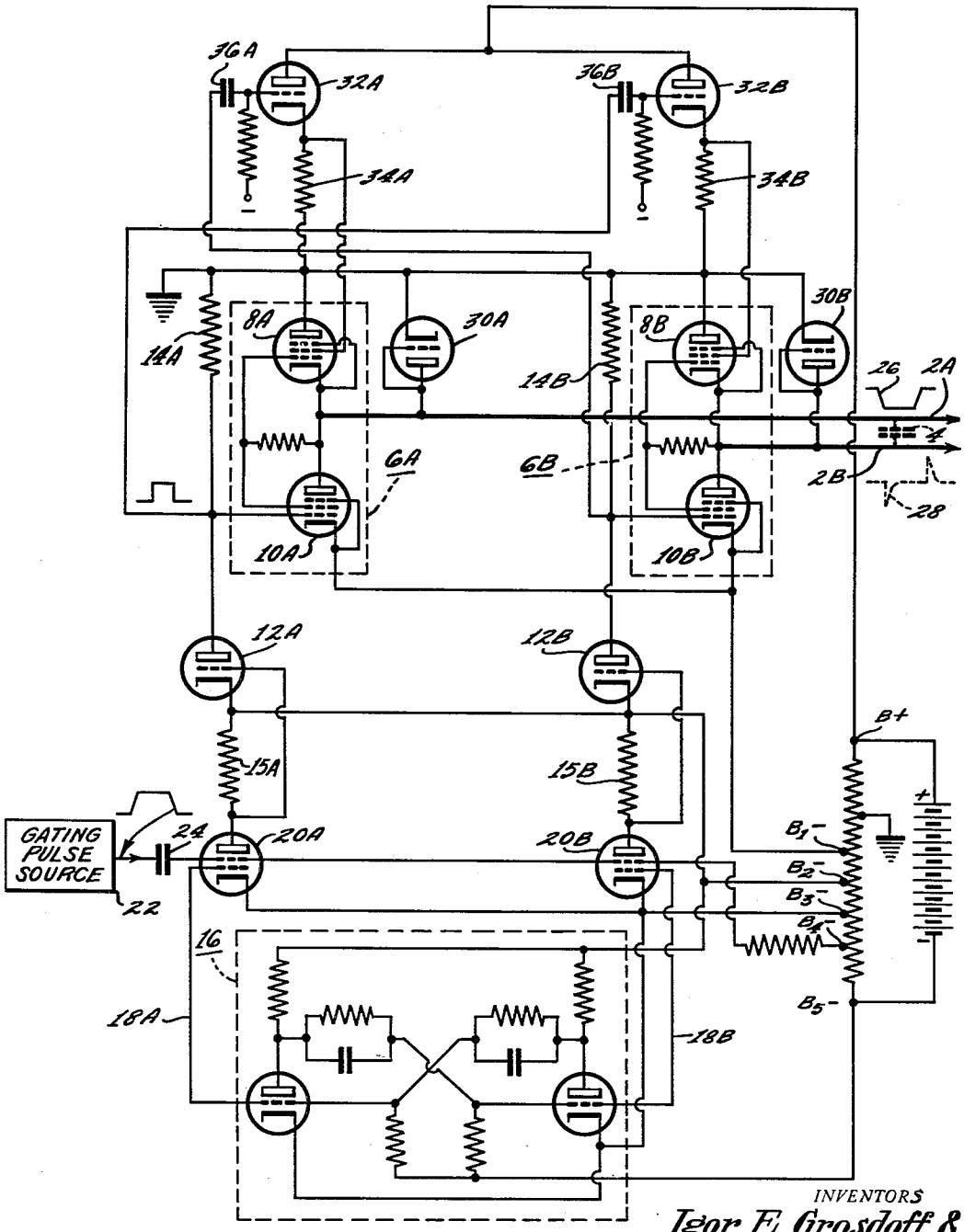
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SYSTEM FOR ELIMINATING ELECTROSTATIC CROSS-COUPLING EFFECTS

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SYSTEM FOR ELIMINATING ELECTROSTATIC CROSS-COUPLING EFFECTS

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This invention relates to electronic apparatus carrying discontinuous signals, and more particularly to the elimination of effects of electrostatic cross-coupling between electrical conductors in such apparatus.

