proportional to the illuminance $E$ of the filter. The proportionality factor is the luminance factor $l = L_s/E$, which is expressed in candelas per lux per square metre [cd · m$^{-2}$ . lx$^{-1}$]. To obtain a factor $l^*$ which does not depend upon the transparency of the filter, the luminance factor is divided by $\tau$, thus producing :

$$l^* = \frac{l}{\tau} = \frac{L_s}{E\tau}$$

This quantity is known as the reduced luminance factor and is expressed in the same units as luminance factor.

NOTE — Variation of diffusion with observation direction : Most oculars have diffusion properties which are symmetrical about the optical axis. For these oculars, the mean value of the reduced luminance factor is constant within an angle limited by the two cones shown in figure 4. This mean value depends upon values $\alpha$ and $\Delta\alpha$.

#### 4.1.2 Fluorescence

The luminance factor also includes fluorescent light caused by any ultraviolet radiation; therefore, the spectral distribution of the source used during measurement shall be similar to that of the source to which the filter is exposed in practice.

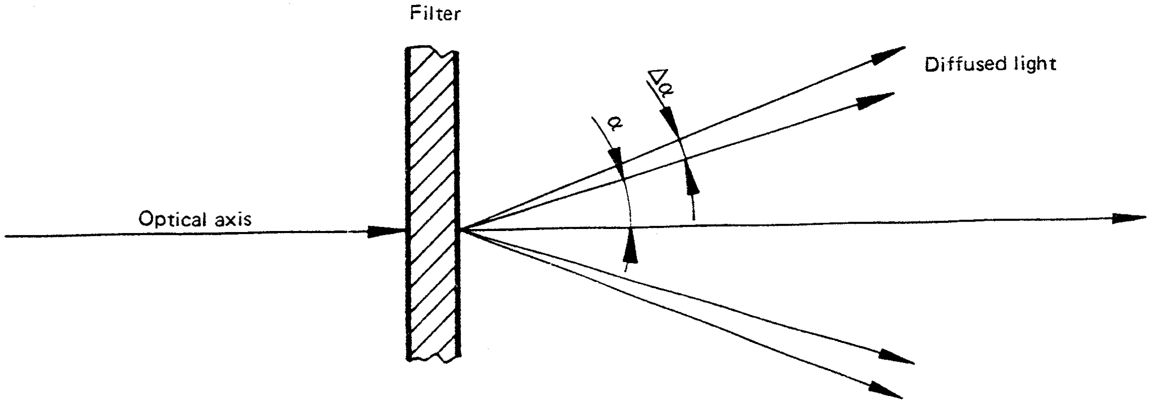



**Figure 4 — Variation of diffusion with observation direction**

## 4.2 Apparatus

Figure 5 illustrates the assembly of the apparatus.

