Light & Engineering
Vol. 5, No. 4, pp. 32-36, 1997

Svetotekhnika
No. 6, pp. 20-22, 1997
UDC 535.27:681.327.12

NEW GONIOPHOTOMETERS FOR LIGHTING-ENGINEERING LABORATORIES*

P. Marx

Technische Fachhochschule Berlin, FB 12 – Elektotechnik,
Haus Gauß, Luxemburger Str. 10 - 13353 Berlin, Germany

The most important trends in the development of artificial lighting systems are as follows:

– miniaturization of many types of light sources and increase in their luminous efficacy and working life;

– expanded use of energy-saving high-quality electronic control gear (ECG) for linear fluorescent tubes and compact fluorescent tubes;

– reduction in size of the luminaire;

– the use of new materials with high reflectance for mirror reflectors and screens;

– the use of fiber-optic systems and hollow lightguides in indoor and outdoor lighting systems;

– optimization of the control systems for indoor light units with fluorescent tubes and ECG by dimmers, in response to variation in the intensity of natural light, the time of day, and the presence of staff at the work station (by means of the Bus-System, a modern digital two-way transmission system for information and control signals.

Such new technology permits electrical-energy savings of up to 75% in indoor lighting systems and also reduces the atmospheric pollution associated with carbon-dioxide emission by thermal power stations (and thereby reduces the greenhouse effect).

In order to develop energy-saving light sources and luminaires, designers and manufacturers require precision measuring equipment with photometers of appropriate size and accuracy for measuring the intensity distribution curves (IDC) and other characteristics. Two goniophotometric systems that meet these requirements are described in the present work.

ECCENTRIC GONIOPHOTOMETER WITH ROTATING MIRROR

This goniophotometer, for measuring the IDC and luminous flux of lamps and luminaires (Fig. 1) [1, 2], may be used in relatively low laboratory buildings (about 5 m), is relatively inexpensive, and rules out perceptible

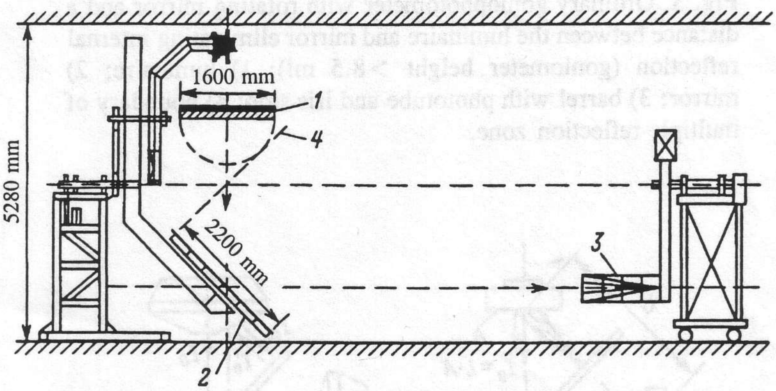


Fig. 1. Eccentric goniophotometer with rotating mirror and reduced height (~5 m): 1) luminaire; 2) mirror; 3) synchronously rotating tube with phototube and iris stop; 4) boundary of multiple-internal-reflection zone.

*This article was originally written in German.

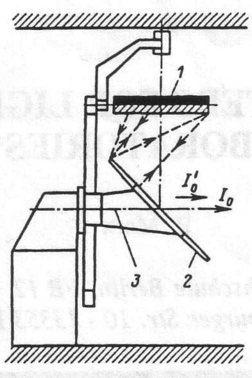


Fig. 2. Usual design of goniophotometer with insufficient distance between the luminaire and the mirror, where errors may arise in measuring I_0 on account of internal reflections (goniometer height ~6.5 m): 1) luminaire; 2) mirror; 3) optical axis.

