*Stanisław Kosek**

An Arrangement for Measuring the Retro-Reflection Coefficient for a Ten Meter Distance of the Reflectors

A device, constructed according to the recommendations of the International Illumination Commission (CIE) for the CIL measurement at a 10 m distance and adjusted to photometric darkroom conditions, has been described. By using a multiplier as a light receiver a sufficient sensitivity and good photometric properties have been achieved without applying an objective as a focusing optical system.

A good visibility of all moving (vehicles and persons) and immobile (traffic signs, road borders etc.) objects plays an important role in night traffic.

This problem is usually solved by applying various kinds of devices which reflect the incident light emitted by the projectors of the approaching carriages. It has been assumed that the driver (the angular distance between his eyes and the straight line connecting the projector of the vehicle with the obstacle being small) should receive a warning signal in form of a light beam reflected from the reflector, within the distance of about 100 m.

The reflection quality of the reflectors is estimated by means of special devices whose small sizes permit to diminish their costs and, simultaneously, to rise their effectiveness. Hereafter, a device performed in the Illumination Technique Research Centres in Warsaw in accordance with the recommendations of the International Illumination Commision (CIE) [1] is described, which is adjusted to the retro-reflection coefficient measurement i.e. under a large photometric darkroom condition for 10 meter reflector distance.

The most important CIE recomendations are the following: view angles of the aperture of radiation source the reflector, and of the receiver (observer) — limited to 10′; correction of the receiver (observer) the same as in a CIE 1931 standard photometric observer; colour temperature of the radiation source illuminating the reflector equal to 2855 K colour temperature of the CIE 1931 standard illuminant A; the deviation from the uniformity of the light spot incident on an arbitrary one tenth of the total reflector area not exceeding $\pm 5\%$.

Also, the measurements of the retro-reflection luminous intensity should be performed at the recommended angles of illumination, observation and reflector tilt. Both reflections from the front surface of the reflector and the diffuse light ought to be avoided.

The solution presented in this paper meets all the requirements mentioned above. Moreover, by eliminating the objective, which is usually used in typical devices to focus the light from the projector on to the reflector position manipulator (reflector holder), an improvement of the light spot uniformity, (discrepancy not exceeding 2%) as well as negligible diffuse light (of order of 3 mcd/lux which is 1%) has been achieved. In view of a non satisfactory light extinguishing by the reflector holder, obtained in our experiments, further improvements in this respect seem to by highly possible.

The general scheme of the setup is shown in Fig. 1. The light emerging from a projection lamp with prefocus P28 cap installed in a P28 lampholder fixed in the illuminator housing, travels to the reflector along on optical channel in the form of a 1m long tube. The tube is equipped with diaphragms of the diameters increassing with the distance from the lamp filament. Their task is to absorb the scattered light and to match the light spot to the size of the reflector. At a 10 m distance from the source an uniform light spot (⌀ = 120 mm) surrounded by half-shadow rings illuminates the reflector mounted in a holder which, in turn, is fastened to a goniometer table. The goniometer allows to realize the requested illumination angles, while the holder

* Illumination Technique Research Center, 04-703 Warsaw, ul. Pożaryskiego 28, Poland.