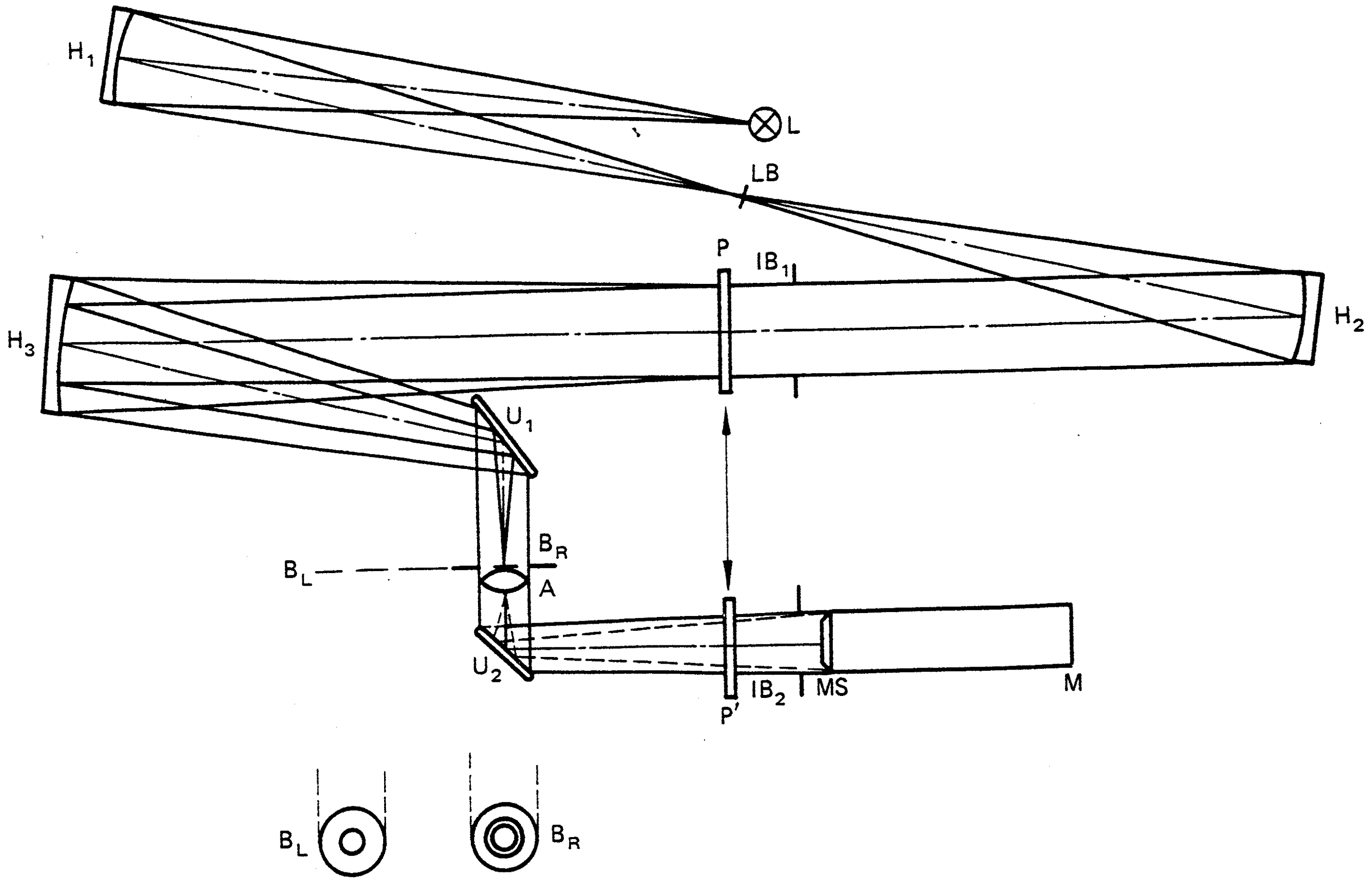



**Figure 5 — Assembly of apparatus for diffusion test**

| | |
|---|---|
| L | Very pure silica-glass high-pressure xenon lamp (for example XBO 150 W – 4 or CS X 150 W – 4) |
| $H_1$ | Spherical concave mirror : focal length 150 mm; diameter 40 mm |
| $H_2$ | Spherical concave mirror : focal length 300 mm; diameter 40 mm |
| $H_3$ | Spherical concave mirror : focal length 300 mm; diameter 70 mm |
| A | Achromatic lens : focal length 200 mm; diameter 30 mm |
| $U_1$, $U_2$ | Flat mirrors |
| $B_R$ | Annular diaphragm : diameter of outer circle 21,00 mm; diameter of inner circle 15,75 mm |
| $B_L$ | Circular diaphragm : diameter of aperture 7,5 mm |
| M | Photomultiplier corrected according to curve V ($\lambda$) with diffusing screen MS |
| $IB_1$ | Iris-diaphragm to adjust diameter of field of observation |
| $IB_2$ | Iris-diaphragm to eliminate edge effects from $IB_1$ |
| LB | Circular diaphragm, diameter of aperture 0,4 mm |
| P, P' | Positions of test sample |

Spherical mirror $H_1$ forms an image of light source L at diaphragm LB of the same dimensions as L. The concave mirror $H_3$ forms an image of diaphragm LB in the plane of diaphragms $B_L$ and $B_R$. The achromatic lens A is positioned immediately behind the diaphragm so that a reduced image of the test sample in position P appears on diffusing screen MS. The image of iris-diaphragm $IB_1$ is simultaneously formed on $IB_2$.

This assembly collects all the light originating from the filter between angles $\alpha = 1{,}5°$ and $\alpha + \Delta\alpha = 2°$ in relation to the optical axis. The angular area is important in the case of welding, where a point in the immediate proximity of the weld spot has to be observed. It is, however, possible to measure scattered light in other angular areas if use is made of an annular diaphragm with suitably modified dimensions.

### 4.3 Procedure

Test oculars shall meet the optical requirements of sub-clause 7.1.2.1 of ISO 4849.

Position the test sample in the beam parallel to position P, then set diaphragm $B_L$ in place. The flux $\Phi_{1L}$ falling onto the photomultiplier corresponds to the undiffused light transmitted by the sample and is in proportion to $E\tau$. Then replace diaphragm $B_L$ by annular diaphragm $B_R$; flux $\Phi_{1R}$ falling onto the photomultiplier corresponds to the total diffused light originating from the filter and from the apparatus. Then arrange the test sample at position P'. Flux $\Phi_{2R}$ falling onto the photomultiplier corresponds to the diffused light coming from the apparatus only.

Difference $\Phi_{1R} - \Phi_{2R}$ is a measure of the light diffused by the filter, and is proportional to $\omega L_s$. The proportionality factor is the same in both cases. The reduced mean luminance factor $l^*_m$ for the solid angle $\omega$ is calculated from the preceding fluxes by means of the formula :

$$l^*_m = \frac{1}{\omega} \times \frac{\Phi_{1R} - \Phi_{2R}}{\Phi_{1L}}$$

where

$\Phi_{1R}$, $\Phi_{2R}$ are the luminous fluxes with the annular diaphragm;

$\Phi_{1L}$ is the luminous flux with the circular diaphragm;

$\omega$ is the solid angle defined by the annular diaphragm.

## 5 Test for quality of material and surface

The apparatus (recommended means of examination) used for this test is shown in figure 6.

The brightness of the lamp shall be related to the optical density of the filter. This subjective examination requires experience and is made at the limit "clear-dark" and without optical magnifying means.

