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A New Device for Atmospheric Transmission Measurements

An extinctionmeter, designed for continuous measurements of the atmospheric transmission and meteorological visibility along the horizontal optical path, is described. The setup consist of a transmitter—receiver unit, electronic data processing unit, a write recorder (plotter) and a reflector. The extinctionmeter is intended to work in meteorological stations, airports, etc.

The range of meteorological visibility (which will be refered to as visibility) is a way of expressing the atmospheric transmission by the distance at which a black body, of angular dimensions not less then 0.3° when observed horizon level against the sky, becomes invisible due to actual atmospheric conditions.

The measurements of the range of meteorological visibility have been the problem studied since the begining of this century. So far, hovewer, no satisfactory results have been obtained, and the studies are still continued. At present the investigations carried out are dealing with theoretical aspect of this problem, the improvement in the method of measurements as well as the construction of better and more accurate instruments. The methods of visibility measurements may be either subjective or objective ones. Consequently, they may be divided in two groups:

1. Subjective methods, i.e. optical measurements taken either with unaided eye or with special devices, performed at day time, exclusively. These measurements cannot be automatized;

2. Objective methods, i.e. photometric measurements which may be automatized and performed for twenty four hours. To introduce photometric methods an equivalent notion of visibility had to be defined, namely that a parallel light beam running along the distance equal to day light visibility of objects is damped 20 ×.

To perform photometric measurements the transmitter emitting a parallel light beam of the intensity E_0 should be placed at the distance L from the receiver which takes in the beam of the intensity E_1 (attenuated by the atmosphere). The visibility is obtained from the formula

$$V = \frac{3L}{\ln \frac{E_1}{E_0}}. \qquad (1)$$

For practical reasons it is convenient to apply a measuring equippment consisting of a transmitter-receiver unit and a mirror (corner prism) which is placed at a distance L. A common housing of the transmitter and receiver simplifies both construction and alignment, and enables to apply additional devices. A model of extinctionmeter designed and constructed in the Institute of Quantum Electronics, Military Technical Academy in Warsaw, is a photometric device for measuring the extinction coefficient and the associated visibility.

Fig. 1 presents the optical scheme of the extinctionmeter. An incadescent lamp *1* emits radiation from which two beams are selected: the working

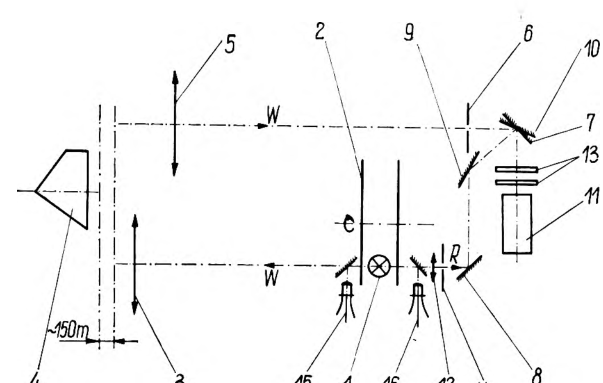

Fig. 1. Optical system of the extinctionmeter

W and the reference *R* ones. Both beams are successively switched by a chooper system *2* with the frequency 50 Hz, each of them being additionally modulated with the frequency 1000 Hz (intensity modulation). This modulation is realized by choppers of a special comb design. Fig. 2a presents one of the choppers. The other one is shifted around the rotation axis by 180° with respect to the first chopper.

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This system allows either working or reference beam to emerge in turn from the illuminator, in form of 10-pulse train during the rotation of the chopper set. (Fig 2b).

