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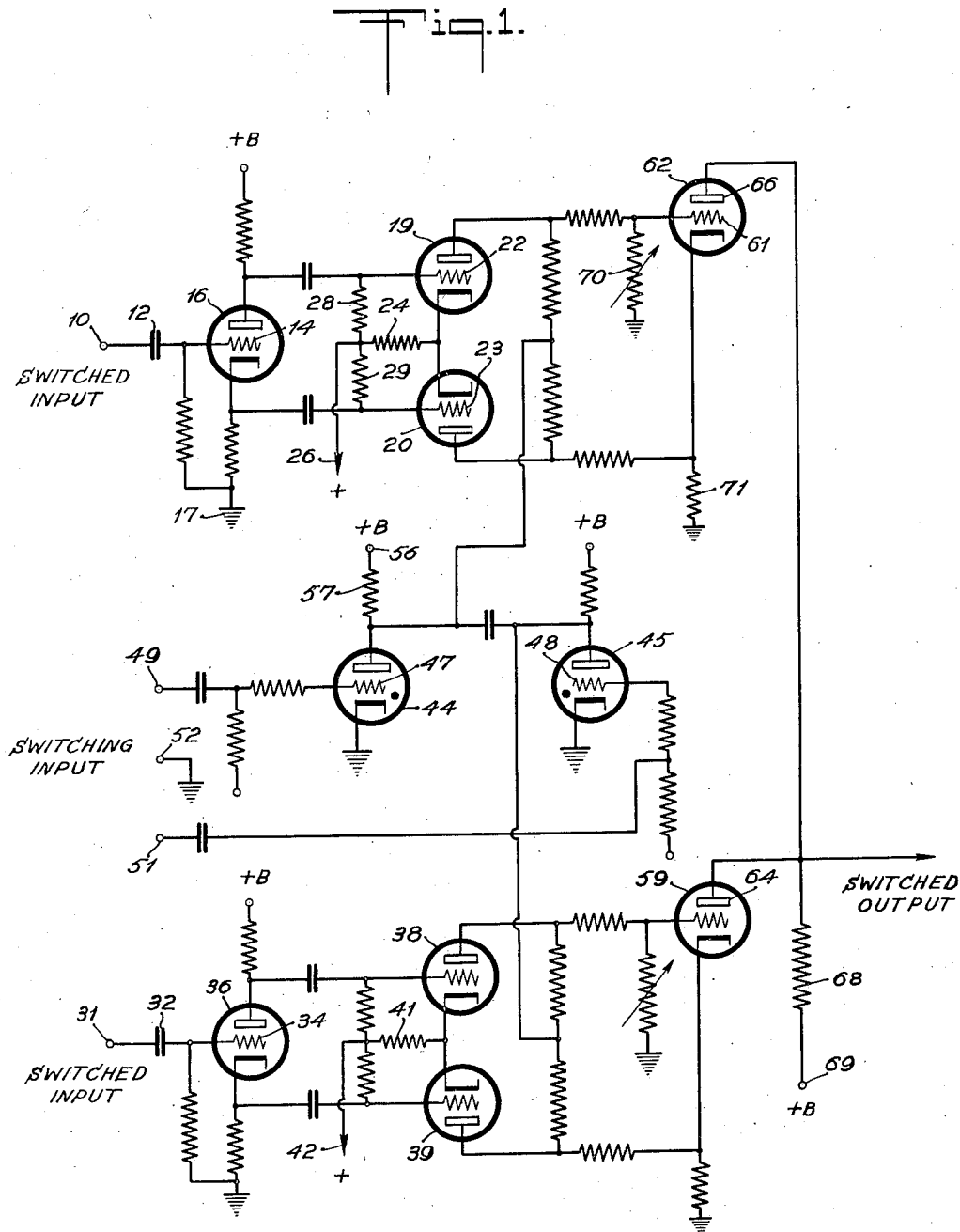
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ELECTRONIC SWITCHING SYSTEM