Dimensions in millimetres

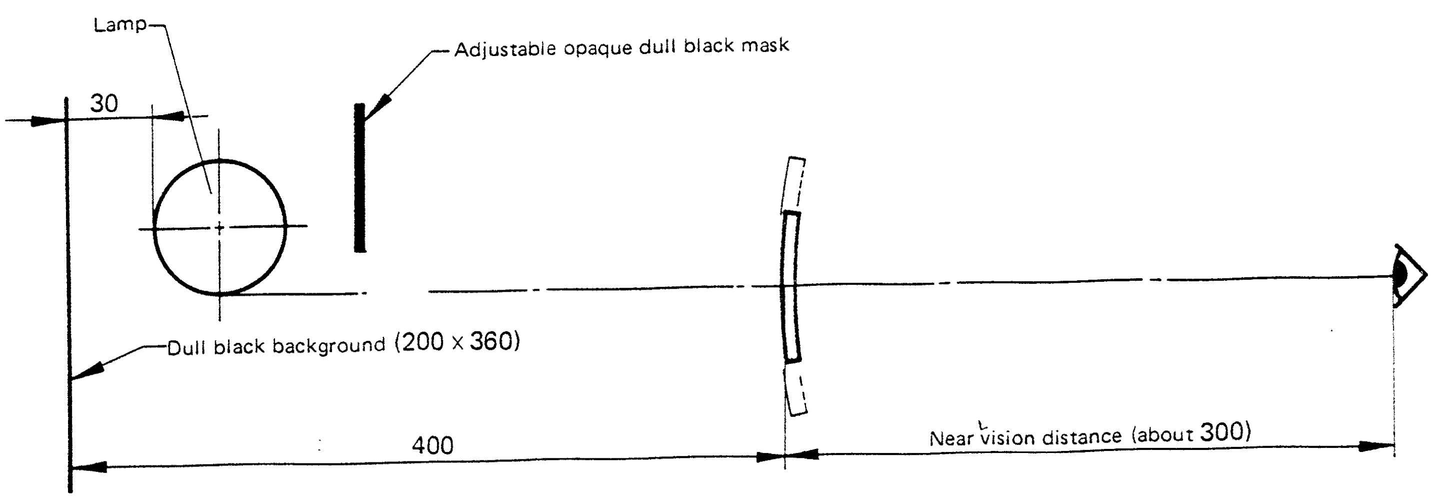



**Figure 6 — Apparatus for test for quality of material and surface**

## 6 Determination of transmittance

Transmittance shall always be measured with incident light falling normally on the test ocular. Light sources, filters and specifications for measurements and calculations are given in table 1.

**Table 1**

| Type of oculars or filters | Sources for measurement of luminous transmittance | Specifications relating to measurements in the infrared spectrum |
|---|---|---|
| Oculars without filter action | CIE Source A, 2856 K | No specification |
| Welding filters | CIE Source A, 2856 K | Mean values of spectral transmittance in near infrared from 780 to 1 300 nm and in mid infrared from 1 300 to 2 000 nm |
| UV filters | CIE Source A, 2856 K | No specification |
| IR filters | CIE Source P, 1900 K | See welding filters |
| Filters for daylight | CIE Source C, 6774 K | Values are calculated by using the spectral distribution of solar radiation energy in the infrared spectrum<br>Approximate values can be obtained by using CIE Source A and a neutral detector in combination with the filters mentioned in ISO 4853 |

Table 2 gives errors inherent in measuring methods, i.e. relative uncertainty of these methods, in relation to the measured transmittance.

**Table 2**

| Transmittance value, % from | to | Relative uncertainty % |
|---|---|---|
| 100 | 17,9 | 5 |
| 17,9 | 8,5 | 10 |
| 8,5 | 0,44 | 10 |
| 0,44 | 0,023 | 15 |
| 0,023 | 0,001 2 | 20 |
| 0,001 2 | 0,000 023 | 30 |
| Reduced luminance factor | | 25 |

## 7 Measurement of colour

Filter colour is characterized by trichromatic co-ordinate values determined in accordance with the methods detailed in CIE standards, using the trichromatic components of a light source. The light sources to be used are specified in table 1.

# Annex A

## Testing of unmounted oculars Method for measuring small refractive and astigmatic powers over small areas

The following method permits the measurement of small refractive and astigmatic powers. The deflection of a parallel light beam of 5 mm diameter (eye-pupil diameter) is observed directly by a photodiode. Whereas the telescope gives a mean value of quantities corresponding to refractive properties over large areas, this method permits the assessment of these quantities in small areas. The resolution is better than $10^{-5}\ m^{-1}$.

### A.1 Introduction

The quantities corresponding to refractive properties of protective filters must not exceed certain maximum values and it is necessary to measure the refractive, astigmatic and prismatic powers of the filters.

In clause 3, the refractive quantities are measured by a method in which a test pattern is observed through a telescope. When a test ocular having refractive properties is placed in the beam, the image becomes unclear and the telescope has to be adjusted. The adjustment is a non-linear function of the refractive power of the test sample.

A disadvantage of this method is that the mean value of refractive quantities over a large area of the filter is measured, which means that the test sample may meet the requirements as far as the mean value of the measured area is concerned even though the refractive quantities at individual points exceed the permitted maximum value. Moreover, such filters produce an unclear image and, therefore, render the adjustment of the test pattern difficult. To avoid these disadvantages, a method has been developed by which the refractive quantities of oculars can be measured in areas corresponding to the size of the pupil of the human eye.

The following pages describe the measuring system and the experimental mounting, and give details of the measured results, which are compared with those obtained by the telescope method.

### A.2 Measuring system

The determination of the refractive quantities by the telescope method presupposes these quantities to be constant over the field of vision of the telescope of 20 mm diameter. By adjusting the telescope, the image becomes clear. The refractive powers of telescope ($1/f_F$) and test ocular ($1/f_P$) are added together, and the image distance $b$ at fixed object distance $g$, is related to the refractive power in accordance with the formula

$$\frac{1}{b} = \frac{1}{f_F} + \frac{1}{f_P} - \frac{1}{g} \qquad \ldots(1)$$

Since in that method the area for which the mean value is determined is larger than the homogeneous area of many filters as regards the refractive power, it was necessary to develop a method permitting the measurement of the refractive power of small areas corresponding to the pupillary diameter.

