May 22, 1945. A. M. SKELLETT 2,376,395

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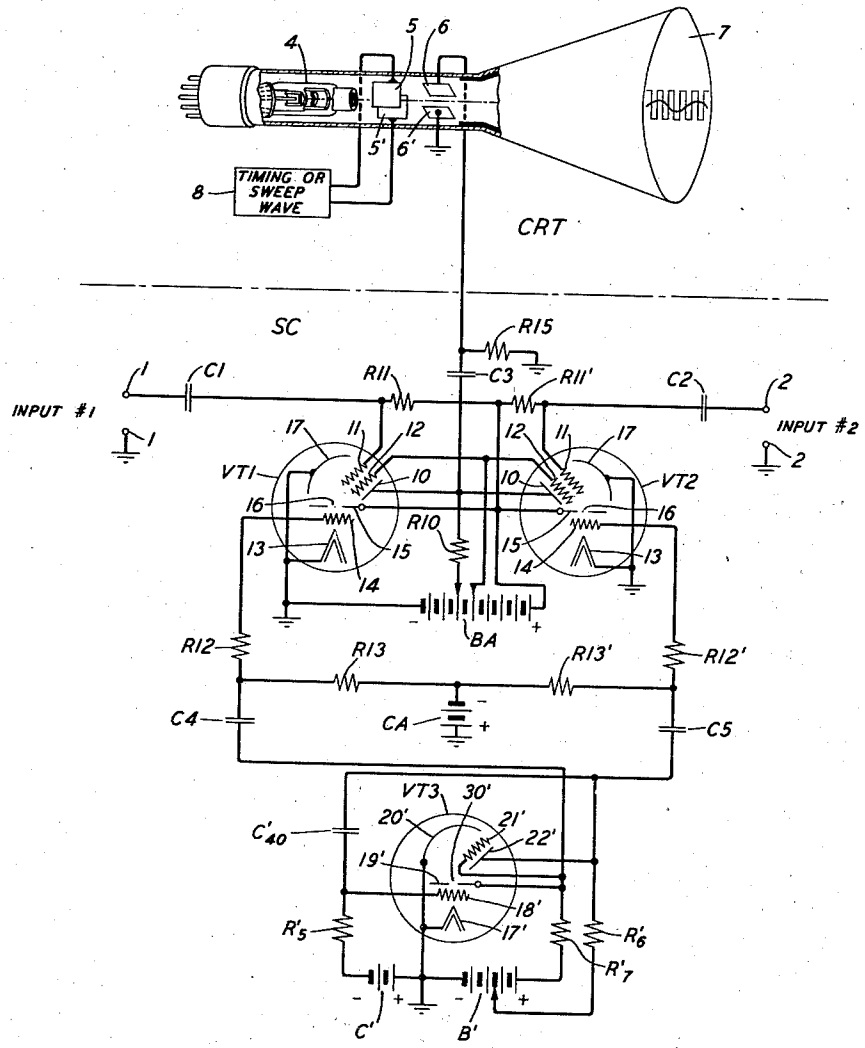
Filed March 5, 1943



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Patented May 22, 1945 2,376,395

UNITED STATES PATENT OFFICE

2,376,395

ELECTRON SWITCHING MEANS AND CIRCUIT

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Application March 5, 1943, Serial No. 478,108

8 Claims. (Cl. 250—27)

In my pending application Serial No. 422,228, filed December 9, 1941, for Electronic devices and circuits, there is disclosed a vacuum tube or electronic device comprising a primary electron section and a secondary electron section, and a number of circuit applications of that device in which the secondary electron section constitutes an "electronic contact." The secondary electron section comprises a pair of spaced electrodes, one of which may be a plate electrode treated on one surface so as to emit secondary electrons in ratio greater than unity when bombarded by primary electrons, and the other of which may be a perforated or grid electrode through which the primary electrons have access to the plate electrode and constituting a collector electrode for the secondary electron emission. The electronic contact is "closed" by establishment of secondary electron emission between the electrodes of the secondary section, and is "open" during absence of or disestablishment of the secondary electron emission condition.