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3 Sheets-Sheet 1



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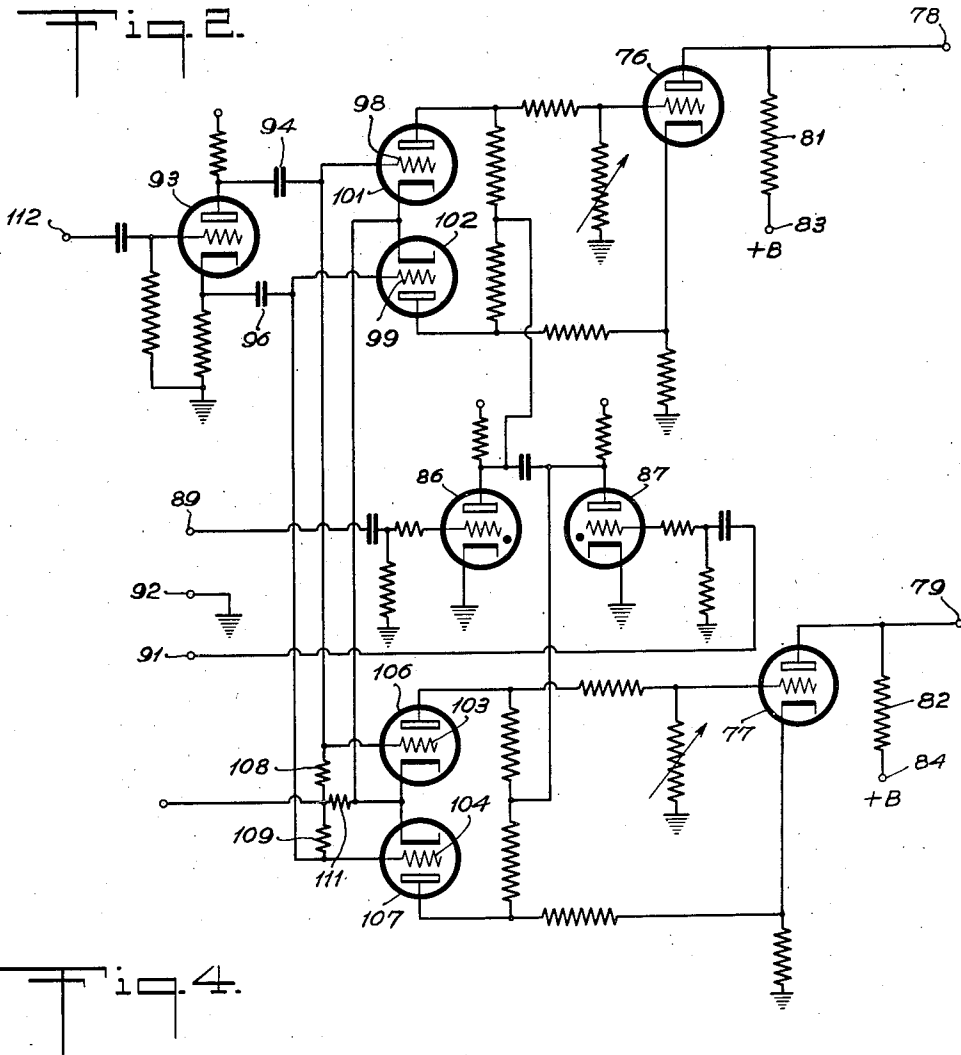
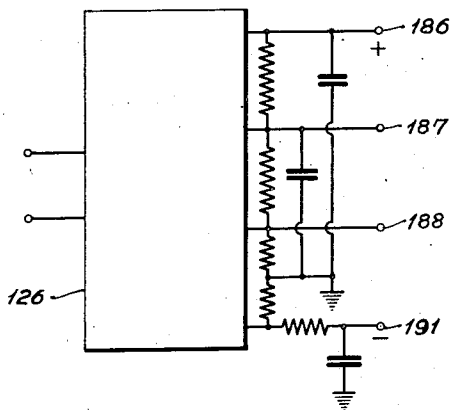


Fig. 3.



