METHODOLOGICAL NOTES

Three-channel color oscilloscope

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The described oscilloscope is intended for lecture demonstrations of oscillatory processes. It permits simultaneous observation of three different oscillograms that are displayed on the screen of a color-television tube in the three fundamental colors red, green, and blue.

The oscillograms are obtained in this instrument by a method different from that used in ordinary oscilloscopes. The gist of the method is the following: Frame and line scanning on the screen of the tube is produced by using conventional television circuity. The horizontal scan of the beam is produced by the frame-scan unit, and the vertical scan by the line-scan unit (to this end, the deflecting system in the neck of the tube is rotated 90° relative to its usual position in the television set). The pattern consists in this case not of horizontal but of vertical lines.

The investigated voltage is converted into short pulses by a special attachment whose operation is strictly matched to the operation of the vertical deflection block. Each vertical scan corresponds to a pulse that is applied to the modulating electrode of the tube and produces a bright spot at a definite point of the screen.

The time distribution of these pulses is determined by the instantaneous values of the investigated voltage. The aggregate of the bright spots on the screen constitutes therefore an oscillogram of the investigated voltage.

Figure 1 shows a functional diagram of the oscilloscope. As seen from the diagram, a type 40LK4Ts picture tube is used, with a unified deflecting system and a convergence system, and also the unified color-television blocks, frame and line scanning blocks, blanking-pulse shaper, high-voltage amplifier, and power supply. In the frame scanning block, the parameters of the frequency-control circuit must be chosen such that the frequency band of the generator begins at approximately 20 Hz. This makes it possible, when the experiments are performed with the mains supply (50 Hz), to obtain on the screen the profile of two sine-wave periods (at a frame sweep frequency 25 Hz). The potentiometer R_4 regulates simultaneously the brightness of all three beams. The potentiometers R_{14}, R_{15}, and R_{16} (Fig. 1) make it possible to regulate separately the beam brightnesses (the shafts of these potentiometers are accessible through a slot). Figure 2 shows a diagram of the converter for one channel. As seen from the diagram, the voltage pulses in the damper winding of the output line transformer (TBC), after passing through a differentiating network (C_3R_8), are applied to the grid of the discharge tube T_{2a}, which is made conducting by the positive pulses. The capacitor C_5 is then discharged through the tube, and a sawtooth voltage is produced across the resistor R_8 and is applied through the capacitor C_4 and the resistor R_7 to the grid of the tube T_{1a}. Tubes T_{1a} and T_{1b} serve as a bilateral limiter of the sawtooth voltage. The limited sawtooth voltages are transformed into trapezoidal pulses close in waveform to square pulses. These pulses are differentiated by the network C_7R_{15} to form pulses of opposite polarity: the instant when the positive or negative pulse is produced corresponds to the start or end of the square pulse. The negative pulses are cut off by the tube T_{2b}, while the positive pulses, being shifted 180° in phase, proceed from the anode of T_{2b} through capacitor C_8 to the cathode of the television tube, causing bright spots to be produced on the screen. The aggregate of these spots forms a luminous horizontal line. If the investigated voltage is applied to the grid of tube T_{1a}, then the bilateral limitation of the sawtooth voltage at different instants of time will take place either above or below that part of the sawtooth voltage with respect to which the limitation was effected in the absence of the investigated voltage. This changes the distribution of the leading fronts of the square-wave pulses with respect to time, and accordingly also the positions of the bright spots on the tube screen, meaning that an oscillogram of the investigated voltage is produced.

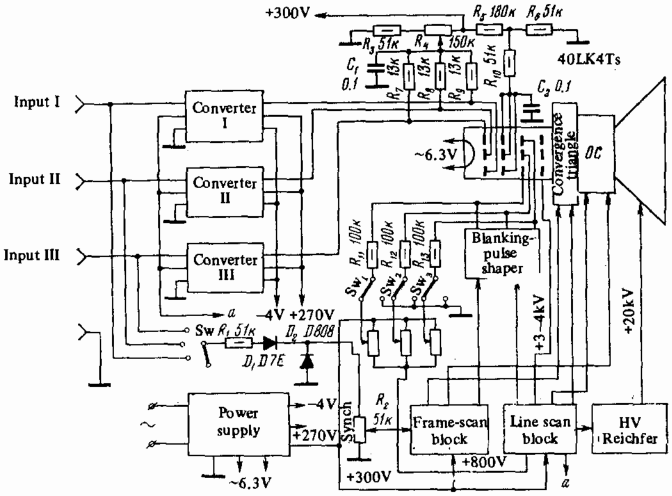

FIG. 1

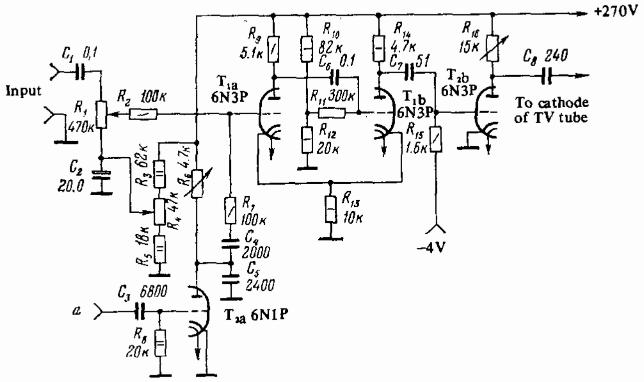

FIG. 2

The sensitivity of the oscilloscope with the described converter is approximately 1 cm/V.

