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APPARATUS FOR ABSOLUTE CALIBRATION OF PHOTOMULTIPLIERS[1]

K. RUSŇÁK[2], M. DROBILOVÁ[2], B. ŠESTÁK[2], Plzeň

In the presented article we describe calibration of photomultipliers on an apparatus, its main part being an improved version of the Anacker-Mannkopff black body. Its temperature can be continously regulated up to 2000 K and is kept automatically with an accuracy of -1 K.

ПРИБОР ДЛЯ АБСОЛЮТНОЙ КАЛИБРОВКИ ФОТОУМНОЖИТЕЛЕЙ

В данной статье описано калибрование фотоумножителей при помощи прибора, главная часть которого представляет собой улучшенную версию абсолютно черного тела Анакера–Манкопфа. Его температуру можно регулировать непрерывным образом вплоть до 2000 K, и данная температура может автоматически поддерживаться с точностью ± 1 K. В приборе не использованы никакие оптические элементы.

I. INTRODUCTION

When using photomultipliers for quantitative spectroscopical measurements, their calibration is necessary. For this purpose secondary radiation normals are commonly used, such as by tungsten ribbon lamp or an anode crater of d.c.. Absolute normals are used less often, mainly because their construction and manipulation with them are relatively difficult.

One of the most simply realizable absolute normal is the Anacker–Mannkopff [1] version of the black body. It is in essence a hollow carbon rod with a longitudinal slot directly heated by electric current. This rod is fixed in cooled metal flanges and is surrounded by a nonclosed protecting carbon cylinder. The cylinder partly prevents the reducing carbon monoxide from escaping and in such a way the rod is partly protected from burning. The radiation issuing from the slot

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[2] Institute of Mechanical and Electrical Engineering, Nejedlého sady 14, 306 14 PLZEŇ, Czechoslovakia.

can be considered as the black body radiation with an accuracy of about 0.5 %. Measurement was performed by the authors at the carbon sublimation temperature (4000 K) and the spectrum was exposed on a photographic plate (exposition time of seconds).

But the above described calibration normal for photomultipliers is not suitable. At the carbon sublimation temperature there appears such a radical burning of the carbon rod that its short lifetime does not enable photocurrent measurements in a wider range of wavelengths. Besides that, such a great temperature needs currents of about 800 A at a voltage of 70 V, which is not usually possible.

The aim of this article is to give a report on such a modification of radiation normal which enables the calibration of photomultipliers.

II. CONSTRUCTION OF RADIATION NORMAL

Our construction is based in essence on the device of Anacker and Mannkopff. The basic part is a hollow carbon rod, with a length of 220 mm, with the outside and inside diameters of 10 mm and 6 mm, respectively (Fig. 1). The rod

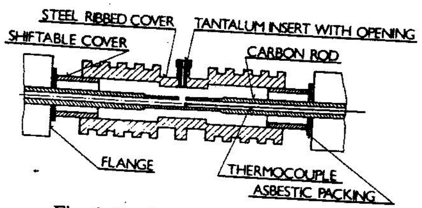

Fig. 1. Radiation normal — section.

in the central part, the length of which is 40 mm is reduced to a diameter of 9 mm and has in the middle a radial circular opening with a diameter of 3 mm. The carbon rod is fixed in two water cooled metal flanges and is airtinght (except for the opening through which the radiation issues out) in a steel cylinder cover of an outside diameter of 50 mm and an inside diameter of 30 mm. This cover is ribbed and intensively cooled by air. The carbon monoxide accumulates inside the protects

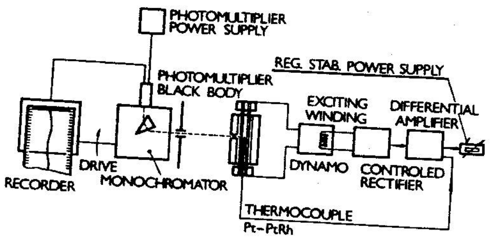

Fig. 2. Experimental arrangement.

the carbon rod from burning. In the movable tantalum insert there is bored a precise opening of a diameter of 2 mm. The carbon rod is directly heated by electric current up to the temperature of 2000 K. This normal is suitable for calibration of photomultipliers, its lifetime being some tens of hours. At the same time the current needed for heating the carbon rod does not exceed 100 A. No optical elements (lenses) for directing radiation out of the normal are used.