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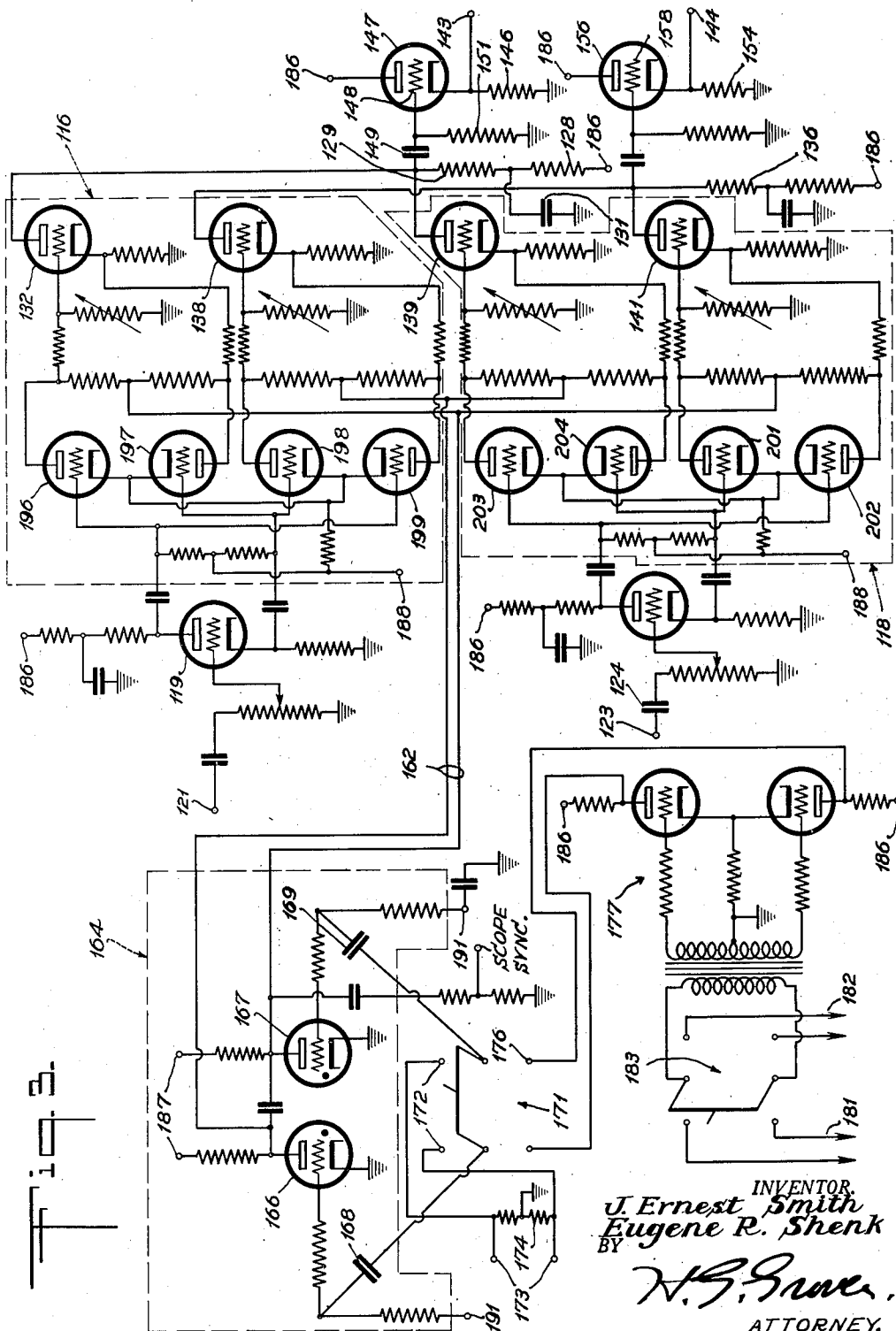
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3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,464,353

ELECTRONIC SWITCHING SYSTEM

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5 Claims. (Cl. 250—27)

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The present invention relates to electronic switching means and more particularly to an electronic switching system in which the controlling wave or controlling impulse does not appear in the output of the system.