The following principle has to be taken into account (figure 7) : if two parallel rays, 1 and 2, pass through the test ocular at different points, they meet in the focal plane at a distance $f$ from the test ocular. Its refractive power is then $1/f$. In the case of a test ocular having different curvatures in two mutually perpendicular directions, or when light falls obliquely on a spherical surface, astigmatic power will result which is equal to the difference between the refractive powers in the two main directions. If, in addition to this, the central ray 1 is deflected by an angle $\delta$ the test ocular will have, besides its refractive power, a prismatic power $\Delta$ :

$$\Delta = 100 \text{ tg } \delta \qquad \ldots(2)$$

When mounting the ocular for test, care shall be taken to ensure that the optical centre corresponds with the visual centre, otherwise unwanted prismatic effect will result.

If the deflection of the light ray is measured in one plane at a distance $w$ from the ocular, the following formula applies for the refractive power according to the geometrical conditions shown in figure 7 :

$$\frac{1}{f} = \frac{u - v}{u \times w} \qquad \ldots(3)$$

where

$u$ is the distance between the two parallel rays 1 and 2 in front of the test sample;

$v$ is the distance between the points of the refracted rays in the measuring plane (figure 7).

For the prismatic power, the following formula applies :

$$\Delta = 100 \frac{v_0}{w} \qquad \ldots(4)$$

The astigmatic power is equal to the difference between the refractive powers in the two principal directions.

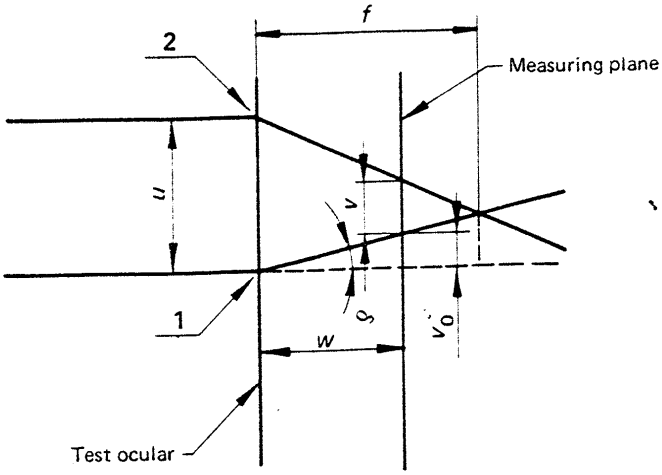



Figure 7 — Determination of the distance $f$ of the focal plane from the test ocular by means of two parallel rays 1 and 2

$u$ = distance between the parallel rays 1 and 2;

$v$ = distance between the refracted rays 1 and 2 in the measuring plane;

$w$ = distance between the test ocular and measuring plane;

$\delta$ = angle of deflection of the central ray 1;

$v_0$ = deflection of the central ray from the optical axis in the measuring plane.

## A.3 Experimental mounting

The measuring device is composed of the following main elements (see figure 8) :

a) a laser supplying a parallel light beam as narrow as possible;

b) a carriage moving the test sample support on a spiral path;

c) a position-sensing photodiode, the photocurrent of which is recorded on an XY-recorder.

The light source is a He-Ne laser of adequate performance (2 mW), supplying monochromatic continuous light.

Two lenses with a diaphragm at the common focal point enlarge the laser beam to a diameter of 5 mm, to match the mean size of the eye pupil. This arrangement also provides a homogeneously illuminated spot.

The carriage moves the test ocular continuously on a spiral path in a plane perpendicular to the direction of the laser beam. During the measurement, the test ocular shall not turn in relation to the photodiode, so that the light is directed in a fixed direction.

To achieve this, the carriage runs on two guides perpendicular to each other, maintaining the directions of the axes of the carriage and the test ocular constant during the measurement. A pivot guided by a spiral transmits the corresponding movement to the carriage (see figure 8).

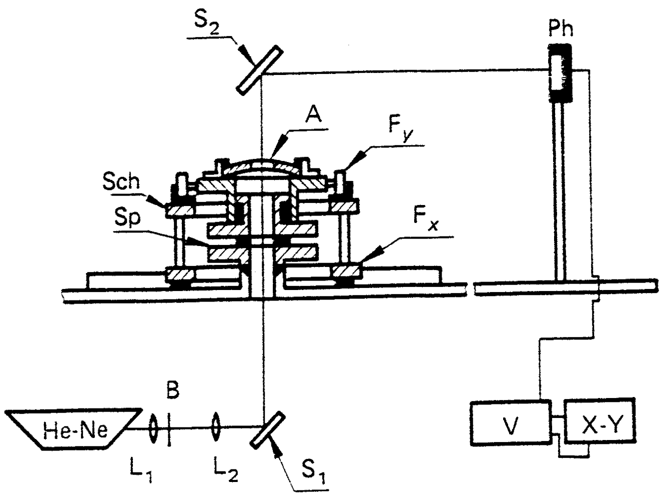



Figure 8 — Experimental mounting for measuring small refractive and astigmatic powers

He-Ne = He-Ne laser

$L_1$, $L_2$ = lenses

B = 20 µm diaphragm

$S_1$, $S_2$ = deflection mirrors

Sp = spiral

Sch = carriage

$F_x$, $F_y$ = guiding in $x$ and $y$ directions

A = test sample

Ph = photodetector

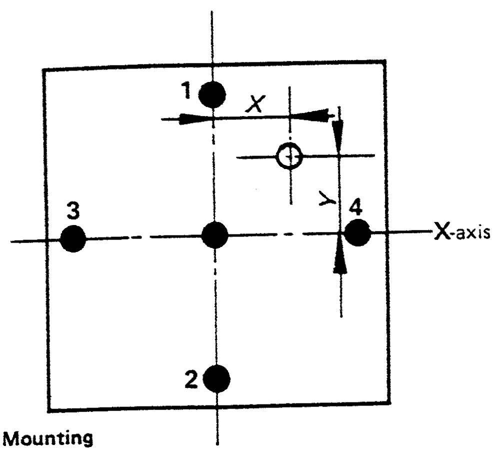
V = pre-amplifier

X-Y = XY recorder

The pitch of the spiral is 1,08 mm. The 5 mm diameter laser beam continuously scans the whole surface of the test ocular. By appropriate markings, the position of the light beam on the filter and its deflection can be noted simultaneously.