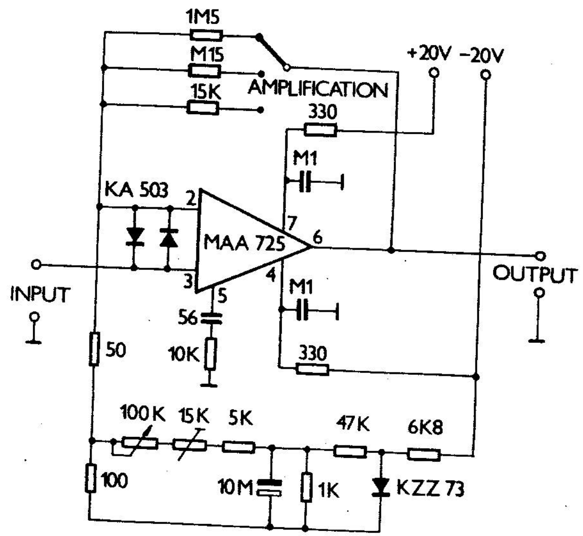

Fig. 3. Differential amplifier and stabilized power supply.

Reflectivity of the normal, which characterizes the deviation from the absolute black body, can be calculated from the formula (1)

$$f=\frac{0.24\,bh^2}{4a}\,\frac{s}{a+b}\,\operatorname{arctg}\frac{s}{2(a+b)}-\ln\left(1+\frac{s^2}{4(a-b)^2}\right)\times$$

$$\times\frac{1}{\left\{h\operatorname{arctg}\frac{h}{a-b}-\frac{a-b}{2}\ln\left(1+\frac{h^2}{(a-b)^2}\right)\right\}\left\{s\operatorname{arctg}\frac{s}{a-b}-\frac{a-b}{2}\ln\left(1-\frac{s^2}{(a-b)^2}\right)\right\}},$$

Where a and h are the width and the length of the slot and a and b are outside and inside diameters of the rod. The derivation of a similar formula for the circular opening is more difficult. For an estimate we can approximate the circular opening by the rectangular one. Using the values $h=s=3$ mm and $a=4.5$ mm, $b=3$ mm we obtain $f=0.320$ %. The accurate value for the circular opening must be even smaller and so the approximation to the black body is in our case better than in [1].

III. EXPERIMENTAL ARRANGEMENT

The motor welding machine Triodyn (experimentally excited dynamo, voltage max. 70 V, current max. 200 A) was used as a power supply for the carbon rod of the normal. The temperature of the rod was measured by a Pt-PtRh thermocouple connected to a galvanometer (Fig. 2). The thermocouple voltage is obtained by

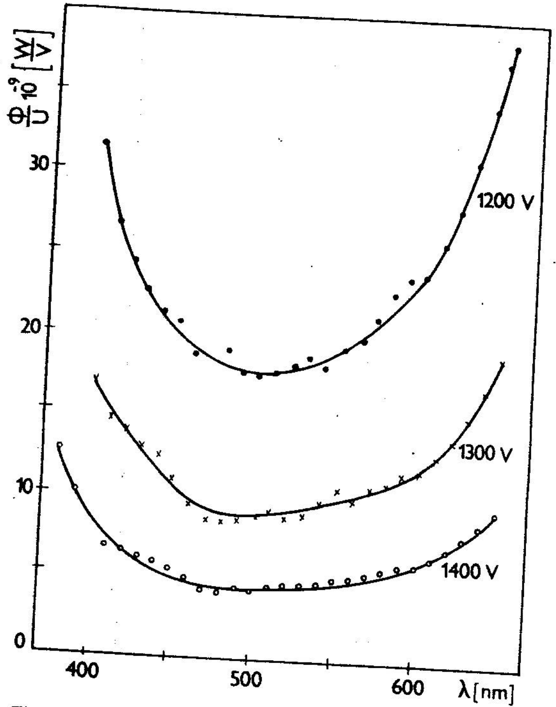

Fig. 4. Calibration curves of photomultiplier M12FVL51.

a stabilized regulated voltage on the input of a differential amplifier. This amplifier operates a controlled rectifier coupled directly to an exciting winding. The scheme of the differential amplifier and the stabilized power supply is in Fig. 3. The controlled rectifier was a three-phase one, controlling a voltage of 0—15 V, a output voltage of 0—70 V, a max. current of 3 A. This arrangement enables on the one hand the smooth manual adjustment of the required temperature and on the other hand its automatical keeping with an accuracy of 1 K. The radiation normal illuminates the inlet slot of the monochromator without the use of optical elements. A recorder was used for calibration. This recorder mechanically controls the drive of the monochromator. The recorder registers the voltage on the serial

resistance in the photocurrent. The time needed for measurement in the region of wavelengths from 360 to 800 nm was 3 min.

IV. MEASUREMENT RESULTS

An example of calibration curves of the photomultiplier is in Fig. 4 in the form of the dependence of the radial current needed for the excitation of 1 V voltage on wavelengths of radiation. The curve parameter is the working voltage of the photomultiplier.

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