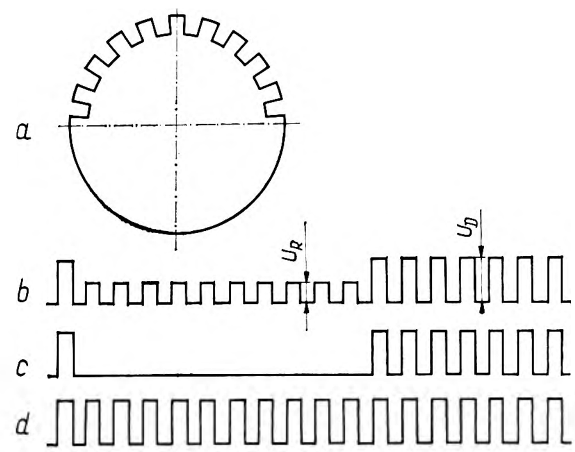

Fig. 2a. Chopper
Fig. 2b, c, d. Signal shapes at the photodetector output

The working beam *W* is collimated by the objective *3*, it passes through the atmosphere then reflected by the corner prism *4* (placed at the distance of about 150 m) it turns back to the receiver and is focused by the objective *5* on the field-aperture *6*. The field-diaphragm *6* stops the radiation scattered by the objects being positioned in the vicinity of the corner prism. The corner prism is located against the black back-ground in order to additionally diminish the back-ground effect. The working beam *W* — after having beem reflected by the mirror *7* — falls onto a photodetector *11*. This beam carries information on the atmosphere attenuation.

The reference beam *R* is collimated by the lens *12* and directed to the photodetector *11* by means of mirrors *8*, *9*, *10*. The reference beam carries information on the emitted beam intensity.

The filters *13* are used to correct the product of the spectral dispersion of the incadescent lamp radiation, and the spectral sensitivity of the photodetector, so that the obtained sensitivity curve be similar to the spectral sensitivity of the average observer's eye. By placing narrow-band interference filters in front of the photodetector, the respective monochromatic coefficients of extinction may be measured. A further signal processing is performed in the electronic system. Its task is to transform the electronic signal from the photodetector output into a corresponding visibility measure; the latter being recorded on the plotter tape as a function of time. Fig. 3 presents a block diagram of the electronic circuit of the extinctionmeter.

The *W* and *R* light signals are detected on the photodetector surface consecutively: on the *W* (*15*) and *R* (*16*) synchronizers only *R* and *W* signals are detected, respectively (Fig. 1). The synchronizers are non-linear photodetectors, their output voltage amplitude is constant and independent of the light signal value. The synchronizers are connected with the suitable synchronous detectors.

On the other hand, the photodetector is connected with the input of a logarithmic amplifier, which assures the 40–60 dB dynamic range. The signal from the output of the logarithmic amplifier is transferred to two synchronous detectors, which are controlled by synchronizers *W* and *R* respectively. A detection of the signal is possible if and only if the respective synchronizer opens the voltage gate. Such a gate is produced when the synchronizer is illuminated.

The 10-pulse working and reference trains are time-shifted with respect to each other (Fig. 2b). To perform the substraction operation the incoming pulses are transformed into d.c. voltage equal to the peak voltages, and then applied to a differential amplifier, of amplification factor equal to unity.

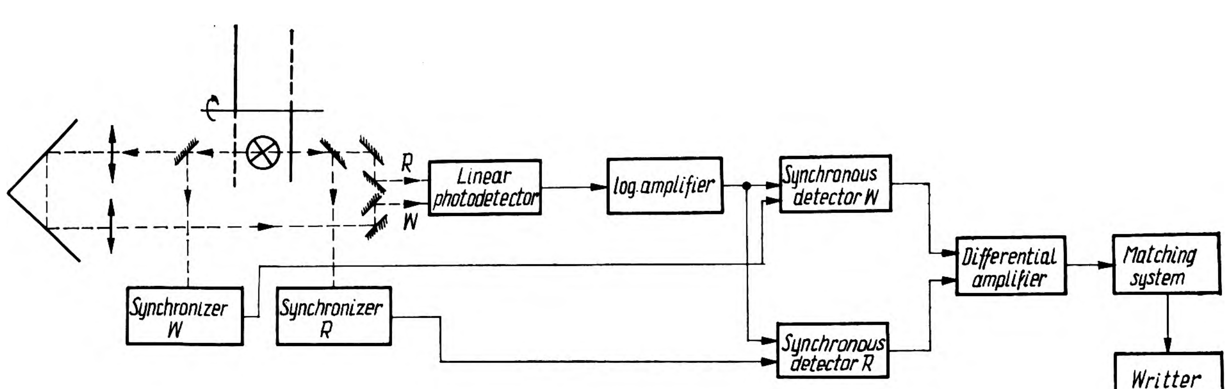

Fig. 3. Block diagram of the electronic system

The amplifier output voltage is given by the formula

$$U_{\text{out}} = K_1 \left| \cdot n \left(\frac{U_{\text{in}} D}{U_{\text{in}} R} K_2 \right) \right|. \tag{2}$$

The signal from the amplifier output is applied to the recorder input via a matching circuit.