This invention involves a modification of the referred to device and the utilization of the device either in its original or its modified aspect in an electron switch or switching circuit.

It is frequently desired or necessary to examine a plurality of variables or transients simultaneously and visually. This may arise in the conduct of experimental investigations; or it may be for the purpose of comparing during the process of manufacture, a characteristic of a device or circuit under construction against that of a standard device or circuit. It is known to use a cathode ray tube oscillograph, the variables or transients to be compared or examined being applied in chosen sequence so that their wave forms or other indicia become visible upon the screen or target of the cathode ray tube in rapid succession. The effect of simultaneous signal application is obtained as a result of the high rate of switching from one signal source to another, the time lag of light decay from the screen or target of the cathode ray tube, and persistence of vision. The switching rate is chosen such that the traces on the luminescent screen are repeated at a frequency equal at least to that required for persistence of vision.

An object of the invention is to provide a switching circuit including secondary emission type vacuum tubes or devices, for successively switching from one to another of a plurality of signal sources.

Another object of the invention is to provide a switching circuit for successively switching from one to another of a plurality of signal sources, at a high rate, for example, at a frequency of 100,000 to 1,000,000 or more times per second.

Still another object of the invention is to enable the use of secondary electron type vacuum tubes or devices embodying electronic contacts, in switching circuits requiring opening and closing of the electronic contacts at high frequency.

In accordance with the invention, a switching circuit is provided which may be used with a cathode ray tube oscillograph to enable simultaneous observation or examination of a plurality (in an illustrative circuit—a pair) of variable signals or transients. The switching circuit comprises a square wave generator or multivibrator and a pair of vacuum tube or electronic switches.

The multivibrator may comprise a single electron discharge device of the type disclosed in my Patent 2,293,177 of August 18, 1942, for Electron discharge device circuits, and the circuit arrangement may be based on that of Fig. 12 of that patent. This generator constitutes a source of two square-topped waves, 180 degrees out of phase, which, by appropriate choice of circuit constants, may be of a desired magnitude and frequency, for example, up to a million cycles per second, or more.

Each electronic switch may comprise a secondary electron type vacuum tube of the type disclosed in my above-mentioned pending application Serial No. 422,228, modified to include an additional electrode in the secondary electron section, the additional electrode comprising a grid electrode interposed between the secondary emitter and collector electrodes and to be maintained at a potential of a magnitude between that to which the secondary emitter and collector electrodes are adjusted. The sources of signals to be examined are connected with one and the same pair of ray deflecting plates of the cathode ray tube through the electronic contacts constituted by the secondary electron sections of the tubes, one source being so connected through the electronic contact in one tube, and the other source through the electronic contact of the other tube.

The square wave generator and the primary electron sections of the electron switches are so interconnected that one square-topped wave is supplied to the input electrodes of the primary section of one electron switch and the other square-topped wave is supplied to the input electrodes of the primary section of the other electron switch. Primary electron flow in each pri-

mary section may thus be controlled or regulated alternately to establish and disestablish secondary electron emission in the secondary electron section of the respective electron switch, the two electron switches operating in sequence by virtue of the 180 degree phase separation of the two control waves. The resultant alternate closing-and-opening of the electronic contacts enables the alternate application to the cathode ray tube of the signals from the sources under examination, at a rate determined by the frequency of the square-topped wave output of the generator.

The additional grid in the secondary electron section of each electron switch constitutes an electrostatic shield between the secondary emitter and collector electrodes of the section. The higher the frequency of switching between the two sources the smaller the capacitance that may be tolerated in the connection coupling the sources to the respective electronic contacts. The inherent capacity of the latter, at or above a particular frequency of operation, might be of the same order or of greater magnitude compared to such coupling capacitance. In the absence of the additional grid, there might be for such conditions, transmission across the electronic contact even during the "open," that is, no secondary electron flow condition of the electronic contact.

