

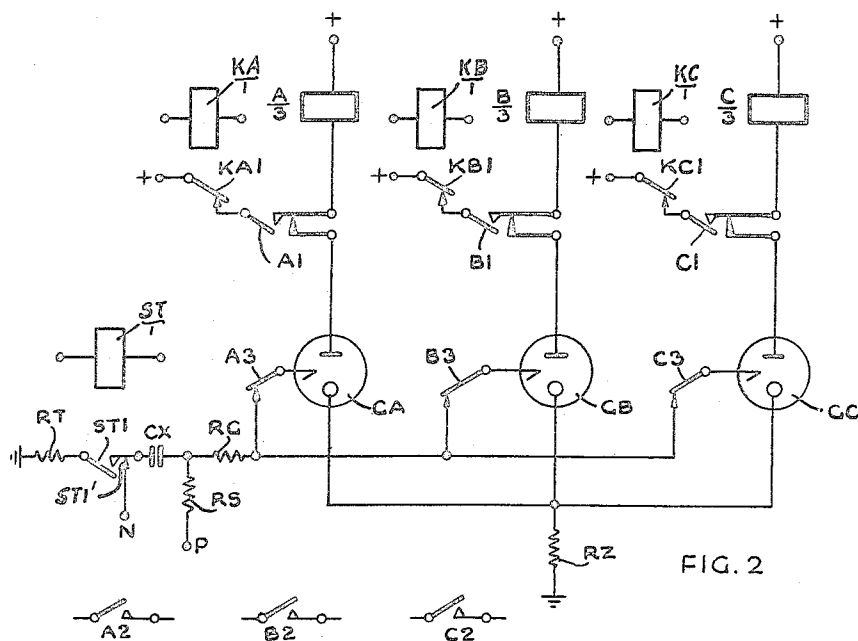
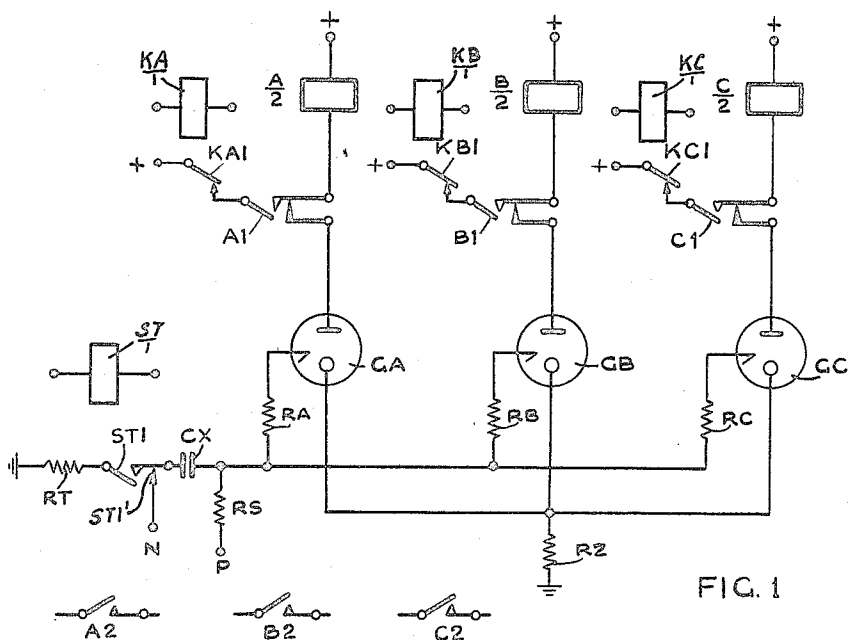
May 22, 1956