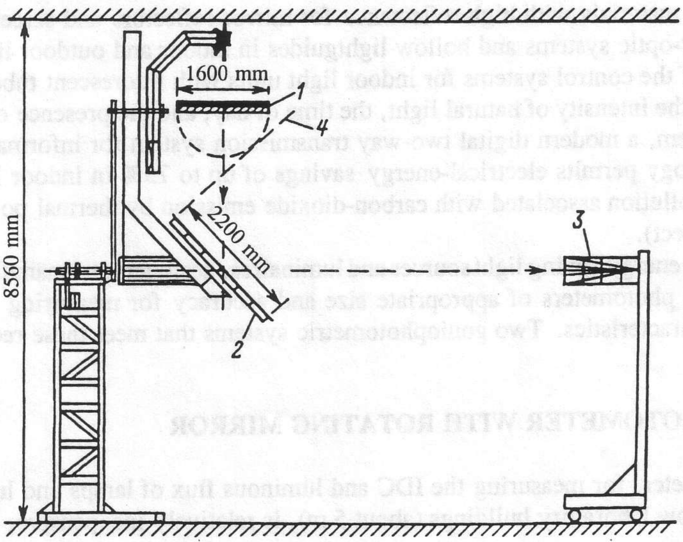


Fig. 3. Ordinary goniophotometer with rotating mirror and a distance between the luminaire and mirror eliminating internal reflection (goniometer height >8.5 m!): 1) luminaire; 2) mirror; 3) barrel with phototube and iris stop; 4) boundary of multiple-reflection zone.

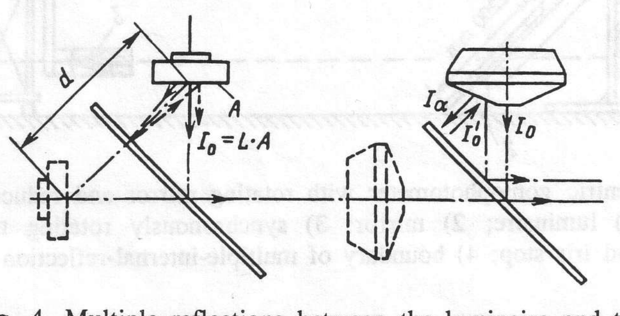


Fig. 4. Multiple reflections between the luminaire and the mirror; I'_0 may reach $0.1 I_0$ (!).

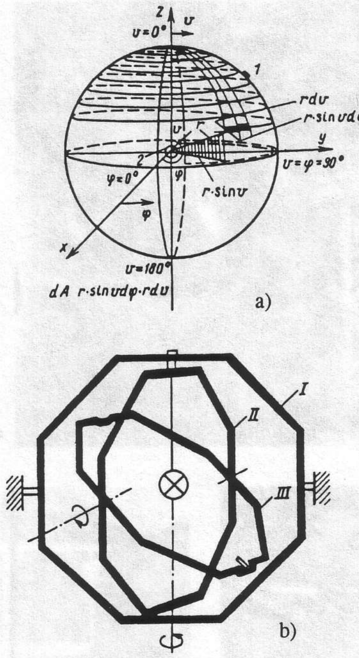


Fig. 5. Cardan goniophotometer for light sources and luminaires whose characteristics depend on their position: a) spiral scanning (spherical coordinate system): 1) light source; 2) scanning photoreceiver; b) Cardan system of frames I-II-III (the photoreceiver is attached to frame III).

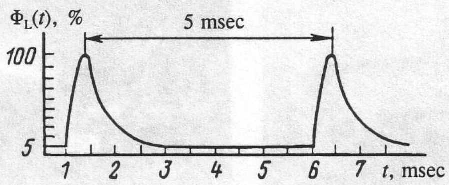


Fig. 6. Time dependence of the luminous flux of a sodium–xenon lamp supplied by pulsed high-frequency current.