A more complete understanding of the invention will be obtained from the detailed description that follows taken in conjunction with the single figure of the accompanying drawing showing a circuit arrangement illustrative of the invention.

The invention is illustrated as embodied in a switching circuit SC for association with a cathode ray tube CRT for enabling simultaneous examination visually of the wave forms of a plurality, for example, a pair of variable signals. The sources of these variable signals are indicated as Input No. 1 and Input No. 2 at the input terminals 1, 1 and 2, 2 of the switching circuit.

The cathode ray tube may be of conventional type comprising an electron ray source or electron gun 4, two pairs of electron ray or beam deflecting plates 5, 5' and 6, 6', and including an enlarged screen or target portion 7 coated on its inner surface with suitable fluorescent or luminescent material to provide "visual" indication of the electron beam incident thereon. The plates 5, 5' may be connected to any suitable source 8 of a sweep or time-axis wave, and the plates 6, 6' are connected through the switching circuit SC to the sources of the signals to be examined.

The switching circuit comprises a plurality of secondary electron emission type vacuum tubes VT1, VT2, VT3. The tubes VT1, VT2 are a modification of a vacuum tube electronic contact device disclosed in my aforementioned pending application Serial No. 422,228. Each tube VT1, VT2 comprises a primary electron section and a secondary electron section or electronic contact, in an evacuated enclosure or envelope. The latter comprises a plate electrode 10 and a grid electrode 11. The former (electrode 10) is treated on one surface so as to emit secondary electrons in ratio greater than unity when bombarded with primary electrons impinging with suitable velocity on the treated surface. The grid electrode is in the path of such primary electrons to the electrode 10, and is adapted to collect secondary electrons emitted by electrode 10. The primary electron section comprises a primary electron source or cathode 13, an input control grid 14 and a primary anode 15, the latter having an aperture or window 16 therein for the escape of a portion of the primary electrons arriving at the primary anode. A deflector electrode or plate 17 at cathode potential, is positioned in the normal path of the escaped primary electrons and deflects or bends such escaped electrons into the secondary electron section and onto the electrode 10. As explained in detail in the aforementioned application, when the electrodes 10, 11 are connected to a suitable source of potential positive with respect to the cathode and through resistors of appropriate proportions, and the electrode 10 is bombarded with primary electrons so as to establish secondary electron flow between the electrodes 10, 11, the latter constitute in effect a low resistance contact and are adapted to transmit electric signals or waves bidirectionally. In the absence of primary electron bombardment sufficient to establish and maintain such secondary electron flow, the electronic contact constituted by the electrodes is "open." By variation within suitable limits of the control grid potential relative to that of the cathode, the magnitude of primary electron flow to the primary anode, and consequently the amount of escaped electron flow to the electrode 10, may be regulated to "close" or to "open" the electronic contact, as explained in greater detail in the aforementioned application.

Each cathode 13 is connected to ground and each primary anode is connected to the high potential terminal of a source BA of direct current potential, for example, a battery, for the primary anodes and the electrodes of the electronic contacts. The electrodes 11 are connected through resistors R11, R11' to the high potential terminal of source BA, and the electrodes 10 are connected to a terminal of lower potential of source BA through a common resistor R10. The electrode 11 of tube VT1 is connected to one of the terminals 1, 1 through a condenser C1, and the corresponding electrode of tube VT2 is connected through a condenser C2 to one of the terminals 2, 2. Each electrode 10 is connected through a condenser C3 to one of the pair of cathode ray tube deflector plates 6, 6', for example plate 6, the other plate being connected to ground, and also to ground through a resistor R15. The input grids 14 are connected through resistors R12, R12', R13, R13' to the low potential terminal of a source CA of direct current biasing potential, for example, a battery, and through coupling condensers C4, C5 to output terminals of the circuit of the tube VT3. The grid bias provided by the source CA may be such that the primary electron flow to the primary anode in each tube VT1, VT2 is insufficient to establish the secondary electron flow in the secondary electron section so as to close the electronic contact, that is, the electronic contacts would be "open." For a purpose to be explained more fully hereinafter, each tube VT1, VT2 includes a third electrode 12 in its secondary electron section. The electrode 12 may be a grid and is interposed between the electrodes 10, 11 and is connected to a terminal of the source BA such that its potential is between the potentials at which the electrodes 10, 11 are operated.

