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An Electro-Optical Device for Measurement of Pulsing Electromagnetic Fields and Current Surges

The paper is concerned with a current surge meter designed for measuring and oscillographing steep single impulse waves and magnetic fields of great amplitude. The operation of the device depends on a deflection of the polarization plane of light beam in magnetic field induced by a current surge. The information about the surge is contained in the degree of deflection of the polarization plane in a beam of light emerging out of a glass core of the Faraday's cage and analyzed in an isolated part of the instrument.

As the measuring element serves a cylinder made of flint glass SF6 inserted into a suitably formed winding, coil or even a hole in the conducting rail. Light beam emerging from this element falls on an analyzing system consisting of a suitable analyzer behind which there is a photoelectric sensor. Assuming that during the absence of electromagnetic field the analyzer is located perpendicularly to the polarizer, through which the beam goes before it enters the measuring cylinder (core of the Faraday's cage), the photoelectric current is a function of the additional deflection of the polarization plane of the beam — caused by the current — induced magnetic field.

The design of the instrument is shown in Fig. 1.

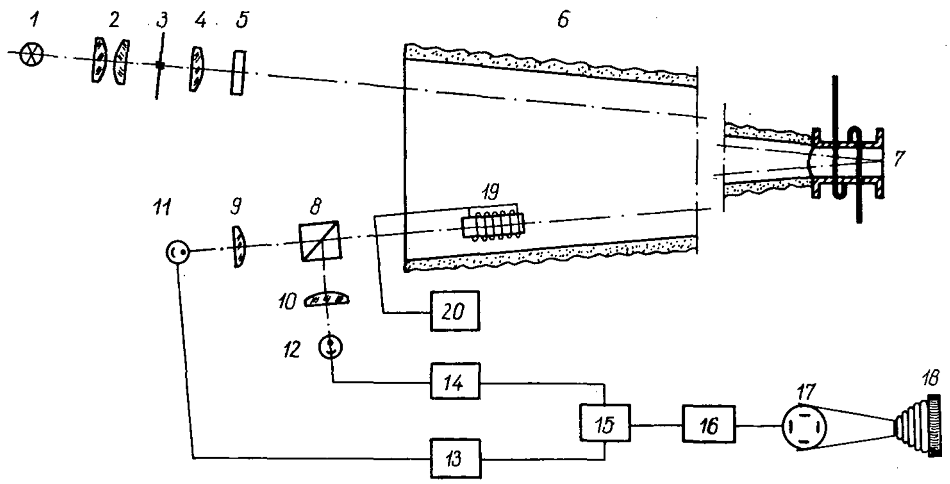

Fig. 1. Schematic diagram of the device

The filament of a halogenic incandescent lamp 1 is imaged with the use of condensor 2 into the opening of diaphragm 3. This diaphragm is located in the object focus of collimator objective 4 which projects a parallel beam through polarizer 5 toward the core of Faraday's cage 7 placed at the end of isolator 6. The core is made of glass of high Verdet's constant. It is shaped as a cylinder with a spherical surface at one end and a flat mirror surface at the other. The parallel light beam passes the core twice, reflecting from the flat mirror surface. The convex surface of the core images the collimator slit on the active surface of interference polarizer 8. The interference polarizer divides the beam into two linearly polarized components with polarization planes perpendicular to each other. The beams coming out of the interference polarizer are then condensed by lenses 9 and 10 onto the active surfaces of photoelectric sensors 11 and 12.

The polarization plane of the polarizer 5 is orientated in such a way that equal signals develop on sensors 11 and 12 when no magnetic field is present. Once the magnetic field appears, the core deflects the polarization plane, causing a decrease of signal intensity in one sensor and corresponding increase in the other. The difference between the two signals is proportional, and has the same sign as that of the electromagnetic field intensity.

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By making use of the two sensors working in a differential system, an optimal linearity of the magnetic field representation can be reached, assuming, of course, that there are no other disturbing agents. In this case the instrument's characteristic transfer function coincides with the quasi-linear part of the sine curve in the vicinity of 45°. For the sine curve range of $30^{\circ}-60^{\circ}$ in the method of differential signal processing the nonlinearity should be less than 1 per cent, and this is being confirmed in practice.

In the actual construction of the instrument the signals from the photoelectric sensors (photodiode FK4 made by ITE) are preamplified in pre-amplifiers 13 and 14 built in as emitter duplicates operating in the Darlington's system, and then put into differential system 15 which operates on a symmetrical amplifying step with emitter coupling. A pair of complementary transistors NPN and PNP constitutes the output of amplifier 16 of the electronic system. The transistors operate in the B class as an emitter duplicate with output resistance of 150 Ω, coupled with oscilloscope 17 which operates in cooperation with photographic camera 18.

For the purpose of the precise scaling of the amplitude, the device is equipped with an additional Faraday's modulator 19 whose winding constitutes an element of sine-wave-form generator 20 with two frequencies: 200 Hz for recording waveforms with the time base less than 5 s, and 1 MHz for faster waveforms.

The designed instrument may serve for making measurements and oscillograms of current waveforms, of current surges of amplitude up to 100 kA and voltages up to 100 kV relative to earth, with the rise time not less than 50 nanoseconds.

The device has been designed and built for the Institute of Nuclear Research, for studying big currents and magnetic fields occuring in works connected with the plasma generation.

The optics of the instrument has been calculated in the COL Geometrical Optics Division. The high voltage and energetic side of the tests and measurements was covered in collaboration with the High Voltage Division of the Institute of Electrotechnology.

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Focal-Length Digital Meter

In the Polish Central Optical Laboratory a new method has been developed for measuring the focal-length of single lenses and complicated condensing systems. The method consists in comparing a fixed spatial frequency of a grating, placed in the focal plane of the measured lens, with changing spatial frequency of a set of moiré fringes. The principle of measurement is shown in Fig. 1. In the objective focal plane of collimator L_1 there are two absorption gratings, *Ga* and *Gb*, of equal spatial frequency, i. e. equal grating spacing t_1. These gratings rotate around a common axis with equal angular velocities but in opposite directions. The rotation axis is parallel to the optical axis O_1 of collimator L_1, and the distance between the axes is H. The grooves of grating G_a when cross-cutting those of grating G_b develope a set of moiré fringes. Rotation of the gratings causes a cyclical change in the spatial frequency of the set fringes, i. e. a cyclical change in the spacing of fringes T_1. During every full circle of the gratings the fringes converge to the rotation axis O_2 and diverge from it twice. Thus the fringes move in the K direction in the collimator field. A light source S_1 sends off light through collimator L_1 and an image D of the set of fringes arises in the focal plane of the measured lens L_2. Behind the lens L_2 there is a reference grating G_2 of grating spacing t_2, and a photocell PH_1 behind the grating. The grating G_2 can be displaced along the optical axis O_1. Let us assume that the grating G_2 is placed in the focal plane of the lens L_2, so that the distance Δ equals zero. Then the moving fringes of the image D create an elementary light signal of cyclical variation in intensity behind every slit of the grating G_2. If these elementary signals are not in phase, the total light flux arriving at the photocell remains constant. However, once the elementary signals become in phase, that is when the distance T_2 between the fringes of image D equals spacing t_2, a short frequency signal arises in the flux. This occurs four times during each full turn of the

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