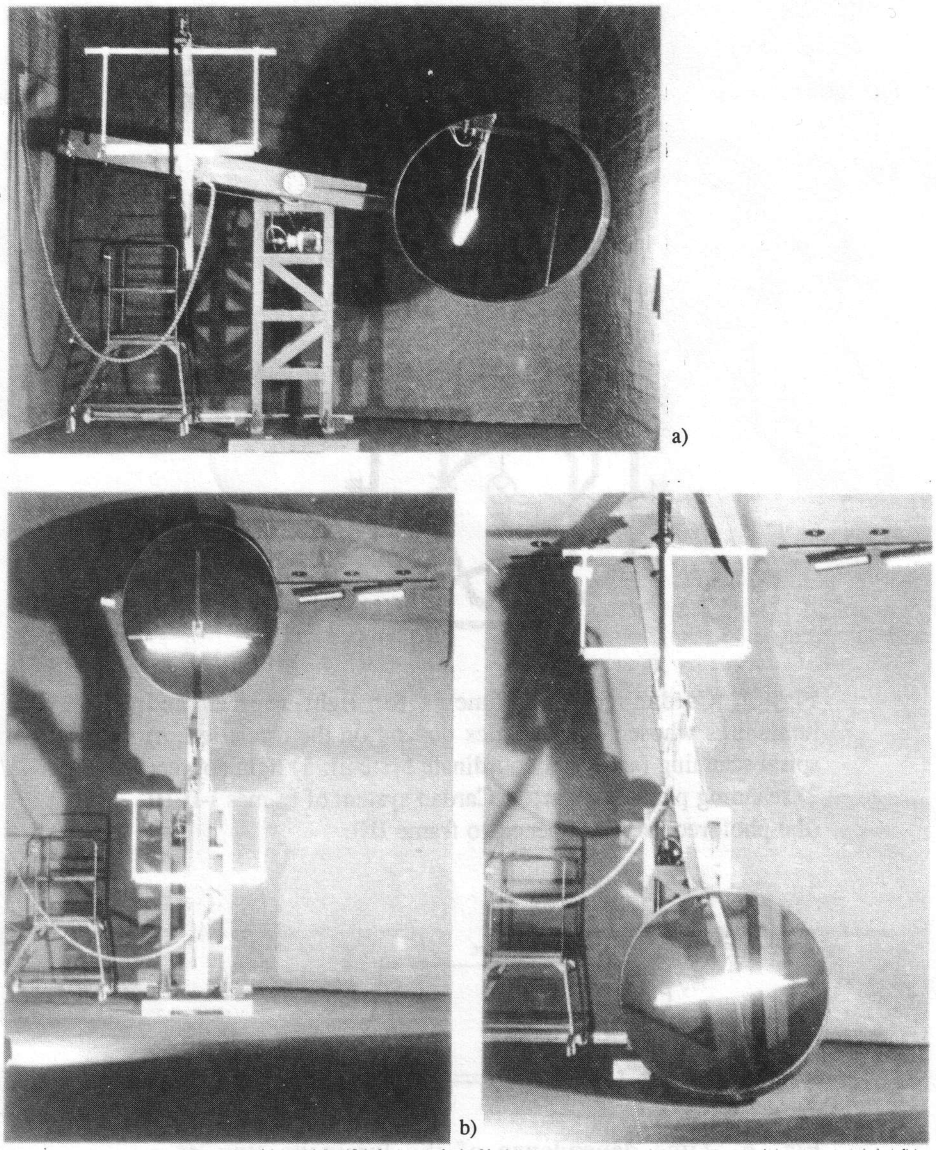
errors due to multiple reflections between the mirror and the luminaire, because of the considerable distance between them.* Such errors are typical of most goniophotometers with rotating mirrors currently in operation (Fig. 2). As shown by Fredericsen, the errors in measuring the luminous intensity may reach +10%, depending on the type of luminaire considered (with a particular reflector or a prismatic or diffuse scatterer).

Reliable elimination of parasitic reflections within standard goniophotometric systems with a rotating mirror (when the mirror is coaxial with the main axis of the photometer) would require increase in height of the structure above 8.5 m (Fig. 3).