The tube VT3 is of the type disclosed in my aforementioned Patent 2,293,177. It comprises a primary electron section having a primary electron source or cathode 17', an input control grid 18' and a primary anode 19' containing an aperture 30' for the escape of a portion of the primary electrons reaching the primary anode; a

secondary electron section comprising a pair of auxiliary electrodes 21', 22', the electrode 22' being a plate having a surface treated to emit secondary electrons in ratio greater than unity when bombarded with escaped primary electrons, and the electrode 21' being a grid positioned in the path of escaped primary electrons to the electrode 22', and adapted to collect secondary electrons emitted by the electrode 22'; and a deflector electrode or plate 20' tied to the cathode and positioned in the normal path of the escaped primary electrons to deflect or bend the latter in a direction to cause the escaped electrons to bombard the electrode 22', all of the electrodes being in a common evacuated envelope. The control grid is connected to grounded cathode through a resistor R_5' and a source C' of direct current biasing potential, and to the electrode 22' through a condenser C_{40}'. The secondary electron collector grid 21' and the primary anode 19' are connected through a resistor R_7' to the high potential terminal of a source B' of direct current potential, the low potential terminal of which is connected to the grounded cathode, and the secondary electron emitting electrode 22' is connected through a resistor R_6' to a point on the source B' at a potential lower than that of the high potential terminal. The tube VT3 and its associated resistors, condenser and potential sources constitute a square wave generator or multivibrator of the type disclosed and described in my Patent 2,293,177 with reference to Fig. 12 of the drawing of that patent, the corresponding components of the square wave generator of this disclosure bearing the same designations primed. By suitable selection of the circuit constants, the instantaneous potential of the control grid 18' with reference to the cathode may be caused to swing repetitiously between wide limits, whereby both primary electron and secondary electron flow in the tube vary abruptly between wide limits because of the trigger action of the tube, such that the instantaneous potentials on the primary anode 19' and auxiliary anode 22' vary abruptly but in opposite directions. These potential variations are impressed on the input control grids 14 of the tubes VT1, VT2, through the condensers C4, C5, as square-topped waves 180 degrees out of phase. The frequency of the waves will be the same and of a value determined by the constants of the multibrator circuit.

In the operation of the circuit arrangement described, the sources constituting Input No. 1 and Input No. 2 will be connected to terminals 1, 1 and 2, 2 and the square wave generator will be continuously supplying the square-topped control waves to the input grids of tubes VT1, VT2. As indicated, in the absence of the control waves, the input grids 14 are at a potential with respect to their cathodes such that the permitted primary electron flow is insufficient to enable secondary electron emission in and closure of the electronic contacts of the tubes. The decrease in the potential difference between the input grid and its associated cathode during each positive half cycle of the control wave will be sufficient to permit such an increase in the primary electron flow in the particular tube that secondary electron flow is established in the secondary electron section and the electronic contact is closed. During the other half cycle of the control wave, the tube will be restored to its initial condition. Since the control waves are 180 degrees out of phase, the secondary electron sections of the two tubes will be energized alternately, that is, one electronic contact will be closed while the other is open, and vice versa. During the time the respective electronic contact is closed, signal wave from Input No. 1 or Input No. 2, as the case may be, will be impressed on the cathode ray tube deflecting plates 6, 6' through the condenser C1 or C2, the electronic contact of tube VT1 or VT2, and condenser C3 and resistor R15. The electron ray or beam of the cathode ray tube will be caused, therefore, to trace alternately the wave forms of the signals, from the two sources. By causing the tubes VT1, VT2, to switch on and off at a sufficiently high rate, and aided by persistence of vision, the traces of the wave forms will in effect appear simultaneously on the cathode ray tube target 7, as illustrated for signal inputs at terminals 1, 1 and 2,2 of different wave forms.