It is sometimes necessary to juxtapose mechanically a plurality of electrically-conductive surfaces. If the surfaces are not shielded from each other, they are electrostatically cross-coupled, so that voltage signals on one of the surfaces may affect the voltage levels on others of the surfaces.

One place in which this capacitive coupling between conductors arises is in a storage tube of the type described in "The selective electrostatic storage tube" by J. Rajchman, RCA Review, March 1951, pages 53–97. In that storage tube, electron emission is controlled by the voltage levels on two orthogonal sets of spaced parallel bars or wires. When the control voltages on two orthogonal pairs of wires are at one level, electron emission passes through the "window" formed by those four wires; when the control voltages are at another level, the electron emission is suppressed. These wires are necessarily capacitively coupled. Consequently, when control voltages are applied to one wire in the form of voltage impulses, adjacent wires which are not pulsed and should not change in voltage, nevertheless, have impulses produced on them through the capacitive coupling.

Accordingly, it is an object of this invention to provide a novel system for eliminating the effects of electrostatic cross-coupling between a plurality of conductors.

Another object of this invention is to provide simple apparatus for a plurality of electrostatically cross-coupled surfaces to eliminate impulses that appear on one surface when voltage impulses are applied to another surface.

Still another object of this invention is to provide a new and simple system and apparatus for maintaining one conductor at a predetermined voltage level when voltage impulses are applied to another conductor which is electrostatically cross-coupled to the first.

These and other objects of this invention are achieved in an embodiment incorporating a pulse amplifier circuit of the type described in the U. S. patent to Igor E. Grosdoff, No. 2,628,290, issued on February 10, 1953. This circuit is made up of two pentodes connected in series, and it applies pulses to an output conductor connected to the junction of the tubes. In an arrangement of a plurality of these pulse amplifier circuits, the plurality of output conductors attendant therewith are electrostatically cross-coupled. Thus, if a square-wave pulse is applied to a first one of the conductors, by its amplifier circuit, and and a second one of the conductors is not pulsed, differentiated pulses appear on the second conductor through the capacitive coupling. To eliminate one of the differentiated pulses, one of the tubes of the amplifier circuit for the second conductor is rendered conductive to provide a low-impedance path for that pulse. This tube is rendered conductive upon the operation of the amplifier circuit for the first conductor. The other of the differentiated pulses is eliminated by a clamping diode connected between the second conductor and a reference potential level. A duplicate arrangement is provided for eliminating the differentiated pulses that apepar on the first conductor when the second conductor is pulsed by its amplifier circuit.

The novel features of this invention, both as to its organization and mode of operation, may be better understood from reading the following description, together with the accompanying drawing.

Shown in the drawing are a first and second electrical conductor 2A, 2B which are unshielded and mechanically mounted adjacent each other so that they are electrostatically coupled. The resulting capacitance 4 between the two conductors is shown in broken lines. Pulses are applied to each conductor 2A, 2B by means of an amplifier 6A, 6B. The pulse amplifier circuit is of the type described in the patent cited above. Each amplifier 6A, 6B is made up of a first and second pentode 8A, 8B, 10A, 10B connected in series. The cathode of the first tube 8A, 8B is connected to the anode of the second tube 10A, 10B and also through a resistor to the screen grid of the second tube 10A, 10B. The control grid of the first tube 8A, 8B is connected to the screen grid of the second tube. The anode of the first tube 8, 8B is connected to a reference potential level or ground. A negative potential B_1— is applied to the cathode of the second tube. Each amplifier 6A, 6B is driven by a driver tube 12A, 12B whose anode is connected to the control grid of the second tube 10A, 10B and also through a load resistor 14A, 14B to ground. A negative potential B_2— is applied to the cathode of the driver tube 12A, 12B, and the control grid of the driver tube is connected to the cathode of that tube through a grid resistor 15A, 15B.