The problems arising with inadequate distance between the luminaire being studied and the mirror is clearly illustrated in Fig. 4. Unfortunately, errors of this kind are not only observed in photometers that do not satisfy these fundamental opticogeometric relations. Therefore, the staff of lighting-engineering laboratories equipped with rotating-mirror goniophotometers should analyze their geometric parameters in terms of the likelihood of errors due

---

*Editors' note: For more details on goniophotometers with computerized control, produced by PRC Krochmann Berlin and LMT Lichtmesstechnik, see [6].



a) b) c)

Fig. 7. General view of eccentric goniophotometer: a) 800; b) 180; c) 10.

to internal reflections, especially in measurements fundamental to expert conclusions or catalogue data regarding the lighting-engineering characteristics of equipment.

CARDAN GONIOPHOTOMETER

Using this device (Fig. 5), with spiral scanning of the phototube, the IDC and luminous fluxes of light sources in any position may be measured [7]. No rotation of the lamp being studied is required, since, in spiral scanning, the photodetector moves over all angular directions and planes in both hemispheres, on account of the corresponding rotation of frames II and III with a universal joint.

This goniophotometer design is preferable for the laboratories of lamp manufacturers and also in state research and certification institutions. The Cardan photometer is very convenient for use with compact fluorescent tubes and other lamps with position-sensitive parameters. Two such instruments are in use in Germany, one at PTB in Braunschweig and one at RADIUM GMBH (a subsidiary of OSRAM GMBH) [3].

POSITIONAL DRIVES, MEASUREMENT AND CONTROL ELECTRONICS

Positional robot drives based on synchronous ac servo motors (with rare-earth magnetic materials) are used for mirror rotation and the necessary orientation of the luminaire-axis position in the goniophotometers. The power supply to the windings is sinusoidal and pulsewidth-modulated. The angles of mirror rotation are recorded by a sensor with 15-bit cyclic Gray code (resolution $\sim 0.01°$). Accurate photometry of high-pressure sodium–xenon lamps with a high-frequency pulsed current supply* calls for a special photocurrent amplifier, which, in accordance with the Talbot–Plato law, reliably estimates the linear mean value of Φ_L, even with unusual time behavior of the function (Φ_{max}/Φ_{min} = 20:1; Fig. 6). Ordinary phototubes are designed for measurements with a ratio Φ_{max}/Φ_{me} = 2:1 (for example, high-pressure mercury lamps without a luminophore). Therefore, to rule out error, the staff of photometric laboratories should heed this recommendation: before measuring such light sources, critical evaluation and investigation of the suitability of the photometer for measurements of pulsating Φ_L is required [4, 5].

SOFTWARE FOR COMPUTERIZED PHOTOMETERS

The program is written in the algorithmic language C^{++} for the Windows operating environment. A menu with graphical dialog elements (input matrices, a menu, a set of icons) is obtained by means of the mouse, with additional data input from the keyboard. Thus, working with the program is simple and intuitive, if the user is familiar with the operation of the Microsoft Windows system.

A relatively inexpensive (250,000 DM) eccentric goniophotometric system with a rotating mirror was installed in 1995-1996 at the laboratory of a well-known luminaire manufacturer in Berlin (Figs. 7-13). I would like to thank engineer Albert (Semperlux GmbH) for collaborating in the design of the goniophotometer's mechanical system using a Hewlett-Packard CAD-CAM system.

REFERENCES

1. P. Marx, Exzenter-Drehspiegelsystem zur Lichtmessung. Deutsches Patent 38 02 115, 1996.
2. P. Marx and K. Strung, "Ein modernes computer-gestuertes Drehspiegel-System," Licht, no. 11, 1981.
3. H. Galachik and P. Marx, Deutsches Patent 22 26 253, 1997.
4. DIN 5032, Lichtmessung.
5. H. Ris, "Natrium–Xenon-Lampe mit umschaltbarer Farbtemperature," Licht, no. 2, 1994.
6. R. Rattunde, "Über die Messung des Lichtstroms," Licht, no. 7-8, p. 613, 1994; RZhE 2B29, 1995; F. Lindemuth, "Weltlichtschau '95: Neuerungen bei den Betziebmutten für Lampen," Licht, no. 7-8, 601, 1995.
7. P. Marx, "Spiral photometer with microcomputer control for measuring the luminous flux and intensity," Svetotekh., no. 1, pp. 7-9, 1995.
8. RZhE 8B28, 1994; Svetotekh., no. 1, p. 19, 1994; no. 1, p. 26, 1995.