As the rate at which the vacuum tubes or electron switches VT1, VT2 are operated is increased, that is, as the frequency of the square-topped control wave input to the tubes is chosen of a higher value the capacity of the coupling condensers C1, C2 must be decreased. If the switching rate or frequency is made sufficiently high, for example, of the order of 10^5–10^6 cycles per second or more, a frequency will be reached at which the magnitude of the interelectrode capacity between the secondary electron emitter electrode 10 and its associated collector grid 11 in each tube VT1, VT2 will be found to be of the same order or greater than that of the coupling condenser C1, C2 required at that frequency. Under such condition, the electronic contact will not be "open" during absence of secondary electron flow between the electrodes constituting the contact, but will provide a capacitive path for the signal wave. The provision of the additional or grid electrode 12 between the electrodes constituting the electronic contact and maintaining such grid 12 at a direct current potential between the operating or working potentials of the contact electrodes corrects for this condition by introducing an electrostatic shield between the electrodes of the electronic contact, thereby reducing the effective capacity between the contact electrodes to a value small compared to that of the condenser.

Since the electronic contacts of the tubes VT1, VT2 have bidirectional transmission properties upon establishment of secondary electron flow therein, it will be evident to the skilled in the art that if the cathode ray tube were replaced by a suitable signal wave source and the signal sources connected to terminals 1, 1 and 2, 2 were replaced by suitable utilization or load circuits, the switching circuit 5C could be employed to supply such utilization circuits sequentially or alternately from a common or single signal wave source, at a rate or frequency governed by the square-topped wave generator. Other circuit applications of the tubes VT1, VT2 will readily occur to the skilled in the art, those specifically described above being by way of illustration of presently preferred embodiments of the invention.

What is claimed is:

1. In combination, a plurality of signal sources of varying voltage, a common utilization circuit for the signals originating in said sources, a separate transmission path connecting each source to said common circuit to supply energy of the source to the circuit, an electronic contact in each path comprising a pair of spaced electrodes in an evacuated enclosure, for changing the ef-

ficiency of the path with respect to transmission of signal to said common circuit upon establishment of secondary electron flow between said electrodes, and means for momentarily establishing secondary electron flow between the electrodes of each contact in sequence, whereby signals are supplied sequentially from said sources to said common circuit.

2. In combination, a pair of signal sources of varying voltage, a common utilization circuit for the signals originating in said sources, a separate transmission path connecting each source to said common circuit, an electronic contact in each path connected in serial relation to one of said sources and said circuit and comprising a pair of spaced electrodes in an evacuated enclosure, for closing the path for transmission of signal to said common circuit upon establishment of secondary electron flow between said electrodes, each of said pairs including a secondary electron emitting electrode and a secondary electron collecting electrode, and means for establishing secondary electron flow between the electrodes of each contact in alternation, whereby signals are supplied alternately from said sources to said common circuit, said means comprising primary electron emitting means associated with said contacts to emit electrons for bombarding said secondary electron emitting electrodes to produce electron emission therefrom, direct voltage supply means, means connecting said primary electron emitting means to a point on said direct voltage supply means, two separate impedances to signal currents, one of said impedances connecting a second point on said direct voltage supply means of higher potential than said first point to an electrode of one of said pairs, and the other of said impedances connecting said second point to an electrode of the other pair, a common impedance to signal currents connecting the other electrode of each pair and said utilization circuit to a point on said direct voltage supply means of potential higher than that of said first point and different from that of said second point, a separate control grid for each electrode pair for controlling said primary electrons, means for fixing the potentials of said control grids with respect to said first point, and means for changing said potentials of said control grids in the same sense alternately.

