Methodological Notes

SOME NEW LECTURE DEMONSTRATIONS*

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1. Young's Interference Experiment at Centimeter Wavelengths. The study of light interference is usually accompanied by a demonstration of phenomena in thin films. It is appropriate to supplement these experiments by demonstrations of the interference of electromagnetic waves from two coherent sources.

Electromagnetic waves of 3 cm length, modulated by a low frequency, are produced by a klystron generator (G in Fig. 1) and are radiated from the open ends 1 and 2 of a branched waveguide (B) with which the generator is loaded. The radiated signal is picked up by a horn-type antenna; the signal from the output of the detector (D), after amplification of the low frequency (ALF), is fed to the loudspeaker (L). One of the openings of the waveguide is covered by an absorbing matched load. Then, when the horn is moved in a direction parallel to the straight line connecting the openings in the waveguide, a single maximum is observed. If both openings are uncovered, four or five maxima are observed. Several other weak maxima can be noted if an electron oscilloscope is used as the detector instead of the loudspeaker.

The distance between the plane of the waveguide apertures and the horn is 50-60 cm. The centers of the radiating apertures were set 20 cm apart.

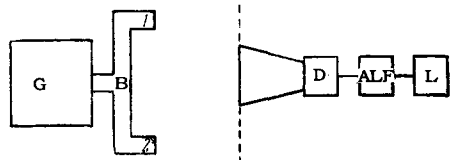

FIG. 1

2. Fresnel Diffraction of Electromagnetic Waves. Direct demonstration of Fresnel diffraction with light waves is not very illustrative in a lecture, because of the difficulty of observation of the diffraction picture in a large auditorium; a demonstration of Fresnel zones is scarcely possible. Therefore, it is useful to accompany the exposition of the corresponding optical part with a demonstration of Fresnel diffraction of centimeter electromagnetic waves by apertures. A 3 cm klystron generator was employed as the radiation source and a horn radiator was used (Fig. 2). The source stood at a distance of 2—2.5 m from a metallic screen (plywood covered with foil) with a circular opening of 30—32 cm diameter. A receiver with a horn antenna was placed at the screen. The low-frequency modulated signal was applied to a cathode ray oscilloscope. The distance from the receiving antenna to the screen varied from 1—2 m down to several centimeters. As the antenna was moved closer, the amplitude of the received signal scarcely changed at first; it then passed through a definite minimum when the aperture corresponded to two Fresnel zones. If the receiving horn was moved in a plane normal to the axis of the aperture and passed through the minimum point, a noticeable increase in amplitude was observed on both sides of the axis, followed by a decrease (diffraction ring). If the aperture is progressively covered from the edge to the center (the receiver being at the minimum point), the signal increases when the dimensions of the aperture become equal to those of a single zone, and then decreases. The size of the screen should be such that there is no reception with the aperture covered (in our case, $\sim 1.5 \times 1.5$ m).

3. Buildup of Forced Oscillations. When a sinusoidal voltage is applied to an oscillatory circuit, forced oscillations are set up within a finite time. The process of their establishment can be observed on the screen of an oscilloscope (EO) (Fig. 3) by exciting the circuit with a voltage from a sound generator (SG) through an electronic switch (ES). The switching frequency must be such that the oscillations can be established during the time that the voltage is applied to the circuit. This is easily achieved (for a switch frequency of 100 cps) by choice of the resistance R. For example, R = 4 kΩ, C = 0.25 mfd, L = 0.01 henry. The character of the buildup of the oscillations is different for excitations at the resonance frequency (Fig. 4a)

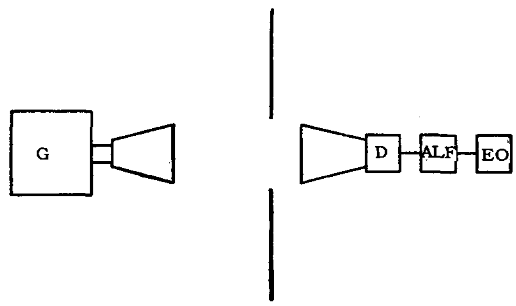

FIG. 2

*This paper describes some new lecture demonstrations used at the Moscow State Pedagogical Institute on April 20, 1961.

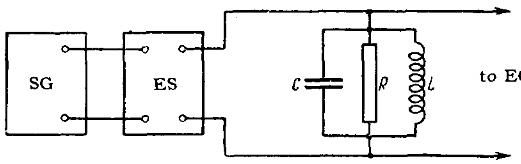

FIG. 3

and off resonance (Fig. 4b). In the latter case, beats are observed. The amplitude of the voltage in this case exceeds the steady-state values in certain time intervals.