A. A. CHUBB ET AL
GAS DISCHARGE TUBE CIRCUITS

2,747,145

Filed Feb. 18, 1952

3 Sheets-Sheet 1



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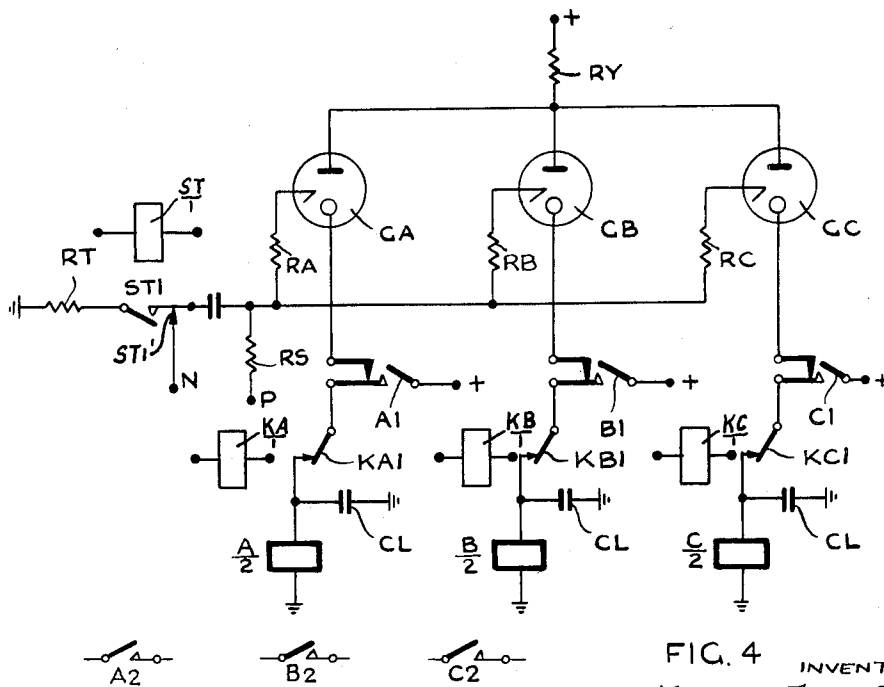
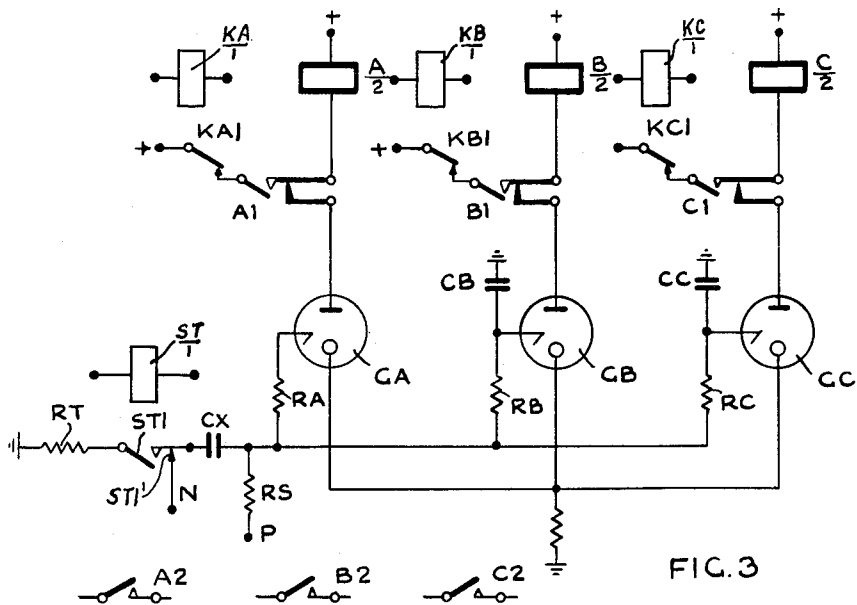
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GAS DISCHARGE TUBE CIRCUITS