Electronic switching devices in the prior art have passed the control or switching signal as well as the signal or impulse which is to be interrupted, as in some switching systems, or selectively passed to different channels as in other switching systems. In these prior art switches and switching systems, if the switching signal were not passed, then a large transient voltage or current pulse followed each switching operation. Where neither of the above disadvantages are present, the signal band width of the circuits involved in the switching operation was restricted by a transformer. The switching means of the invention to be disclosed suffers from none of the foregoing disadvantages.

The primary object of the present invention is to provide in a novel manner for the suppression of the control wave, impulse, or switching signal in an electronic switching system.

Another object of the invention is to provide novel means for the control of amplifiers employed as electronic switches.

A further object is to provide a novel method of selectively associating any one of a plurality of input circuits with any one of a plurality of output circuits.

Still another object is to provide a novel arrangement for supplying anode voltage to an electronic repeater in accordance with a control impulse or signal.

Still further objects of the present invention will become apparent and suggest themselves to those skilled in the art upon reading the following specification in connection with the accompanying drawings in which:

Fig. 1 is a diagrammatic showing of an electronic switching system in accordance with the invention;

Fig. 2 shows an arrangement similar to Fig. 1 but in slightly modified form;

Fig. 3 shows still another modification of the invention as embodied in an electronic switching system; and

Fig. 4 is a schematic showing of a power supply source of usual form which may be used in conjunction with Fig. 3 of the drawings.

The switching system of Fig. 1 of the drawings in normal operation is capable of alternately switching signals from two input circuits to a single output circuit. The input terminal of one

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of the switching circuits is indicated at 10 and is connected by way of the usual blocking condenser 12 to the grid 14 of a space discharge tube 16 connected as a phase inverter. It will be understood that the remaining terminal of the electronic switch is provided by the ground connection 17 when the system is connected to apparatus which is grounded in the usual manner. However, the connection 17 may be part of the chassis of the equipment, a connection to earth, or a terminal on the usual power supply equipment.

The space discharge tube 16 serves as a phase inverter to feed a pair of discharge tubes 19 and 20 which are connected in push-pull relationship. The grids 22 and 23 respectively of these tubes are connected through blocking condensers to the anode and cathode of the phase inverter tube 16. The cathodes of the discharge tubes 19 and 20 are connected through a cathode resistor 24 to a source of positive potential connected to a terminal 26. Grid resistors 28 and 29 are provided for the grids of the discharge tubes 19 and 20.

The second input connection for another series of signals is provided by a terminal 31 which is connected by way of a blocking condenser 32 to the grid 34 of a discharge tube 36 which is connected in the same manner as the discharge tube 16 to serve as a phase inverter.

Discharge tubes 38 and 39 serve as a push-pull amplifier in the path of signals from the terminal 31 in the same manner that discharge tubes 19 and 20 serve as a push-pull amplifier in the path of signals from the input terminal 10. The cathode resistor 41 for the cathodes of the discharge tubes 38 and 39 is connected through a terminal 42 to a suitable source of positive potential. The terminals 26 and 42 may be connected to the same source if desired.

A pair of "Thyratron" or other gas discharge tubes 44 and 45, connected in the well-known back-to-back circuit, is shown by way of example to supply switching voltage to the push-pull stage comprising discharge tubes 19 and 20 and also the push-pull stage comprising discharge tubes 38 and 39 in accordance with a controlling wave or controlling impulse. While the back-to-back gas discharge tube circuit is shown as the means for supplying the switching voltage, the switching voltage may be obtained from any source such as relays or high vacuum tubes for example. A trigger circuit having only one stable position or other similar circuit could be used to supply the switching voltage to the switch

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comprising the tubes 19 and 20 or the switch comprising the tubes 38 and 39. With such a device, either or both switches could be switched and then automatically returned after a predetermined interval of time.