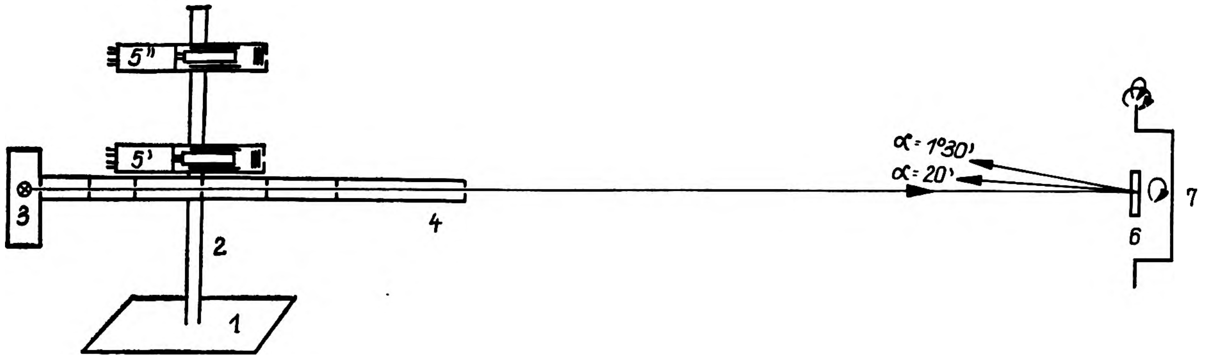

Fig. 1. Scheme of the arrangement used for measuring the retro-reflection coefficient for the 10 m reflector distance: 1 — — foot of the EXACTA multimanipulator, 2 — guide, 3 — housing, 4 — blackened optical channel of illuminator, 5 — receiver with an EMI 9529 multiplier in two positions realizing the observation angles 20′ and 1°30′, respectively, 6 — reflector, 7 — reflector holder in the goniometer

enables to adjust the needed tilt angles. The light, reflected from the reflector paralelly to the light incidence direction, reaches the receiver placed above the illuminator. The receiver directed toward the reflector may be slided along the guide of a multimanipulator EXACTA device and takes two positions with respect to the illuminator, consequently two angles of observation i.e. 20′ and 1°30′ are realized.

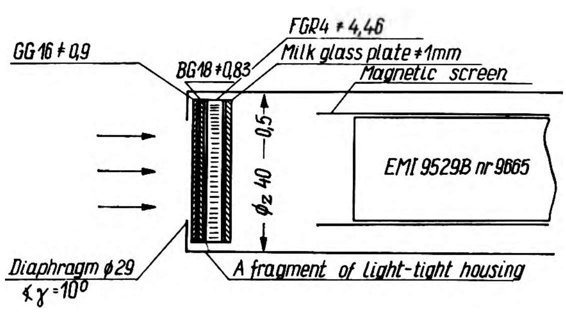

Fig. 2. The luminous intensity receiver including an EMI 9529 B multiplier corrected with a set of optical colour filters used as an normalized CIE 1931 photometric observer. The multiplier in the light shield screened against the electric and magnetic fields is separated from the filter set and the milk glass screen by a space in which the uniformity of the radiation lux density is realized

The receiver shown in Fig. 2 is equipped with an EMI 9529B photomultiplier placed in a light shield and is screened against the electric and magnetic fields. The photomultiplier is corrected by the filters: GG16 ∓ 0.90 mm BG18 ∓ 0.83 mm and FGR4 ∓ 4.46 mm. The above set of filters, shielded additionally by a milk glass screen is separated from the photocatode surface by the space in which a homogenizing process of the radiation flux density occurs.

The correction of the receiver was made by the author's own of method approximation of a function by applying the least mean-square technique which to the logarithmic function and representing the transmission of filters by the Bouger's Law [2], [3], [4].

The curves *1*, *2* and *3* in Fig. 3 represent a spectral distribution of the multiplier sensitivity, a two-filter correction of the multiplier, and three-filter correction of the multiplier, respectively. The ideal curve $V(\lambda)$ represents the relative photopic spectral luminous efficiency, established by the CIE in 1924.

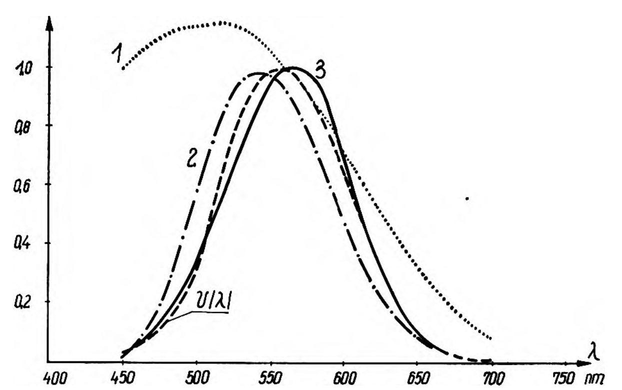

Fig. 3. Approximation of characteristics of the receiver as a CIE 1931 standard photometric observer. Curve (*1*) represents the distribution of the spectral sensitivity of the EMI 9529B multiplier, the curves (*2*) and (*3*) express a multiplier correction with two GG16 and BG18 and three filters, respectively. The ideal curve $V(\lambda)$ is the relative photopic spectral luminous efficiency established by the CIE in 1924