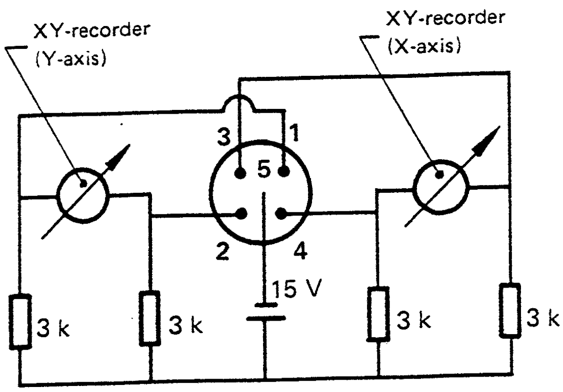
The deflection of the laser beam is recorded by a position-sensing photodiode (see figure 9). On this photodiode (PIN SC-25) a rectangular system of co-ordinates is established by the five connections. When the centre, 5, is illuminated, the photocurrent of the remaining four connections is equal. When the light spot is moved over the sensitive surface, the photocurrent of connections 1 to 4 changes according to the position of the light spot in relation to the centre. The photocurrent of connection 5 remains constant and is directly proportional to the radiant flux.

Because of the variation of the photocurrent between the connections, the potential difference between the connections of one axis is proportional to the displacement on this axis (see figure 9) as well as to the radiant flux.




a) Mounting

• = electrical connections from 1 to 5




b) Connections

**Figure 9 — Position-sensing photodiode**

The radiation receiver has an active sensitive surface of 1,9 cm × 1,9 cm. In this experimental mounting, it can be positioned at distances between 50 and 250 cm from the test ocular as required, so that, at a scanned area of 30 mm diameter, a refractive quantity up to a maximum of 2 $m^{-1}$ can be measured. The sensitivity of this experimental mounting corresponds to approximately $10^{-5}$ $m^{-1}$.

## A.4 Measurements

### A.4.1 Interpretation of various measuring results

When making measurements, the test ocular is scanned on a spiral path. The undeflected laser beam always points to the centre of the photodiode and only the test ocular is moved. This allows the distance $(u - v)$ (equation 3) to be measured directly in the plane of the receiver.[1)]

Since directions X and Y are read in an equivalent way by the photoelectric cell and by the recorder, the spiral path, depending on the refractive quantity of the test ocular, is presented on the recorder either enlarged or reduced.

With a plane test ocular, the direction of the light beam is independent of its position on the test ocular, because it does not change when passing through the test ocular. As a first approximation, the image on the recorder is, therefore, a point. With a curved test ocular without refractive power, i.e. a meniscus, the point may be slightly broadened because of deflection of the light within the ocular.

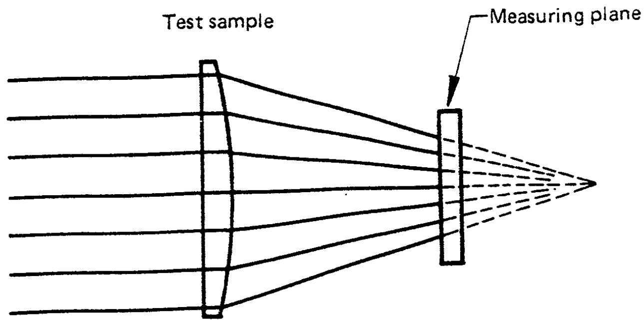



**Figure 10 — Diagrammatic view of image in the measuring plane**

An ocular with uniform refractive power (lens) may be assumed to have the same focal length in all zones. Therefore, the scanning path is reproduced either reduced or enlarged depending

1) In the measuring plane, this corresponds to the distance between the deflections of the central ray 1 and 2 (see figure 7).

on the refractive power (see figure 10), without changing its form. The spiral scanning path is drawn also on the recorder as a spiral with constant distance between adjacent lines [see figure 11 a)].

Oculars that have astigmatism, i.e. different focal lengths in different axial directions, record a similar curve. Since the dimensions of the curve depend on the refractive power, the distance from one line to the next is different for various axial directions and the spiral is, therefore, distorted.

If, for example, the minimum and maximum values of the focal length are in two axial directions perpendicular to each other, the circular spiral becomes an elliptical spiral [see figure 11 b)].

With test oculars producing variable change of focal length, the spiral path is distorted [see figure 11 c)]. From this distorted spiral, a full analysis of the refractive powers at all points on the surface of the ocular may be obtained.

