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DEMONSTRATION OF THE MALUS LAW

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THE Malus law, which states that $I = I_0 \cos^2 \varphi$, where I is the intensity of light passing through a polarizer and analyzer and I_0 is the intensity of the light passing through the polarizer and analyzer in the case when the oscillations passing through them are collinear in direction, and φ is the angle between the directions of the transmitted oscillations of the polarizer and analyzer ($\varphi = \omega t$), is demonstrated on an oscilloscope screen. The idea of the experiment consists of the following. If we write the Malus law in the form $I = (I_0/2)(1 + \cos 2\varphi)$, then when the analyzer rotates uniformly at frequency ω, the intensity of the light I changes in accordance with a cosine law at a frequency 2ω.

The character of the change of the intensity of light I can be determined with an oscilloscope fed from a resistance in the photocell circuit (Fig. 1).

If markers denoting a complete revolution of the analyzer are superimposed on the oscillogram, then a cosine wave with two maxima and two minima should be contained between two markers. Demonstration of this fact confirms the Malus law.

Parallel rays of light are incident on a photocell through a polarizer and a rotating analyzer. The voltage picked off the load resistance R_L is fed to a type ÉO-7 cathode-ray oscilloscope. Two openings in the mounts of the filters (one of which rotates together with the analyzer) can be used to record on the oscilloscope screen a complete revolution of the analyzer. To prevent electric induction from the working motor (which drives the analyzer), the shield of the electric wires is grounded. The light source lamp is fed with direct current.

The analyzer is rotated by the device shown in Fig. 2. It consists of a housing 1, in which a sleeve 2 with analyzer 3, mounted in plates having apertures 4, are rotated by means of a pulley. The polarizer 5 is mounted in plates having three apertures 6, the radius vectors of which are shifted relative to one another by 45°. These apertures are moved relative to the stationary aperture 8 with the aid of a set screw 7.

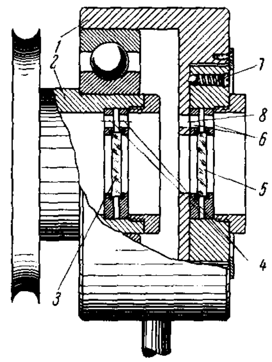

FIG. 2. Device rotating the analyzer.

When the analyzer rotates, harmonic voltage oscillations are produced across the load resistance R_L in the photocell circuit; these are seen on the oscilloscope screen. Vertical lines arising when the apertures 4, 8, and 6 are aligned (see Fig. 2), are superimposed on these curves.

An analysis of the oscillogram shown in Fig. 3 leads to the following conclusion: the intensity of the light changes like the square of the cosine of the angle of rotation of the analyzer. This is evidenced by the fact that between two vertical lines the cosine curve reaches two maximum and two minimum values. The photograph corresponds to the case when apertures 4, 8, and 6 coincide and $\varphi = 90°$. On the other hand, the oscillogram shown in Fig. 1 is obtained when apertures 4, 8, and 6 coincide at $\varphi = 45°$. (To obtain the usual oscillograms, (i.e., those in which the increase in voltage applied to the vertical plates of the oscilloscope leads to a shift of the electron beam upward) it is necessary to interchange in the diagram of Fig. 1 the terminals of the battery and the anode and cathode of the photocell.)

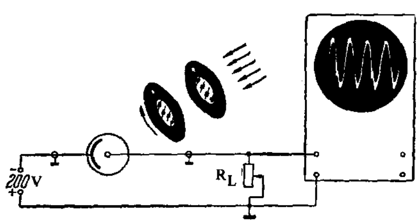

FIG. 1. Diagram of demonstration.

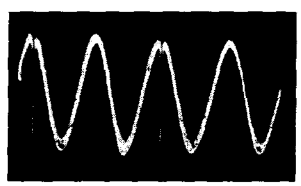

FIG. 3. Oscillogram.