The controlling signal is applied to the grids 47 and 48 of the tubes 44 and 45 at input terminals 49 and 51. Terminal 52 serves as a common ground when the input signal is applied from a push-pull stage. The push-pull input connection provided by the terminals 49 to 52 is suggestive only of a means for supplying a switching control signal, and it will be understood by those skilled in the art that a single-ended input may be used with the tubes 44 and 45 connected together in a self-restoring trigger circuit.

The plate voltage of the gas tube 44 serves as the plate supply voltage for the tubes 19 and 20. Similarly, the plate voltage of the gas tube 45 serves as a plate supply voltage for the tubes 38 and 39.

It is well known that if a pair of gas tubes is connected as shown for the tubes 44 and 45, then only one of the tubes can be conducting at a time. Igniting the other tube automatically extinguishes the one previously conducting. Therefore, depending on whether 44 is conducting or non-conducting, the plate supply voltage for the tubes 19 and 20 is substantially equal to the voltage drop in the tube 44, or it will be the voltage of the plate supply source connected at 55. The positive voltage, which is connected to terminal 26, should be approximately equal to or greater than the drop across the tube 44 when it is conducting. With this arrangement the plate to cathode voltage of the tubes 19 and 20 will vary between a negative value or zero and a positive value sufficiently high for normal operation. Therefore, when the tube 44 is conducting, the tubes 19 and 20 will be non-conducting so that the signal applied to the terminal 10 will not be transmitted by the tubes 19 and 20. Tube 45 will be non-conducting so that normal plate voltage is supplied to the tubes 38 and 39, and the signal applied to the terminal 31 will be transmitted by these tubes.

The signal transmitted by the tubes 38 and 39 in this manner will be supplied to a tube 59. The input electrode 61 of a tube 62 is connected to the output circuit of the tubes 19 and 20, and this tube 62 corresponds in function to the tube 59. The anodes 64 and 66 of the tubes 59 and 62 respectively are connected to an output load resistor 68. The terminal 69 of the load resistor is connected in the usual manner to a source of positive anode voltage.

If the gas tube 45 is ignited, the signal from the terminal 31 will be blocked, and the signal from the terminal 10 will be transmitted by the tubes 19 and 20 and the tube 62 so that it appears across the load resistor 68. In this manner signals from the terminals 10 and 31 appear alternately across the load resistor 68.

The tubes 59 and 62 are connected in such a manner that a push-pull signal input will be amplified, but a push-push signal input will not be present across the output load resistor 68. These tubes, therefore, act the same as a transformer for going from a push-pull input connection to a single-ended output connection. The action of tubes connected in this manner is described in detail in the application of C. N. Gillespie for Discharge tube circuits, Serial No. 500,618, filed August 31, 1943. The tubes 59 and 62 are shown as having their input circuits con-

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ductively coupled to the output circuit of the preceding tubes. This conductive connection may also be employed where only a single preceding tube is used.

Considering the tube 62 and its connections, the same value of positive D. C. voltage will be coupled into the grid circuit as into the cathode circuit of the tube. As a result, the net grid-cathode voltage from this source will be zero. This is true because the D. C. voltage is supplied as a push-push voltage. Since the switching voltage, that is, the voltage applied through the agency of the gas discharge tube 44, is also push-push, it will not be present in the output. The desired signal, being applied push-pull to the tube 62, will be present in the output circuit of this tube.

An adjustable resistor 70 in the grid circuit of the tube 62 is provided for the purpose of balancing out the switching voltage resulting from signals applied to the terminal 10. A resistor 71 is connected in both the grid and the plate circuits of the tube 62. Therefore, the values of the resistors 70 and 71 will not necessarily be equal for cancellation of push-push voltages.