The constants K_1 and K_2 depend on the amplifier circut and optical system parameters as well as on certain physical magnitudes. For a definite value of K_2 obtained by an appropriate selection of circuit parameters the numerical coefficients in (1) and (2) become identical.

Since a theoretical estimation of the constants occuring in (2) is difficult, the extreme points of the visibility scale are adjustable. The zero visibility is determined by closing the receiver line and an appropriate adjustment of electronic circuit (Fig. 2c). Estimation of the maximum visibility (the coefficient of extinction close to zero) is performed with the extinction-meter switched on under perfect weather conditions when the visibility ranges within 30–100 km. The necessary adjustments are done with the diaphragm *14* (set in thel ens mount *12*), which is stopping down the reference beam *R* till the equilibrium with the working beam is reached (Fig. 2d).

By the same method the effect of geometric vignetting may be also eliminated. Because of the beam divergence only a fraction of radiation falls on to the corner prism; consequently, only a part of light reflected by the prism finds its way to the receiver. Mathematical estimation of this effect is difficult.

The extinctionmeter consists of the following units:

1. transmitter-receiver unit,
2. corner prism,
3. signal processing and supply system,
4. write recorder (plotter).

The units *1*, *2* and *3* (Fig. 4) are located at the measurement point, the corner prism being set northwards with respect to the transmitter at 150 m distance. In this way the transmitter-receiver system "looks" to the North, and the receiver photoelement cannot be blinded by the sun.

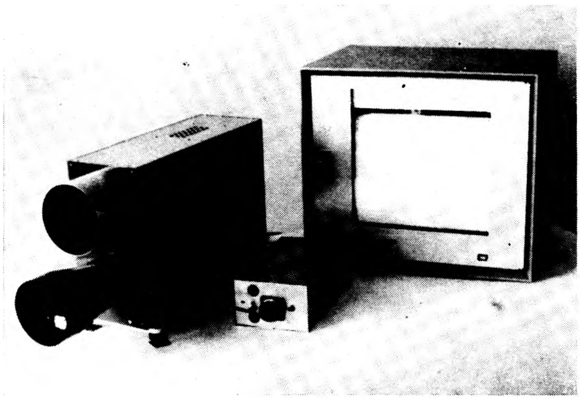

Fig. 4. Measuring stand of the extinctionmeter

The measurement stand as well as the reflector are set on two concrete foundations sunk deep into the ground (their protruding parts being about 1.5 m high). All other meteorological measurements are taken at similar altitudes. Concrete foundations are applied in order to eliminate the vibrations of the device, assure the time-stability of the setup, and reduce the effect of slow misaligning of the setup. All these factors are of a great importance, since with the assumed optical path (300 m) even the slightest instabilities may affect considerably the accuracy of the device. Under favourable weather conditions (maximum visibility) the indications of the device are, independently of natural stability, occasionally controlled to make them consistent with those obtained by visual measurements.

The measurements stand and the reflector are shielded with two huts, which are independent of the foundations. They are to protect the devices against noxious effects of atmospheric conditions. The huts are heated in order to assure the stability of working conditions as well as to prevent the separate elements of the optical instruments and the transmission windows from being wet with dew. The transmission windows are situated under a negative angle to eliminate unwanted reflexions and depositions of dust. The extinctionmeter allows the visibility measurements to be taken continuously within 10 km range. The device is intended to be applied whenewer continuous measurements of visibility are required, e.g. meteorological stations, airports, etc.

Nouveau dispositif pour mesurer la transmission de l'atmosphère

On a décrit un extinctiomètre destiné aux mesures de la transmission de l'atmosphère en continu et à celles de la visibilité météorologique le long de chemins optiques horizontaux. Le dispositif se compose d'un élément de transmission et de réception, d'un système électronique de traitement de l'information, d'un enregistreur et d'un réflecteur. L'extinctiomètre est prévu pour être utilisé dans des stations météorologiques, aéroports etc.

Новое устройство для измерения переноса воздуха

Описан экстинкциометр для непрерывного измерения переноса воздуха и метеорологической видимости вдоль горизонтальных оптических длин пути. Устройство состоит из передаточно-приемной электронной системы для обработки данных, регистрирующего прибора и отражателя. Экстинкциометр предназначен для применения на метеорологических станциях, аэродромах и т. д.

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