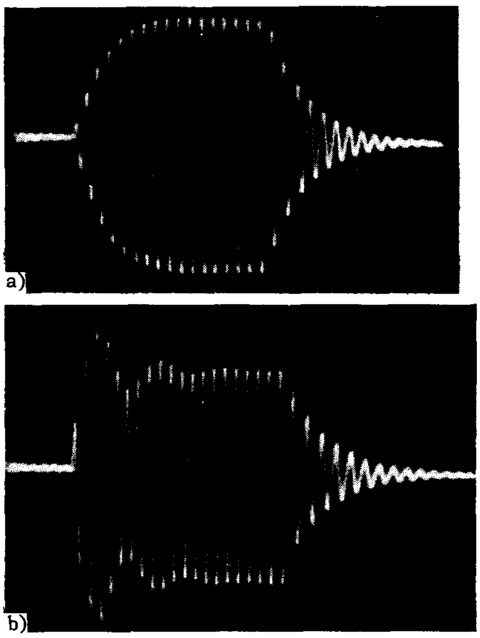

FIG. 4

4. Characteristics of a Tunnel Diode. Recently, a new semiconductor instrument—the tunnel diode[1]—has come into application in technology. It has a volt-ampere characteristic with a negative slope; consequently, under certain conditions, it is a device that possesses a negative resistance R. A circuit is shown in Fig. 5 which makes it possible to demonstrate the volt-ampere characteristic of the tunnel diode and its variation as a function of the resistance R connected in parallel with the diode. $R \approx 100$ ohms, $R_1 = 10$ ohms, $R_2 = 15$ ohms. By changing the value of R, we can change the slope of the decreasing part of the curve, and consequently, we can change the value of the negative resistance in the circuit. For $R > R_-$, the part AB of the circuit has a negative resistance (Fig. 6a). For $R < R_-$, this portion has a positive resistance (Fig. 6b). For $R = R_-$, the slope of the "decreasing" part is equal to zero (Fig. 6c). The latter allows us to determine experimentally the value of the negative resistance R_- of the diode itself.

5. Radiation and Absorption of Nonblack Bodies. The smoking flame of a gas burner gives more light than a properly regulated nonsmoking one, although the temperature of the latter is higher (the temperature can be measured by a thermocouple). Upon placing this flame in the path of the light beam from a

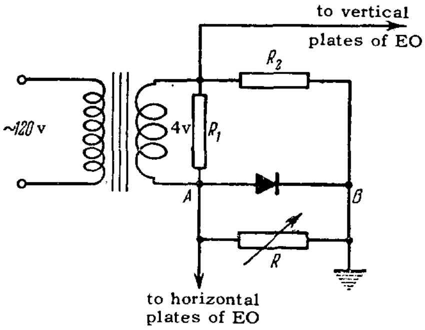

FIG. 5

projector lamp and focusing it on a screen, the smoking flame gives a considerable shadow and the nonsmoking one gives none. Thus, high absorption corresponds to high radiation. In the experiment a more distinct shadow is found for the very strongly smoking flame. This is achieved, for example, by introduction of cotton wadding soaked in oil into the adjusted flame of the gas burner.

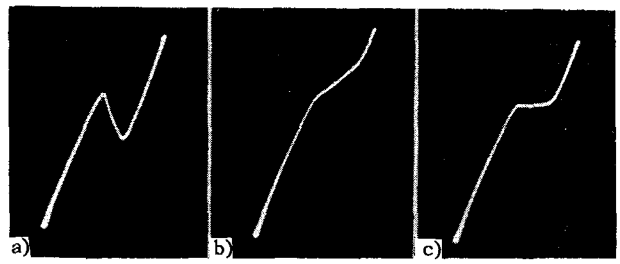

FIG. 6

Another demonstration (Kirchhoff's law) consists of the following. A white porcelain cup with a dark rim is heated in a muffle furnace. On opening the door of the furnace, the thermal equilibrium is disrupted, the temperature of the cup becomes lower than the temperature of the walls, and the observed picture is due to reflected light. Therefore, the rim is seen more plainly than the cup. Upon taking the cup from the furnace and observing it in a dark room (the experiment lasts about a half a minute, since the cup cools quickly) the rim radiates more than the white part of the cup.

6. Transients in RC and RL Circuits. The transients in RC and RL circuits in response to switching a constant emf on and off are demonstrated effectively with the aid of a low-frequency electron oscilloscope (ÉNO-1). Thanks to a long-persistent screen, one can observe the successive development of single phenomena in circuits with time constants of the order of 1 second.

[1] Lesk, Holonyak, Davidsohn, and Aarons, Germanium and Silicon Tunnel Diodes, Design, Operation, and Application, 1959 Wescon Conference Record.

Translated by R. T. Beyer
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