The operation of the driver tubes for the first and second amplifier circuits is in accordance with the condition of a trigger circuit 16 of the bistable multivibrator type. The trigger circuit 16 shown is a well known Eccles-Jordan circuit in which a pair of tubes have their anodes and control grids cross-coupled. This circuit has two stable conditions and it produces two output potentials, one high and one low, depending upon which tube is made conducting. The outputs 18A, 18B of the trigger circuit 16 are coupled to the driver tubes through separate gating tubes 20A, 20B which afford a time control of circuit operation. The outputs 18A, 18B of the trigger circuit are connected respectively to the first of the control grids of each of the gating tubes 20A, 20B, and gating pulses are applied from an appropriate pulse source 22 to the second control grids of the gating tubes 20A, 20B in parallel through a capacitor 24. The anode of each gating tube 20A, 20B is connected to the control grid of the associated driver tube 12A, 12B, and also through the grid resistor 15A, 15B to the second negative potential level B_2—. A third negative potential level B_3— is applied to the cathodes of the gating tubes 20A, 20B, a fourth and a fifth potential level B_4— and B_5— respectively provide the negative bias for the second control grids of the gating tube and the grids of the trigger circuit tubes, and the second and third negative potential levels B_2— and B_3— are applied across the trigger circuit tubes.

The operation of the circuit described thus far is as follows: In the absence of a gating pulse, the driver tubes 12A, 12B are at zero bias and conducting so that their anodes are at a low potential level, and the second pentodes 10A, 10B of the amplifier circuits are cut off. Thus, there is no current flowing in either series arrangement of the two pentodes 8A, 10A, 8B, 10B and both output conductors 2A, 2B are at ground potential. One or the other of the amplifier circuits 6A, 6B is operated with the application of a gating pulse depending upon the condition of the trigger circuit 16. Assuming the left tube of

the trigger circuit is conducting and the right tube is cut off, then the first control grid of the first gating tube 20A is high with respect to the cathode potential B_3- and the tube conducts with the application of a positive gating pulse. When the first gating tube 20A conducts, the control grid of the driver tube 12A goes negative cutting the driver tube 12A off. Thus, a large positive pulse is applied to the control grid of the second pentode 10A of the first amplifier and it conducts causing the potential at the first conductor 2A to drop sharply. As screen current is drawn through the second pentode 10A, the voltage at the control grid of the first pentode 8A drops so that the first pentode is at least partly cut off. Upon termination of the gating pulse, the operation reverses itself as the driver tube 12A is restored to its normal conductive state cutting off the second pentode tube 10A. The first pentode 8A then starts to conduct heavily restoring the first output conductor 2A to ground potential. Thus, a negative output pulse 26 appears on the first output conductor 2A.

Since the first control grid of the second gating tube 20B is at the low output potential of the trigger circuit 16, the tube 20B is not rendered conductive by the gating pulse, and the second amplifier 6B is not operated at this time. However, due to the capacitive coupling 4 between the first and second output conductors, the second output conductor is not maintained at ground potential; but, instead differentiated pulses 28 (shown with broken lines) appear on the second output conductor 2B. In a similar manner when the trigger circuit condition is reversed, a gating pulse causes the operation of the second amplifier circuit 6B so that a negative output pulse is produced on the second output conductor 2B and differentiated pulses appear on the first output conductor 2A through the capacitive coupling 4.

In order to eliminate the positive going swing of the differentiated cross-talk voltages 28, a first and second triode 30A, 30B are provided with the anodes respectively connected to the first and second conductors 2A, 2B and the cathodes connected to ground. The control grids of these triodes are connected to their anodes to provide diodes of large current capacity. By means of these diodes 30A, 30B, the first and second output conductors 2A, 2B are clamped to ground so far as positive-going pulses are concerned.