3. In combination, a source of variable signal, a utilization circuit, a signal transmission path connecting said source and circuit, a condenser and an electronic contact serially included in said path in serial relation to said source and said circuit, said electronic contact comprising a pair of spaced electrodes in an evacuated enclosure, the signal path between said electrodes being closed by establishment of secondary electron flow between said electrodes, the capacity of said condenser and the capacity between said electrodes being of about the same order of magnitude, an electrostatic shield between said electrodes to reduce the effective capacity between said electrodes to a value small compared to that of the condenser, and means to establish secondary electron flow between said electrodes intermittently at a high frequency, whereby signal from said source is supplied to said circuit intermittently at such frequency.

4. In combination, a pair of sources of variable signal, a common utilization circuit, a signal transmission path individual to each source for connecting it with said common circuit, a condenser and an electronic contact serially included in each of said paths in serial relation to its connected source and said common circuit, each electronic contact comprising a pair of spaced electrodes in an evacuated enclosure, the signal path between said electrodes being closed by establishment of secondary electron flow between said electrodes, the capacity of the condenser in each path and that between the electrodes of the electronic contact in the same path being of about the same order of magnitude, an electrostatic shield between the electrodes of each electronic contact to reduce the effective capacity between its electrodes to a value small compared to that of its associated condenser, and means to establish secondary electron flow between the electrodes of the respective electronic contacts in alternation, whereby signal will be supplied alternately from said sources to said common circuit.

5. A wave translating system comprising an evacuated enclosure, a pair of spaced electrodes therein, an electrostatic shield in the space between said electrodes, a source of electrons for establishing electron flow between the electrodes in the form of secondary electrons emitted by one electrode upon its being bombarded with electrons from said source, two separate impedances of substantial value for high frequency, one of said impedances being connected between said shield and one of said electrodes, and said other impedance being connected between said shield and said other electrode, and means maintaining the electrodes at different potentials positive with respect to said source and maintaining the average potential of the shield at a value between the working potentials of the electrodes.

6. A switching circuit for interconnecting a plurality of signal wave circuits, comprising a signal wave transmission path connecting one of said circuits and a second of said circuits to supply signal energy of one to the other, a second signal wave transmission path connecting a third of said circuits and said second-mentioned circuit to supply signal energy of one to the other, each of said paths including an electronic contact comprising a pair of spaced electrodes in an evacuated enclosure, the signal path between said electrodes being closed for bidirectional transmission therethrough upon establishment of secondary electron flow between said electrodes, a direct current path from one electrode of each pair to the other electrode of the pair with means for producing direct voltage included in each of said two direct current paths, and means to establish secondary electron flow in said contacts alternately at a selected frequency, whereby said transmission paths are closed alternately for signal wave transmission between said first-mentioned and third-mentioned circuits and said second-mentioned circuit.

7. A wave translating system comprising an electronic device having a primary electron section including an electrode and a secondary electron section including two other electrodes, a source of voltage waves coupled to said first-mentioned electrode and one of said two electrodes, a load circuit coupled to said first-mentioned electrode and the other of said two electrodes, an electrostatic shield interposed between said two electrodes, and a connection of low impedance to high frequency between said shield and said first-mentioned electrode.

8. A wave translating system comprising a source of voltage waves, a load circuit, a coupling circuit for coupling said source and said load cir-

cuit including a secondary electron emitter and a secondary electron collector having a secondary electron discharge path therebetween for controlling the transmission efficiency of said coupling circuit, an electrostatic shield between said emitter and said collector, means comprising a source of primary electrons for producing a stream of electrons bombarding said emitter, means producing variations of said electron stream that vary the impedance of said discharge path with such rapidity that in the absence of said shield the interelectrode capacity of said emitter and said collector would substantially reduce the control of said discharge path over said transmission efficiency, means for supplying direct voltage, a resistance connecting said emitter to a point having one potential on said direct voltage supply means, a resistance connecting said collector to a point of higher potential on said direct voltage supply means, and a connection between said shield and a point on said direct voltage supply means at a potential between the potentials of the two first-mentioned points.

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