The switching transient in the output of the tubes 59 and 62, or either, has been found in practice to be very small. If there is any switching transient at all, it is due to the difference in the total capacitances and inductances in the two sides of the push-pull system feeding the tube 59 or the tube 62 and the capacitances and inductances in the tubes themselves. These effects can be overcome by properly neutralizing the unbalance in the inductances and capacitances. While triodes have been chosen to simplify the disclosure and description of the embodiment of the invention shown in Fig. 1 of the drawings and the other figures, other types of tubes such as tetrodes and pentodes are equally applicable and, in some cases, preferable.

It should be noted that the switching arrangement comprising the tubes 19, 20, and 62, due to its direct coupled connection, is capable of passing all frequencies down to and including direct current. If it is desired to switch a direct current input applied to the terminal 10, direct current coupling may be employed from the terminal 10 to the input connections to the tubes 19 and 20. The foregoing is also true of the switch comprising the tubes 38, 39, and 59.

A transformer could be used in the plate circuits of the tubes 19 and 20, or the tubes 38 and 39, eliminating the need for the tube 62 or the tube 59 and their associated circuits. If switching transients are to be avoided, the windings of the transformer, if it is used, must be carefully balanced.

The phase inverter tube 16 could be omitted and the input signal could be fed single ended to either the tube 19 or the tube 20. In either case the output from the tube 62 would be reduced to approximately one-half of its former value. Assume a case where the signal is fed only to the tube 19. A signal will exist in the grid circuit of the tube 20 due to the plate current of the tube 19 in the cathode resistor 24. In this case the cathode resistor may be bypassed or left unbypassed if desired.

Fig. 2 of the drawings discloses an arrangement very similar to the arrangement disclosed in Fig. 1. The arrangement of Fig. 2 is used for switching a common input signal between two output circuits. Discharge tubes 76 and 77, correspond-

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ing in function to the tubes 59 and 62 of Fig. 1, have separate output connections 78 and 79. Separate load resistors 81 and 82 are provided with the terminals 83 and 84 thereof connected to a suitable source of positive potential.

Gas discharge tubes 86 and 87 correspond in function to the tubes 43 and 44 of Fig. 1. The controlling signal or controlling impulses are applied at the terminals 89 and 91, the terminal 92 being provided for convenience as a common ground connection.

Discharge tube 93 serves the same purpose as either the tube 16 or 36 in Fig. 1 of the drawings and is connected through coupling condensers 94 and 96 to the grids 98 and 99 of the discharge tubes 101 and 102 respectively. The tubes 101 and 102 are controlled by a gas discharge tube 86.

The grids 103 and 104 of a pair of tubes 106 and 107 are also connected to the coupling condensers 94 and 96 so that these elements are effectively in parallel and the two pairs of tubes have common grid resistors 108 and 109 and a common cathode resistor 111.

The tubes 106 and 107 are controlled from the gas discharge tube 89 in a manner similar to the control of tubes 38 and 39 of Fig. 1 from the tube 43. The signal which is to be switched from the output terminal 78 to the output terminal 79 is applied to the input terminal 112 of the phase inverter tube 93.

It is believed that the mode of operation of the apparatus of Fig. 2 of the drawings will be obvious from the foregoing description of the operation of the apparatus of Fig. 1 of the drawings.

Fig. 3 of the drawings shows a system embodying the invention for alternating two inputs between two outputs.

Referring to this figure of the drawings, reference numerals 116 and 118 indicate switching arrangements each of which are substantially identical with the apparatus shown by Fig. 2.

A phase inverter tube 119 passes signals from the input terminal 121 into the switching arrangement 116. The terminal 123 is available for applying signals to be switched by way of a phase inverter tube 124 to the switching arrangement 118. Inasmuch as the arrangement of Fig. 3 so far described has been discussed in detail in connection with Fig. 2 of the drawings, a further detailed description of these parts will not be given.