---

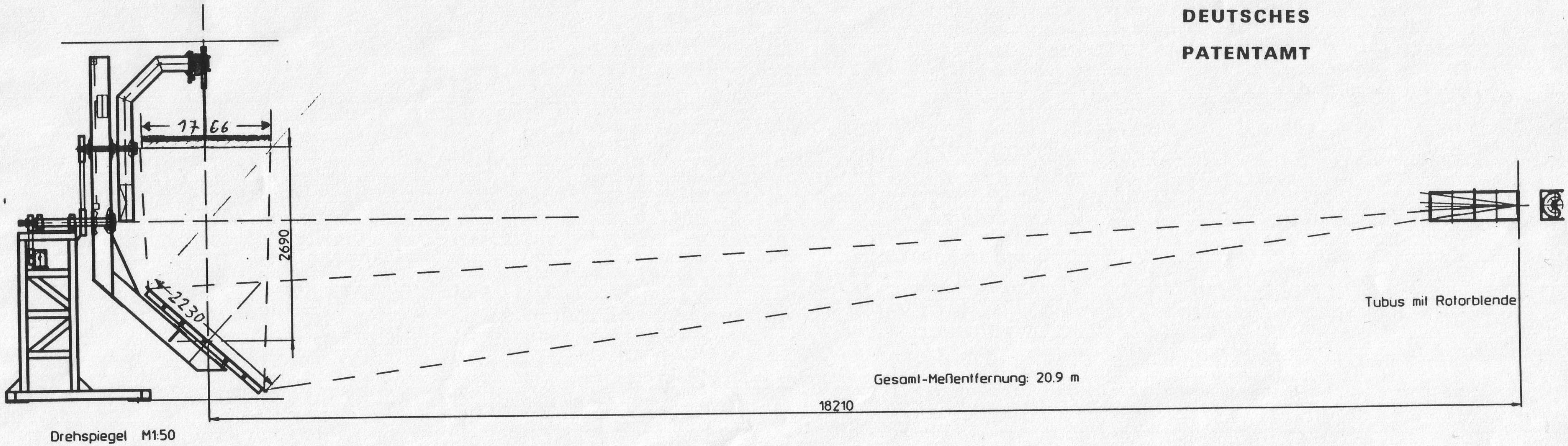
*Editors' note: This is a reference to the Osram Colorstar DSX 50 and 80 mercury-free high-pressure sodium lamps, with step variation in E_c (2500 and 2900 L) or power; these lamps are filled with xenon rather than mercury. The lamp parameters are regulated by special electronic control gear with a microprocessor control system. The power supply is a pulsed high-frequency current with a 5-msec interval between the pulses. Between the pulses, a low-amplitude sinusoidal current maintains the discharge [8].

A NEW ECCENTRIC MIRROR GONIOPHOTOMETER FOR OPTIMAL ROOM UTILIZATION

BUNDESREPUBLIK
DEUTSCHLAND

DEUTSCHES
PATENTAMT

GERMAN-PATENT-N°: P 38 02 115.3 / 1995
PATENT-OWNER: PROF. DR.-ING. PETER MARX



MANUFACTURER: *MX–ELEKTRONIK*
Prof. Dr.-Ing. Peter Marx
Am Kleinen Wannsee 12 J
D-14109 BERLIN (GERMANY)
PHONE: 030-8051980 // 030-45042315
FAX: 030-4504-2284
TELEX: 1631