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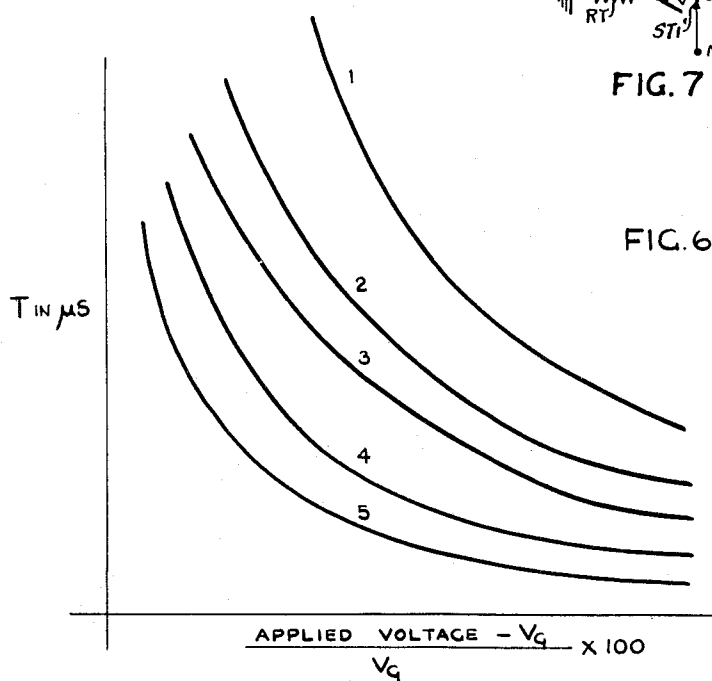
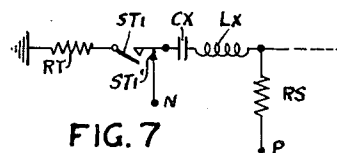
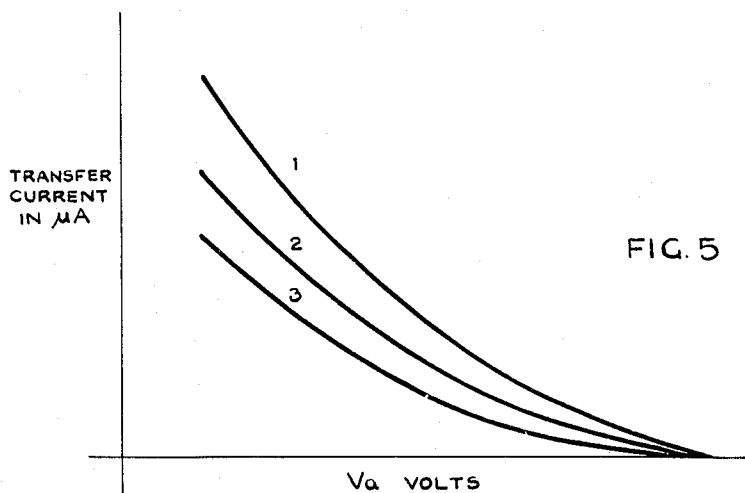
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GAS DISCHARGE TUBE CIRCUITS

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3 Sheets-Sheet 3



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2,747,145

GAS DISCHARGE TUBE CIRCUITS

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10 Claims. (Cl. 317—140)

The present invention relates to electric switching circuits. More particularly the present invention relates to electric switching circuits in which operation of a start contact, application of a switching pulse, or some like initiating operation causes operation of one of a plurality of switches, the particular one being immaterial provided it is not already operated. Each of the switches when operated remains so until some condition, for which its operation is required, has terminated. The order in which the switches are operated in response to a succession of initiating operations does not matter provided that at each of the initiating operations a free switch is operated assuming there is one left available in the unoperated condition.

Such switching circuits are required in some automatic telephone systems for example, where it may be required to route a call from a given line onto any free one of a number of outgoing lines, or to connect an incoming line on which there is an originating call to any free one of a number of junctions. In each case the particular line or junction selected is immaterial provided it is free.

Previously step by step switches have been employed in switching circuits for carrying out the above operations, the switch stepping until a contact is reached corresponding in the above examples to a free line or junction. It then locks into position at that contact. However such operation may have to be carried out in a short time, during for example an interdigital pause of a dialling sequence, and in such circumstances the step by step switches are usually too slow.

According to the present invention therefore an electric switching circuit includes: a plurality of gas-filled electric discharge valves each having at least an anode, a cathode and a trigger electrode; a plurality of electro-magnetic switching devices each having; an operating winding and a contact controlled by said winding connected in series with the anode-cathode discharge path of a corresponding one of the valves, the contact being closed when the winding is not energised; means connecting all said series connected combinations (each consisting of an operating winding, a contact and the anode-cathode discharge path of a valve) in parallel across a resistance and a source of direct current potential connected in series, the potential of the source and the magnitude of the resistance being such that an anode-cathode discharge can only be initiated in any of the valves by the application of a triggering potential to the trigger electrode, but that whilst a discharge is maintained in one of the valves, a discharge cannot be initiated similarly in any other of the valves; means for normally maintaining in operation the potential of the trigger electrodes at a value such that trigger electrode-cathode discharges are not initiated, and for applying a triggering potential for a period less than the operating time of the electro-magnetic switching devices but greater than the time required to fire one of the valves to all the trigger electrodes when it is required to operate one of the electro-magnetic switching devices; contact means associated with each relay for

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effecting a required operation; and means associated with each electro-magnetic switching device for maintaining its contacts in the operated condition until the said required operation is completed.