In order to eliminate the negative swing of the cross-talk voltages 28, a first and second cathode follower 32A, 32B are respectively connected to the first and second amplifiers 6A, 6B. The cathode of each cathode follower 32A, 32B is connected to the screen grid of the associated first pentode tube 8A, 8B. The cathode resistors 34A, 34B are connected to ground. The anodes of the cathode followers are connected to the positive side of a source of operating potential B+, and their control grids are negatively biased to cutoff potential, and, also, respectively coupled through capacitors 36A, 36B to the anodes of the second and first driver tubes 12B, 12A.

The operation is as follows: When the first driver tube 12A is cut off and the first amplifier circuit 6A operated, the positive going pulse at the anode of the first driver tube 12A is also applied to the second cathode follower 32B. The voltage at the cathode of the tube 32B rises, so that the voltage at the screen of the first pentode 8B in the second amplifier 6B also rises. This causes screen current to flow in the first pentode 8B reducing the impedance of that tube and, thereby, likewise reducing the impedance of the second output conductor 2B. Consequently, the negative cross-talk voltage which appeared on the second output conductor is eliminated or reduced to tolerable limits. Similarly, when the trigger circuit 16 is in the opposite state, and the second amplifier 6B is operated to produce a negative output pulse on the second conductor 2B, a positive pulse is applied to the control grid of the first cathode follower 32A. Thus, there is an increase in voltage at the screen grid of the first pentode tube 8A of the first amplifier 6A causing screen current to flow. Accordingly, a low impedance path is provided for the negative cross-talk voltage on the first output conductor 2A.

In the absence of a gating pulse, neither one of the amplifiers 6A, 6B are operated, and, correspondingly, the cathode followers 32A, 32B remain cutoff so that both output conductors 2A, 2B remain electrically flat. The circuit has been described with either one or the other, but not both, of the amplifier circuits 6A, 6B being operated, in accordance with the trigger circuit 16 being in one or the other of two possible states. The invention, of course, is not restricted to any particular system for determining the operation of the amplifier circuits 6A, 6B. In other arrangements than that shown, both amplifier circuits might be operated at the same time. Under such circumstances, logic circuitry may be provided to keep both cathode followers 32A, 32B cut off at that time. An alternative system is made possible by the fact that an increase in voltage at the screens of the first pentodes during the plateau of the pulse does not affect the output-pulse waveshape materially, because the control grids of the pentodes are held negative during this time. Therefore, when both amplifiers are operated, both cathode followers may be pulsed without adverse effects.

This invention is not limited in its application to an arrangement involving two capacitively-coupled conductors. It may also be applied to an arrangement in which several conductors are capacitively coupled. Under such circumstances, an alternative system for rendering the cathode followers conductive may be used: The control grids of the cathode followers are all connected in parallel and capacitively coupled to the pulse source or otherwise connected to receive a positive pulse when one or more amplifiers are operated. Thus, when one or more of the amplifier circuits are driven, all of the cathode followers are pulsed at the same time. As a result, the negative cross-talk voltage is eliminated from all the output conductors which are to remain at reference potential and there is no material effect on the signals on the output conductors which receive negative output pulses.

It is seen from the above description of this invention that a simple, reliable and relatively economical system is provided for eliminating cross-talk effects of capacitively coupled conductors that have voltage pulse applied to them.

What is claimed is:

1. Electronic apparatus comprising a first and a second conductor electrostatically cross-coupled to each other, an electronic circuit operable for applying voltage impulses to said first conductor, and means for eliminating resulting differentiated pulses on said second conductor by substantially maintaining said second conductor at a reference potential level comprising means providing a low impedance current path to said second conductor upon operation of said electronic circuit including an electron control device having a plurality of electrodes, one of said electrodes being connected to said second conductor, and means for causing said electron control device to conduct responsive to operation of said electronic circuit.