An output connection comprising a source of anode supply voltage 126, mentioned later, and load resistor 129 is provided for an output tube 132. Resistor 128 together with condenser 131 constitute a decoupling filter to prevent reaction to and from tubes 132 and 139 and the power supply. A similar output connection comprising load resistor 136 is provided for the tube 138.

The tubes 132 and 138 correspond in function to the tubes 76 and 77 of Fig. 2 of the drawings. An output tube 139 has its output circuit also connected to the output resistor 129. Also, another output tube 141 is connected to the output resistor 136. The tubes 139 and 141 bear the same relationship to the arrangement 118 as the tubes 132 and 138 bear to the arrangement 116. Terminals 143 and 144 are the final output terminals at which signals from the input terminals 121 and 123 appear in accordance with the operation of the switching arrangements 116 and 118. The terminal 143 receives its signal from the cathode resistor 146 of an amplifier tube 147. The grid 148 of this tube is coupled to the output

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circuit of tubes 132 and 139 by a coupling condenser 149 in conjunction with a grid resistor 151.

The terminal 144 receives its signal from the cathode resistor 154 of an amplifier tube 156, the grid 158 of which is connected by way of a coupling condenser 159 to the output circuit of the tubes 138 and 141.

Switching signals or impulses are applied to the arrangements 116 and 118 over connections 162. Any desired source of switching signals may be employed, but the connections 162 are shown by way of example as being connected to a circuit 162 comprising a pair of discharge tubes 166 and 167 connected in the same manner as the tubes 44 and 45 of Fig. 1 of the drawings. Control signal potentials are applied to the grids of the tubes 166 and 167 by way of condensers 168 and 169. A convenient arrangement for applying control signals to these condensers is disclosed comprising a double-pole-double-throw switch 17. One set of stationary contacts 172 of this switch is connected to a pair of input terminals 173. If desired, a coded switching signal or two independent coded switching signals may be supplied to the terminals 173.

The other pair of stationary contacts 176 of the switch 171 is connected to a push-pull amplifier 177 which serves to amplify input signals from a control signal source connected to terminals 181 or 182. A double-pole-double-throw switch 183 provides for connecting the amplifier 177 to either the terminals 181 or the terminals 182.

The terminals 182 may be connected to a convenient source of alternating current of commercial frequency such as the source of heater current for any of the tubes shown. The terminals 181 may be connected to any other source of alternating current of any desired frequency. The terminals 173, because of their direct connection to the grids of the tubes 166 and 167 without intervening transformers, are suitable for very low frequency or direct current switching signals.

Fig. 4 shows any well known power supply system or power pack 126, mentioned above, which may be employed to supply the various voltages required by the tubes in Fig. 3 of the drawings. The usual voltage divider with its filter condensers is shown diagrammatically and the taps on the voltage divider labelled 186 to 188 are used to provide positive potentials to the tubes of Fig. 3. The connections from the tubes on Fig. 3 which are to be connected to these taps are labelled with corresponding numerals. Negative biasing potentials may be obtained from the tap 191, and tube connections labelled 191 on Fig. 3 may be connected to this tap.

The operation of the switching arrangement shown in Fig. 3 of the drawings will be obvious from the foregoing discussion of the arrangement shown in Fig. 2. Briefly, an incoming signal applied to terminal 121 may follow a path through the tubes 196 and 197 so to appear in the output circuit of the tube 132 which will result in the signal being switched to the final output terminal 143 with tubes 196 and 197 conducting tubes 198 and 199 will be cut off. When the tubes 196 and 197 are cut off, the tubes 198 and 199 will be conducting so that the signal will appear in the output of the tube 138 and also in the signal output terminal 144. When the tubes 196 and 197 are conducting, tubes 201 and 202 will also be conducting. When these last-named tubes are conducting, tubes 203 and 204 will be cut off.

Signals applied simultaneously to the input terminals 121 and 123 will appear in the terminals 143 and 144 respectively, and after the reversal of operation of the tubes 166 and 167, the signal from the terminal 121 will appear in the final output terminal 144 and the input signal applied to the terminal 123 will appear in the final output terminal 143.