Four electric switching circuits in accordance with the present invention will now be described, by way of example, with reference to the accompanying drawings in which,

Figures 1 to 4 show circuit diagrams of the electric switching circuits, and

Figures 5 and 6 show graphs illustrating the characteristics of gas-filled discharge valves.

In the electric switching circuit shown in Figure 1 of the accompanying drawings, three gas-filled discharge valves GA, GB and GC are employed, the cathodes of the valves GA, GB and GC being connected to one end of a common cathode resistor RZ the other end of which is earthed and their trigger electrodes each being connected to one end of resistors RA, RB and RC respectively the other ends of which are connected together. The operating winding of an electro-magnetic relay A, B or C is connected in the anode circuit of each of the valves GA, GB and GC respectively. Although only the three valves GA, GB and GC are shown in the circuit, it should be understood that a greater number of valves may be employed, their cathodes and trigger electrodes being connected similarly to those of the three valves GA, GB and GC, whilst the winding of a further electro-magnetic relay is connected in the anode circuit of each of them. The windings of the relays A, B and C each have one side connected to the anode of the associated valve GA, GB or GC and the other side to the positive terminal of a source of direct current potential, the value of which is such as to lie between those necessary for maintaining an anode-cathode discharge in one of the valves GA, GB or GC once triggered and for striking an anode-cathode discharge without first triggering the valve. The negative terminal of the source is connected to earth.

A contact ST1, which closes when the winding of the relay ST is energized by applying a suitable potential across it, is provided and which, when closed, causes one of the relays A, B or C to be operated. The circuit operates so that one and only one of the relays A, B or C is energised on each occasion of closing contact ST1. In addition if one of the relays A, B or C is operated, the valve GA, GB or GC associated with it is excluded from being triggered if the contact ST1 is closed subsequently, unless that relay A, B or C is energised and not released, subsequent closure of contact ST1 will cause another of the valves GA, GB or GC to be triggered and another relay A, B or C to be operated.

One side of the contact ST1 is connected to terminal N through an auxiliary contact ST1' which is opened when the contact ST1 is closed. In operation the terminal N is connected to the negative side of a direct current potential source, the other side of which is earthed. The same side of the contact ST1 is also connected to one terminal of a capacitor CX the other terminal of which is connected to the common terminals of the resistors RA, RB and RC and also to one terminal of a resistor RS. The other terminal of resistor RS is connected to terminal P which in operation is connected to the positive side of a direct current potential source, the other side of which is earthed. The potential applied at terminal P is of a value such that the trigger electrodes of the valves GA, GB and GC are at a voltage somewhat below that at which a discharge between the trigger electrode and the cathode starts. The magnitude of the negative potential applied at terminal N is such that when added to the magnitude of the potential applied at the terminal

P (ignoring polarities), the sum of the potentials is greater than that necessary to start a discharge between the trigger electrode and the cathode of any of the valves GA, GB and GC. The other side of the contact ST1 is connected to earth through a resistor RT.

In operation, assuming that all relays are in the positions shown in Figure 1, that is unoperated, contact ST1 is closed and subsequently released, the period of closure being longer than the time required for one of the valves GA, GB or GC to fire. When the contact ST1 closes, the auxiliary contact ST1' opens and breaks the connection, which normally applies a negative potential to one side of the coupling capacitor CX. That side of the coupling capacitor CX is therefore raised from a negative potential to earth potential for the time interval during which the contact ST1 closes, and a positive voltage pulse of the magnitude of the potential applied at terminal N is applied to the trigger electrodes of all the valves GA, GB and GC in parallel through the common coupling capacitor CX and the separate series resistors RA, RB and RC, which are of relatively high value. The effect of this, the potentials applied at terminals N and P having been chosen as described above, is to start a discharge between the trigger electrode and the cathode of one of the valves GA, GB or GC.