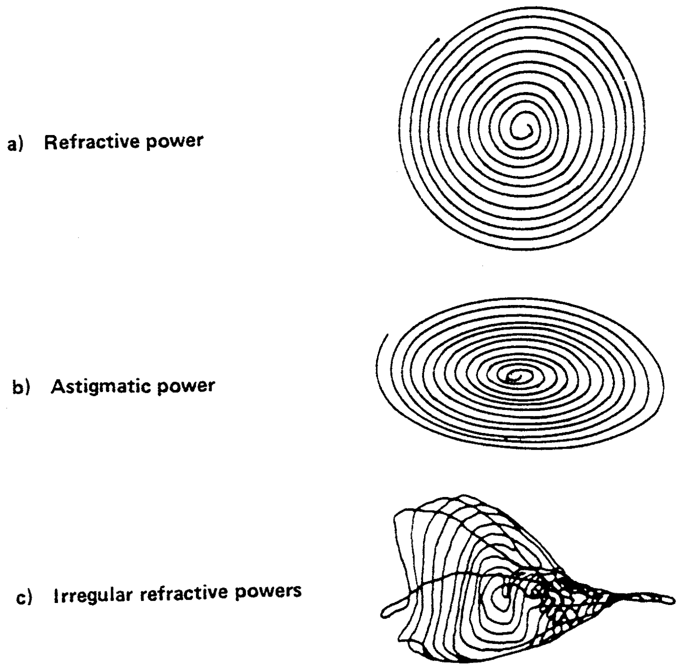



**Figure 11 — Measuring curves for oculars with different refractive properties**

### A.4.2 Calibration

As indicated in clause A.3, the photocurrent of the receiver is linearly dependent on the deflection of the light spot from the electrical centre as well as on its intensity. However, for the determination of refractive quantities, only the deflection is of any interest, and for this reason it is necessary to eliminate the factor of intensity.

The best method of calibration is to measure the photocurrent of the receiver at connection 5 and to allow for this in calculation. With test oculars having a high optical density, this method is somewhat inexact because the small photocurrent generated may be similar to the size of the signal produced when there is no light input.

With a wedge-shaped test piece of a determined prismatic power, the experimental mounting can be calibrated for any filter. If first the refractive power of the wedge-shaped piece with the test ocular as filter in front of the receiver, and then the refractive power of the test ocular with the wedge-shaped piece directly in front of the receiver, are measured, there is the same radiant flux for both measurements.

A 2 mW laser at a transmittance of $10^{-4}$ is suitable for measuring refractive powers down to 0,06 $m^{-1}$.

### A.4.3 Comparison with the telescope method

For a test ocular with spherical effect, the determination of the refractive power by the telescope method is as simple as the method described above, since a clear image of the test pattern [see figure 12 a)] can be obtained and the image distance $b$ can be determined precisely.

It is more difficult to measure test oculars with astigmatism effect in different axial directions [see figure 12 b) and c)], since the adjustment of the test pattern for the two extreme focal distances of the test ocular may depend on the observer and the adjustment of the ocular in relation to the optical axis of the experimental mounting.

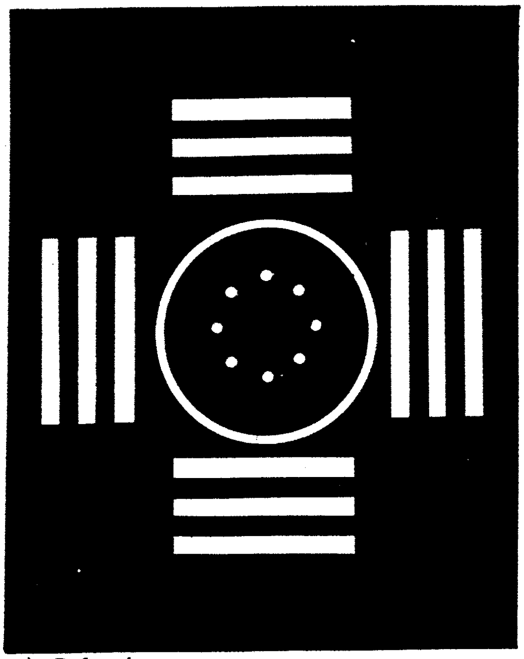
When testing oculars having any variation of the focal length, it is almost impossible to obtain a really clear image [see figure 12 d)]. In such cases the refractive power cannot be determined precisely, and the results for large areas obtained by the telescope method are meaningless.

## A.5 Conclusion

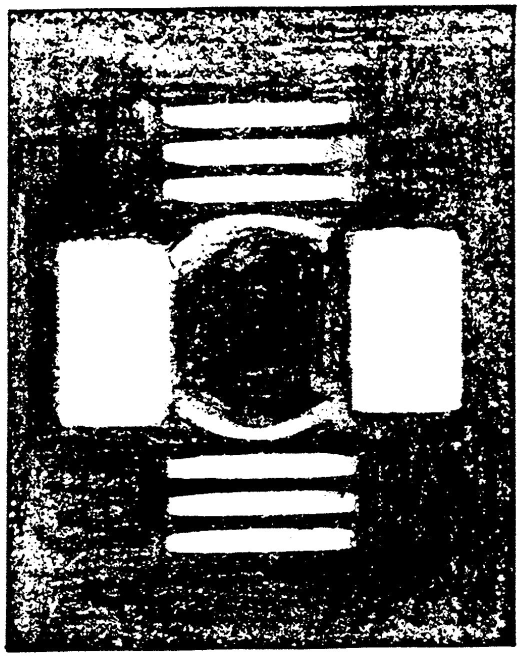
As compared with the telescope method, this method has the advantage that the refractive quantities of very small areas can be determined. Thus, the irregular refractive power of certain oculars which, by the telescope method can only be recorded as a mean value, can be determined exactly.

The determination of the power of an ocular by this method is not dependent on the person carrying out the measurements, as the beam deflection used in the calculation is detected electrically by a photodiode.