Although only three arrangements employing a switch of the present invention are shown by way of illustration and example, it is possible, by suitable interconnection of the switches and switching voltages, to switch n inputs among the m output circuits.

The several switching arrangements disclosed herein are of general application and are specially suited to the operation of facsimile privacy systems such, for example, as is disclosed in the copending application of Hallborg et al., Serial No. 491,537, filed June 19, 1943, now Patent No. 2,425,616.

Having now described the invention, what is claimed and desired to be secured by Letters Patent is the following:

1. In an electronic switching system, a switching amplifier comprising a pair of space discharge devices connected in push-pull relationship, each space discharge device comprising a cathode, an anode, and a control electrode, a control tube for said amplifier comprising a cathode, an anode, and a control electrode, means to supply a switching signal to said control electrode of said control tube to cause said control tube to become conducting, means to supply positive operating voltage to said control tube, a connection from said anode of said control tube to said anodes of said switching amplifier, and means to supply a voltage to said cathodes of said switching amplifier having a positive value at least equal to the voltage drop from cathode to anode of said control tube when it is conducting.

2. In an electronic switching system, a switching amplifier comprising a pair of space discharge devices connected in push-pull relationship, each space discharge device comprising a cathode, an anode, and a control electrode, a second switching amplifier comprising a pair of space discharge devices connected in push-pull relationship, each space discharge device comprising a cathode, an anode, and a control electrode, a pair of control tubes each having an anode, a cathode, and a control electrode, means to supply positive operating voltage to said anodes of said control tubes, a capacitance interconnecting said control tube anodes, means to apply a switching signal selectively to said control electrodes of control tubes, a connection from said anode of one of said control tubes to said anodes of said first-named switching amplifier tubes, and a connection from said anode of said second-named control tube to said anodes of said second-named switching amplifier tubes.

3. An amplifying system comprising an amplifier, an output connection for said amplifier

comprising a coupling device including a space discharge tube having a cathode, an anode, and a control electrode, an output circuit for said tube comprising a source of anode voltage, a cathode circuit for said tube, a resistor in said cathode circuit, an impedance connecting said cathode to said amplifier, and a conductive connection from said amplifier to said control electrode.

4. In an electronic switching system, a switching amplifier, an input circuit for said switching amplifier, an output connection for said switching amplifier comprising a coupling device including a space discharge tube having a cathode, an anode, and a control electrode, an output circuit for said tube comprising a source of anode voltage, a cathode circuit for said tube, a resistor in said cathode circuit, an impedance connecting said cathode of said tube to said switching amplifier, and a conductive connection from said switching amplifier to said control electrode.

5. An electronic switching system comprising a plurality of electronic switches, each electronic switch comprising a plurality of switching amplifiers each having a cathode and an anode connection, a plurality of control tubes one for each of said switching amplifiers in said electronic switches, each control tube having a cathode, an anode and a control electrode, means to supply a positive operating voltage to the anode of each of said control tubes, a connection from said operating voltage supply means for each control tube anode to the anode connection of the switching amplifier associated with the control tube to supply a voltage depending on the condition of the associated control tube, an input connection for each of said electronic switches, an output connection for each of the electronic switches, and means of such nature that said switches in operation under said control tubes function to alternate said input connections with said output connections.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,055,883	Terry	Sept. 29, 1936
2,089,430	Roy et al.	Aug. 10, 1937
2,140,004	Falloon	Dec. 13, 1938
2,146,862	Shumard	Feb. 14, 1939
2,189,317	Koch	Feb. 6, 1940
2,221,115	Shepard, Jr.	Nov. 12, 1940
2,265,868	Schonland	Dec. 9, 1941
2,272,070	Reeves	Feb. 3, 1942
2,300,999	Williams	Nov. 3, 1942
2,324,314	Michel	July 13, 1943

FOREIGN PATENTS

Number	Country	Date
356,111	Great Britain	Aug. 24, 1931