The graph in Figure 5 of the accompanying drawings shows curves illustrating the fact that in order to initiate an anode-cathode discharge in a gas-filled valve it is necessary to produce a trigger electrode cathode-discharge current greater than a particular value known as the transfer current. The value of the transfer current varies with the anode voltage V_a and also with the characteristics of the particular valve, i. e. its dimensions, gas pressure, degree of cathode activation, etc. However for valves of a given type there is a random variation of this characteristic, curves 1 and 3 in Figure 5 showing extreme examples and curve 2 an average example, found by plotting the characteristics of a number of triodes of a single type. It will be appreciated therefore that in the circuit shown in Figure 1, on closing the contact ST1 an anode-cathode discharge will be initiated in that one of the valves GA, GB and GC, in which the trigger electrode-cathode discharge current first reaches the transfer current value. The random nature of the characteristics of a number of valves of single type are such as to ensure, assuming that the resistors RA, RB and RC are of fairly high value for example of the order of megohms, that one of the valves GA, GB, and GC will always fire before the others after closure of the contact ST1.

The initiation of an anode-cathode discharge in one of the valves GA, GB and GC has the following effects. Firstly, the discharge current flowing in the common cathode resistor RZ reduces the trigger electrode-cathode potentials of those of the valves GA, GB and GC, thus ensuring that no further increase in trigger electrode-cathode discharge currents can take place in those which have not yet been fired, and therefore that none of the other valves GA, GB and GC can be fired. This effect may be enhanced by arranging that the waveform of the pulse applied to the trigger electrodes of the valves GA, GB and GC on the closure of contact ST1 has an appreciably sloping leading edge. This may be effected for example by inserting a small inductance LX in series with the capacitor CX, as is shown in Figure 7 of the drawings, which shows the relevant parts of the circuit of Figure 1 with the inductance LX inserted. Secondly, if for example the valve GA fires, relay A operates and its contact A1 breaks the connection between one side of its operating winding and the anode of the valve GA, thereby extinguishing the discharge in the valve GA. At the same time it completes a circuit which locks the relay A operated as long as the winding of the relay KA remains unenergized and the contact KA1 is thus closed. It should be noted that the time required for the oper-

ation of the relay A (or of the other relays in equivalent circumstances) must be longer than the duration of the pulses applied to the trigger electrodes of the valves GA, GB and GC when contact ST1 is closed, otherwise more than one of the relays A, B and C might be fired at a single occasion of closing the contact ST1. As most gas-filled valves may be fired in a matter of microseconds and as most relays require milliseconds to operate, this condition is easy to fulfill. Once relay A is operated and the discharge in the valve GA extinguished, the current in the common resistor RZ ceases and release of the contact ST1 followed by a further closure, will fire one of the valves GB or GC and operate the corresponding relay B or C. This action may be repeated until all the relays A, B and C have been operated.

Contact A2 of the relay A is a work contact, and with the other contacts B2 and C2 associated with relays B and C may be employed for switching purposes as required. It will be remembered as mentioned previously that the circuit may be extended by including further valves and relays and therefore increasing the number of independent work contacts available. At the same time the relays may each have more than a single work contact associated with them. When the operation effected by operation of the contact A2 has been completed the contact KA1 is opened momentarily by application of a suitable potential across the winding of the relay KA to energize it thereby releasing the relay A and reconnecting its winding between the high tension voltage terminal and the anode of the valve GA. The valve GA and the relay A are then ready to take part in further switching operations. Similar operations occur on energizing the winding of either of the relays KB or KC and opening one of the contacts KB1 and KC1. If in any sequence of operations the contact KA1 is opened before contact ST1 is closed for a second time, the relay A would be operated again on the second closure of contact ST1. In general with a given set of valves, the valve fired at any closure of the contact ST1 will be that one, having the lowest transfer current value, of those, the relay associated with which is not operated at the moment of closing the contact ST1.

In Figure 2 of the accompanying drawings an alternative circuit is shown. It will be seen that three gas-filled valves designated GA, GB and GC as in Figure 1 are again each associated with a relay A, B and C and have their cathodes connected to a common cathode resistor RZ. The circuit is the same as that shown in Figure 1 except that contacts A3, B3 and C3 associated with the relays A, B and C are connected one in each of the leads to the trigger electrodes of the valves GA, GB and GC respectively, and the resistors RA, RB and RC are replaced by a single resistor RG having a high resistance of several megohms, which is connected in the common lead to the trigger electrodes of all the valves GA, GB and GC.