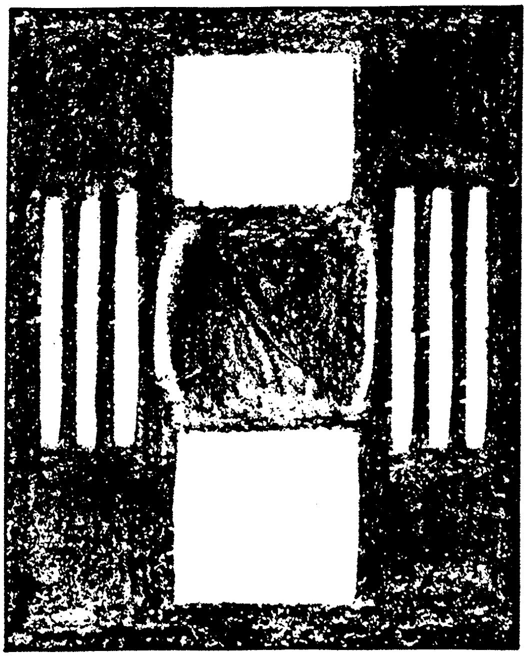
The new apparatus has an indication sensitivity of about $10^{-5}$ $m^{-1}$; and consequently it is better than the vertex refractometer by which refractive powers up to 0,1 $m^{-1}$ can be measured.



a) Refractive power



c) Astigmatic power



b) Astigmatic power

d) Irregular refractive powers

Figure 12 — Images of test patterns with the telescope method, obtained as results of measurements of filters with different refractive properties

# Annex B

## Control method for mounted oculars

## Test method for determination of the prismatic effect (Optional method A)

### B.1 Apparatus

The experimental mounting is as shown in figure 13.

Dimensions in millimetres

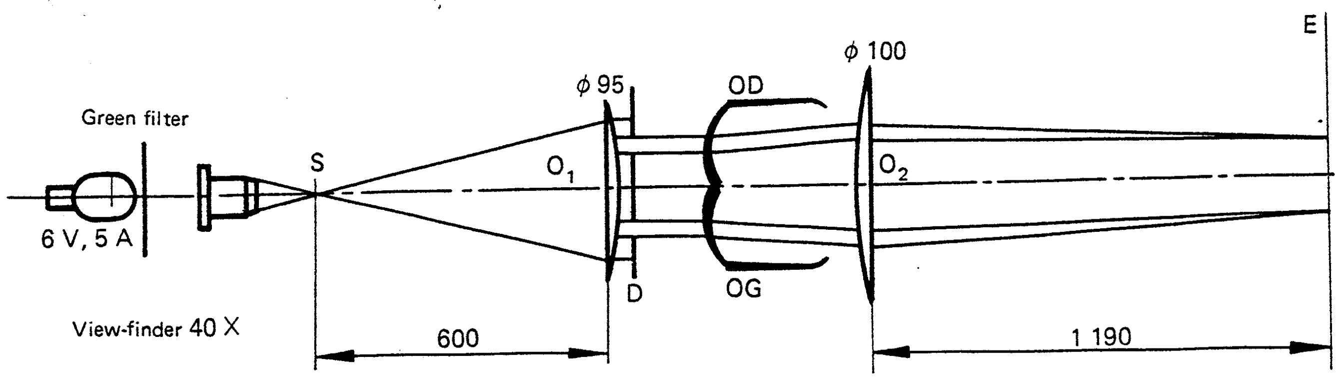



**Figure 13 — Experimental mounting for optional method A**

### B.2 Procedure

Image S of the 6 V, 5 A lamp filament formed by the 40 X microscope objective is used as a point source. S is at the focus of the lens $O_1$. With no spectacles in position, image S becomes S′, on screen E. Diaphragm D, pierced with two 5 mm diameter holes the centres of which are 66 mm apart, allows two parallel beams of light to pass through, these falling onto the spectacle oculars OD and OG.

Prismatic error of spectacles will result in the image of S no longer being formed at S′, but at other positions such as $I_d$ and $I_g$ corresponding to oculars OD and OG.

### B.3 Assessment of results

For the spectacles to be deemed satisfactory, both images $I_d$ and $I_g$ shall fall within the rectangle of tolerances (see figure 14).

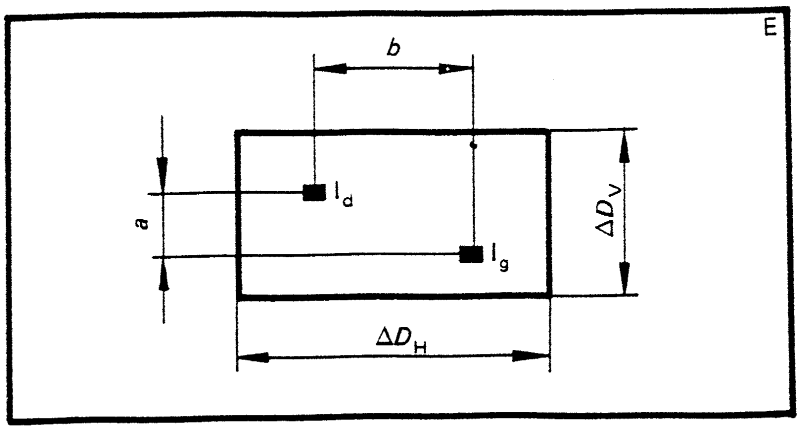



**Figure 14 — Rectangle of tolerances**

The sides of the rectangle have measurements corresponding to the tolerances adopted for the deviations, i.e. vertical $\Delta D_V$, and horizontal $\Delta D_H$, and the focal length of $O_2$. If

$F$ is the focal length of $O_2$, in millimetres,

$\Delta D_V$ is the vertical prismatic tolerance, in centimetres per metre, and

$\Delta D_H$ is the horizontal prismatic tolerance in centimetres per metre,

then $a_{mm} = F \dfrac{\Delta D_V}{100}$ and $b_{mm} = F \dfrac{\Delta D_H}{100}$

It will also be necessary to take into account the dimensions of the images $I_d$ and $I_g$, which are not negligible. Monochromatic light is used to avoid chromatic dispersion of the lenses, thus giving well-defined images $I_d$ and $I_g$.