The potentiometer R_1 is used to set the vertical dimension of the image. The potentiometer R_4 makes it possible to shift the oscillogram in a vertical direction. (The potentiometers R_6 and R_{16} are used only to adjust the converter.) The converters for channels II and III are similar in circuitry. To obtain static oscillograms the frame-scan block generator is synchronized with the pulses of the investigated voltage. The presence of the network $R_1D_1D_2R_2$ makes it possible to feed to the generator pulses of the required polarity with amplitude not higher than 8 V, thus protecting the generator against damage when high voltages (hundreds of volts) are applied to the oscilloscope input. The switch SW makes it possible to connect the synchronization circuit to one of the three oscilloscope inputs.

The upper frequency limit of the voltages at which high-grade oscillograms are obtained is about 2—2.5 kHz. The quality of the oscillograms deteriorates at higher frequency, since the number of points per period of the investigated voltage becomes too low. In spite of this feature of the oscilloscope, its potential for demonstrations is quite extensive.

The oscilloscope can be used to study phase relations in RLC circuits, series and parallel resonance, three-phase current (phase and amplitude relations), phase relations in a transformer; tank circuits, low-frequency oscillators; amplifiers and many other questions connected with oscillatory processes.

Detailed instructions for these demonstrations can be found in many texts[1-6]. Figure 3 shows an overall view of the oscilloscope (the screen displays a demonstration of superposition of oscillations).

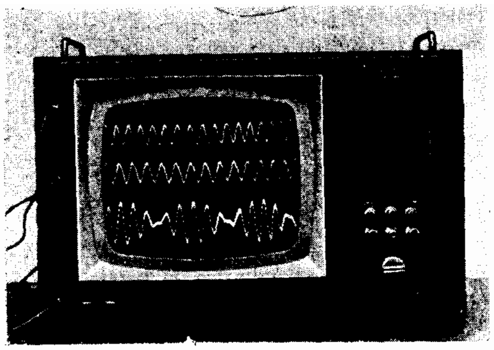

FIG. 3

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[1] M. A. Grabovskiĭ et al., Lektsionnye demonstratsii po fizike (Lecture Demonstrations in Physics), Nauka, 1965.

[2] M. A. Zgut, Naglyadnye posobiya po radiotekhnike (Demonstration Devices in Radio Engineering), Svyaz', 1964.

[3] B. Yu. Mirgorodskiĭ, Radioélektronika v shkil'nomu fizychnomy éksperymentu (Radio Electronics in Physics Classroom Experiments), Radyan'ska shkola, 1968.

[4] B. Sh. Perkal'skis, Ispol'zovanie sovremennykh nauchnykh sredstv v fizicheskikh demonstratsiyakh (Use of Modern Scientific Means in Physics Demonstrations), Nauka, 1971.

[5] G. D. Polyanina, Demonstratsii na laktsiyakh po élektrotekhnike i radiotekhnike (Lecture Demonstrations in Electrical and Radio Engineering), Uchpedgiz, 1963.

[6] The Television Set as an Oscilloscope (Editorial), Radio, No. 1, 50 (1959).

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Lecture demonstrations with an argon laser

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1. Demonstration of light interference and diffraction phenomena. We have previously described[1] certain lecture demonstrations of interference and diffraction of light, performed with a gas He-Ne laser having an optical power 10—15 mW. To demonstrate these phenomena in a large auditorium, however, requires careful prior darkening of the auditorium and preliminary adaptation of the observers' eyes. This is due, first, to the low power of the He-Ne laser and, second, to the insufficient sensitivity of the eye to the red light of this laser.

Argon lasers have much higher optical power. We used an argon laser with power from 0.5 to 2 W, depending on the operating conditions. In addition, the emission of this laser lies in a spectral region more favorable for the human eye. Using the schemes described in[1], we obtained with an argon laser patterns of diffraction by a round hole and by a sphere. The dimensions of the patterns observed on the screen reached 40—50 cm in diameter and could be photographed on "Orvo Chrom" reversible color film with an exposure of approximately one second, thus evidencing good illumination of the screen. When demonstrating these phenomena, we did not separate one of the two most intense emission lines of the argon laser (4880 and 5145 Å), since the intensity of one of the lines, depending on the laser regime, greatly exceeds that of the other and the diffraction pattern corresponding to the weaker line did not interfere with the observation of the brighter pattern.

2. Demonstration of the three-dimensional properties of a holographic image. We have previously described[2] a lecture demonstration that makes it possible to display in a large auditorium the reconstruction of the holographic image of a flat object and to illustrate certain properties of Fourier holograms.

We have now used an argon laser to reconstruct the