Electronic Transient Visualizers

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The field of application of the cathode-ray oscillograph can be greatly increased by the use of auxiliary equipment which makes possible the visual observation of circuit and line transients. The author has described a transient visualizer which accomplishes this result by means of a relay opened and closed by the sweep oscillator.[1] This device, while functioning perfectly at low frequency, had the limitations which are imposed by relay inertia and contact chatter. Experiments then in progress on the replacement of the relay by a vacuum tube circuit were not advanced sufficiently to justify more than a mention in that paper. The present paper covers a discussion of several types of electronic transient visualizers which have been developed during the past two and a half years.

In order to be of most general application it is essential that an electronic transient visualizer should have, at least during the initiation and duration of the transients, the characteristics of a switch. It should possess neither inductance, capacity, nor resistance, and should serve merely to open or close the circuit without in itself affecting the behavior of the circuit during the duration of the transient. This requirement immediately prohibits the use of devices in which the discharge or charge of a condenser or inductance is inherently associated with the action of that part of the switching circuit through which the transient current flows. The well-known parallel type of two-tube thyratron inverter circuit[2] fulfills the requirement if properly used. Since the operation of this circuit has been adequately discussed by a number of writers it does not seem advisable to discuss it here further than to state that the application of periodic voltage pulses to the grids results in a periodic transfer of anode current from one tube to the other.

Unmodified transients may be initiated in a transient circuit connected in series with the anode of either tube. If the grid excitation voltage is obtained from the sweep circuit which provides the linear time axis, then one transient can be produced for each sweep of the oscillograph spot, and a stationary image be obtained.

[1] "A Combination Sweep Circuit and Periodic Contactor, etc."; H. J. Reich; R. S. I.; 5; 7-9; (1934).
[2] "Hot Cathode Thyratrons"; A. W. Hull; G. E. Rev.; 32; 399; (1929) Electron Tubes in Industry; Keith Henney; 205-215; (McGraw-Hill; 1934).

A number of circuits based on the parallel type of inverter were developed by the author at the University of Illinois and by Mr. John Bennett at Cornell University[3] during the years of 1934 and 1935.

Although the operation of these parallel switching circuits was found to be excellent at high anode currents, the author observed that the action was somewhat erratic when an attempt was made to work with small currents. Further investigation revealed that the difficulty resulted from the fact that at small currents the anode current of grid-controlled arc-discharge tubes is not independent of grid bias, but that the current may be decreased and even cut off by the application of negative grid voltage.

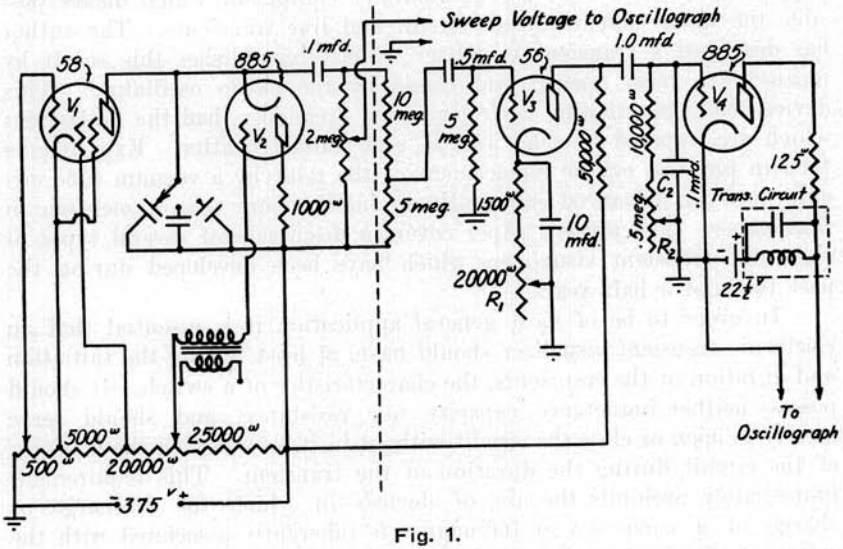

Fig. 1.

Fortunately this dependence of anode current upon grid voltage, although it is undesirable in a two-tube parallel circuit, makes possible the design of a simplified single-tube circuit. If the saw-tooth voltage of the sweep oscillator is applied to the grid of an 885 tube in such a direction that the sudden voltage jump at the end of the sweep makes the 885 grid negative, then, because of the rapidity of this change in voltage, the anode current of the 885 tube will fall to zero in a small fraction of a second. The tube fires instantaneously when the negative grid voltage has fallen to a critical value, the magnitude of which depends upon the applied anode voltage. The tube therefore has the required switching characteristics both for starting and interrupting current flow, and may be used in initiating repeated transients in synchronism with the sweep voltage. The complete combined sweep-circuit and single-tube transient visualizer is shown in the accompanying

[3] A thesis submitted for the degree of Master of Science at Cornell University, June, 1935, by John Bennett.

diagram. The portion of the circuit to the left of the dotted line is a standard sweep oscillator; the portion to the right represents the addition which must be made to the circuit for transient visualization. In many transient studies the 22½ volt battery in the visualizer circuit may be replaced by a tap on the main supply-voltage divider. The 125-ohm resistor in the anode circuit of V_4 may be reduced or eliminated if the resistance of the transient circuit is sufficient to limit the anode current to a value small enough so that the grid can extinguish the tube (50 milliamperes or less). The function of C_2 is to delay the firing of V_4 until after the cathode spot has returned to the beginning of its timing sweep. The conduction time of V_4 is adjusted by varying either R_1 or R_2.

The circuits which have been described in this paper have been found to be of considerable value in the lecture demonstration and laboratory study of circuit and line transients. The possibility of observing directly the effects of variation of circuit parameters is an especial advantage. Photographic records may be obtained by photographing the oscillograph screen, an uncorrected 2½-inch double-convex lens giving very satisfactory results. The high stability of the circuits is proved by the fact that sharp photographs are obtained with exposures of 15 seconds or more. An important feature of these circuits is that they can, with little complication, be added to a standard sweep oscillator.