2. Electronic apparatus as recited in claim 1 wherein said means for maintaining said second conductor at a reference potential level further comprises diode means having one electrode connected to said second conductor and another electrode at said reference potential level, said electron control device and said diode being connected to pass differentiated pulses of opposite polarities respectively.

3. Electronic apparatus as recited in claim 1 wherein said means for causing said electron control device to conduct includes means for increasing the potential of another one of said plurality of electrodes.

4. Electronic apparatus as recited in claim 3 wherein

said electron control device is an electron discharge tube having anode, cathode, control grid and screen grid electrodes, said cathode is connected to said control grid and to said second conductor, and said another one of said electrodes is said screen grid which is connected to said means for increasing the potential thereat.

5. Electronic apparatus as recited in claim 4 wherein said anode of said electron discharge tube is at said reference potential level, and said means for increasing the potential at said screen grid includes another electron discharge tube having anode, cathode and control grid electrodes, and a resistor having one end connected to said screen grid and to the cathode of said another tube and the other end at said reference potential level.

6. In electronic apparatus wherein a first and a second conductor are electrostatically cross-coupled to each other, and an electronic circuit operates to apply to said first conductor voltage impulses of one polarity with respect to a reference potential level, the combination therewith of means for eliminating resulting differentiated pulses on said second conductor by substantially maintaining said second conductor at said reference potential comprising means responsive to initiation of operation of said electronic circuit for providing a low impedance current path for impulses of said one polarity produced on said second conductor including an electron discharge tube having a plurality of electrodes, one of said electrodes being connected to said second conductor, and means for applying to another of said electrodes a potential of polarity opposite to said one polarity, at substantially the same time said impulses are applied to said second conductor and in response thereto.

7. Electronic apparatus as recited in claim 6 wherein said means for maintaining said second conductor at said reference potential further comprises means providing a low impedance current path for impulses of opposite polarity produced on said second conductor including diode means having one electrode connected to said second conductor and another electrode at said reference potential.

8. In electronic apparatus wherein a first and a second conductor are capacitively coupled whereby upon the application of voltage impulses to one of said conductors impulses appear on the other of said conductors, the combination therewith of means for eliminating impulses appearing on said first and second conductors due to said capacitive coupling comprising a first and second electron discharge tube each having one electrode respectively connected to said first and second conductors, and first and second means for respectively controlling the impedance of said first and second tubes responsive respectively to the application of voltage impulses to said second and first conductors, said first and second impedance-controlling means respectively including a third and fourth grid-controlled electron discharge tube each having another electrode respectively connected to another electrode of said first and second tubes.

9. In electronic apparatus wherein a first and a second conductor are electrostatically cross-coupled, and a first and a second electronic circuit respectively operated to apply voltage impulses to said first and second conductors and respectively include a first and a second electron discharge tube each having a plurality of electrodes, one electrode of said first and second electron discharge tubes being respectively connected to said first and second conductors; the combination therewith of means for eliminating impulses produced on one of said conductors by the application of voltage impulses to the other of said conductors including first and second means for respectively reducing the impedance of said first and second electron discharge tubes responsive respectively to the operation of said second and first electronic circuits, said first and second impedance-reducing means being respectively coupled to another electrode of said first and second electron discharge tubes.

10. Electronic apparatus as recited in claim 9 wherein said first and second electron discharge tubes each have anode, cathode, control grid and screen grid electrodes, said cathodes are respectively connected to said first and second conductors, said anode is at a reference potential level, said first and second means for respectively reducing the impedance of said first and second electron discharge tube each include another electron discharge tube having anode, cathode and control grid electrodes, and a resistor having one end connected to the cathode of said another tube and to the screen grid of the associated one of said first and second tubes and the other end at said reference potential level, and said means for eliminating impulses produced on one of said conductors by the application of voltage impulses to the other of said conductors further includes first and second diodes each having one electrode respectively connected to the first and second conductors and the other electrode at said reference potential level.

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