Discussion

The absolute value of the flux scattered is rather low because of small angular aperture of the solid angle enclosing the beam leaving the source housing. It has been stated that at large illumination angles (of order of 20°) the scattered light reaching the receiver does not exceed 1mcd/lux and increases up to 3mcd/lux at 0°, i.e. for perpendicular position of the blackened reflector holder. The later value may be diminished by the front surface of the holder with a set of tiny groovings performed before blackening. Small size of the lamp filament (6×6 mm when projected on the plane perpendicular to the beam axis) and a great (10 m) distance between the lamp and the reflector, have yielded a high uniformity of the light spot. Due to the above conditions, no aberrations, are involved except for the imaging defects resulting from the air movements, structure of glass envelope and existance of half-shadows.

The illumination uniformity was controlled with a photocell (∅ = 38 mm) of the area not exceeding one tenth of the light spot area (∅ = 120 mm). The detected nonuniformity $\frac{I_{\text{examined}} - I_0}{I_0}$ was of order of 2%.

Even if I_0 the light spot illuminating the reflector is of high uniformity the reflected candle power-distribution solid exhibits a very complex intensity figure. On a screen placed in front of the receiver all kinds of light spots and streaks appear. This effect, produced by the reflector and undetectable by devices operating at smaller optical path, induces random errors apearing when repeatedly measuring the same reflector. The systematic errors lowering the value of CIL of retro-reflection coefficient result from a substantial influence of the scattered light unavoidable in the devices with complex optical systems.

The value of the CIL of retro-reflection coefficient for standard square reflectors of red colour, designated for Polish Fiat cars, determined by this methods was equal to 900mcd/lux its order of magnitude being the same as that established in the Fiat Laboratories.

In conclusion a justification of the method proposed will be briefly given. During measurements the CIL luminous intensity of the light reflected from the reflector was employed the latter being illuminated by a direct geometric projection of the light spot from the source as formed by the respective system of diaphragms. The range of photocurrent at the output of a corrected EMI 9529B multiplier at 900 V supply voltage turned out to be sufficient for measurements. The current of order of 10μA was measured with a LG-1 multirange galvanometr produced by ERA, which enabled an easy change in the measuring range and a reliable readout in the darkness of the photometric darkroom. Since the supply voltage range of the multipler used, exceeded 1200 V a surplus in device sensitivity of one order of magnitude was obtained.

Under the above geometrical conditions a projection objective to collimate the light beam falling on the reflector cannot be applied, since the required diameter of the light spot on the reflector surface amounts to 120 mm, while the angular distance of the reflected beam from the objective axis (a 20′ observation angle and a 10 meter distance of the reflector) amounts to 58 mm. This difficulty can not be avoided by shifting the receiver with respect to the illuminator along the beam axis. Application of a focusing lens, which would reduce the beam divergence and increase the light flux magnitude in the beam is unnecessary in view of the sensitivity reserve mentioned above.

Summing up it may be stated that devices with optical path of order of 10 m and with a multiplier used as a light receiver may assume a sufficient sensitivity and good photometric properties without applying an objective as a focusing optical system.

Dispositif pour mesurer les coefficients de réflexion CIL avec réflecteurs placés à 10 mètres

On a décrit in appareil, fait conformément aux recommandations de la Comission Internationale de l'Eclairage (CIE) pour mesurer la CIL à la distance de 10 mètres et adapté au travail dans une chambre sombre photométrique. En utilisant un photomultiplicateur comme récepteur de lumière on a obtenu une sensibilité suffisante et de bonnes propriétés photométriques sans utiliser un objectif comme système optique de focalisation.

Прибор для измерения коэффициентов отблеска CIL при 10-метровом расстоянии отражателей

Описан изготовленный по рекомендациям Международной Комиссии по Освещению (CIE) прибор для измерения CIL при расстоянии 10 м, приспособленный к работе в большой фотометрической комнате. Применение умножителя в качестве светоприемника позволяет получать устойчивую чувствительность и хорошие фотометрические свойства без употребления объектива как фокусирующей оптической системы.

References

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