This method is carried out in the same manner when the spectacles are replaced by a goggle or a shield.

# Annex C

## Control method for mounted oculars

## Test method for determination of the prismatic effect (Optional method B)

### C.1 Apparatus

The experimental mounting is as shown in figure 15, where

$L_a$ = lamp 6 V, 5 A, adjustable

J = interference filter, $\lambda$ max. = 555 ± 20 nm

$L_1$ = condenser

$LB_1$ = diaphragm with 5 mm diameter hole

P = eye-protector being tested

$LB_2$ = diaphragm as per detail A

$L_2$ = lens of 1 000 mm focal length and 75 mm diameter

B = focal plane

### C.2 Procedure

The eye-protector is placed at a distance of 2 m from the focal plane B in front of the lens $L_2$ in such a way that the eye-protector axis is parallel to the optical axis of the experimental mounting. In the case of spectacles with adjustable inclination, a value of 15° is set. The diaphragm $LB_1$ is adjusted in such a way that its image on focal plane B does not include the eye-protector (P).

After placing the eye-protector into the path of the rays, the vertical and the horizontal distances of the two shifted images are determined. Half the distance, in centimetres, is the prismatic effect, in centimetres per metre.

### C.3 Assessment of results

Results are considered satisfactory if the values of prismatic effect determined in accordance with clause C.2 do not exceed the values specified in table 2 of ISO 4849.

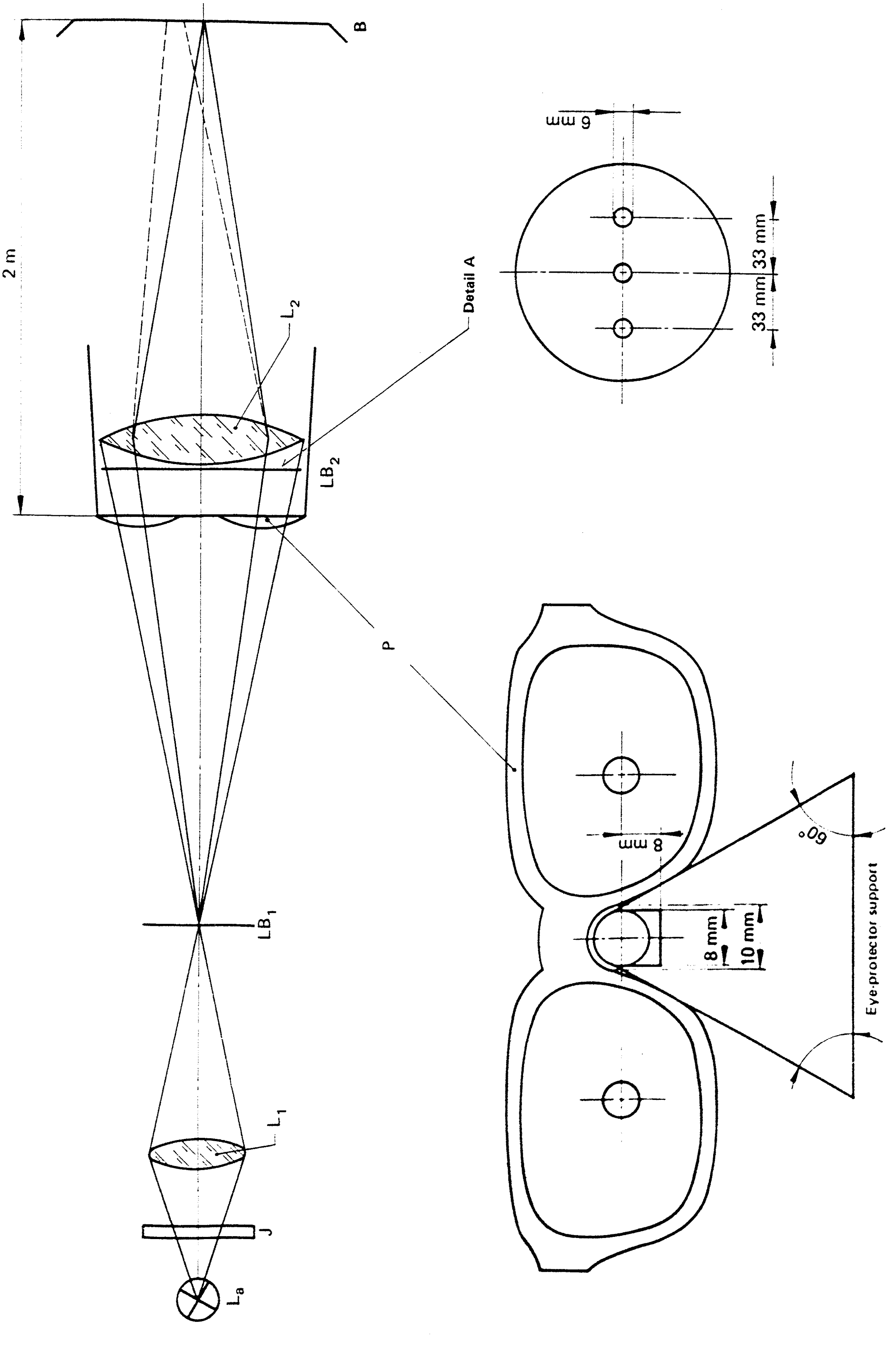



**Figure 15 — Experimental mounting for optional method B**