The time taken to initiate the anode-cathode discharge in a gas-filled valve after the application of a given voltage to the trigger electrode varies as shown in the graph of Figure 6. The value (applied voltage— V_G)/ V_G is plotted horizontally and the time in microseconds for the anode-cathode discharge to start is plotted vertically. The valve V_G for any particular curve is the lowest voltage which must be applied to the trigger electrode of the valve, for which the curve is plotted, before a discharge from the trigger electrode to the cathode takes place. The five curves shown are plotted for a single valve having various values of a resistor connected in series with the trigger electrodes, the values being:

Curve 1	-----megohms	4.7
Curve 2	-----do-----	2.2
Curve 3	-----do-----	1
Curve 4	-----ohms---	330,000
Curve 5	-----do-----	100,000

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These characteristics vary appreciably from one valve to another of the same type so that if a voltage step of say 90 volts is applied in parallel to the trigger electrodes of two separate valves through a common resistor one valve might strike before the other after a period of say 10 microseconds. If the valves are connected in the circuit as shown in Figure 2, initiation of the main discharge in one of the valves will lower the trigger electrode-cathode potential of all the valves and prevent an anode-cathode discharge being initiated in any of the others.

In this way it is arranged that on closure of the starting contact ST1 one of the valves GA, GB or GC is fired, operating its associated relay A, B or C, and is then disconnected from the circuit until the associated contact KA1, KB1 or KC1 is opened and the relay A, B or C released as described previously with reference to Figure 1.

Figure 3 shows another alternative circuit. It will be seen that it is similar to that of Figure 1 except for the fact that capacitors CB and CC are connected between the trigger electrodes of the valves GB and GC respectively and earth. The operation of the circuit is similar to that of the circuit shown in Figure 1, except that on closing the contact ST1 there is a delay in the rise of voltage at the trigger electrodes of valves GB and GC determined by the time constants of the resistance-capacitance combinations RB—CB and RC—CC in the trigger electrode circuits of valves GB and GC, and assuming none of the relays A, B and C is operated the valve GA will always fire first. The time constants of the circuits RB—CB and RC—CC are made progressively greater in the order given, either by increasing the value of the resistor RC, of the capacitor CC, or both components so that the valve GB will always fire in preference to the valve GC. This principle of determining an order of preference for the firing of the valves may be extended equally to circuits where greater numbers of valves than three are employed.

Figure 4 shows yet another alternative circuit. In this circuit the valves GA, GB and GC are provided with a common anode resistance RY and the windings of the relays A, B and C are connected in the cathode circuits the valves GA, GB and GC are fired in the same way as previously described with reference to Figure 1 on closure of the contact ST1. On operation of the relays A, B and C the contacts A1, B1 and C1 lock the relays operated whilst contacts KA1, KB1 and KC1 respectively connected in this case between the corresponding winding and contact release the relays A, B and C when the operation for which the respective work contact A2, B2 and C2 is required has been completed. If the inductances of the windings of the relays A, B and C are high, which condition would tend to reduce the rate of increase of anode current in the corresponding valve, capacitors CL may be connected across the windings as shown to prevent this happening. When one of the valves GA, GB and GC strikes anode current rises rapidly to a maximum, and this current flowing in the common anode resistor RY causes the anode potential of all the valve to fall thereby preventing the other valves from firing.

We claim:

1. An electric switching circuit including: a plurality of gas-filled electric discharge valves each having at least an anode, a cathode and a trigger electrode; a plurality of electro-magnetic switching devices each having an operating winding and contacts controlled by said winding, the winding and contacts of each said device being connected in series with the anode-cathode discharge path of a corresponding one of the valves and constituting a series connected combination, the contacts being closed when the winding is not energized; a resistance; a source of direct current potential; means connecting said resistance and said source in series; means connecting all said series connected combinations in parallel with one another

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across the end terminals of the circuit comprising the resistance and the source connected in series, the potential of said source being less than that potential necessary to cause an anode-cathode discharge in any one of the valves without a discharge first occurring between the trigger electrode and the cathode, but greater than the minimum potential which will cause an anode-cathode discharge if a trigger electrode-cathode discharge is initiated, and the magnitude of the resistance being such that the potential drop across it on initiating an anode-cathode discharge in one of the valves reduces the anode potential of the valves to a value less than the said minimum but greater than the minimum anode-cathode discharge maintaining potential; means for normally maintaining in operation the potential of the trigger electrodes of all the valves at a value such that trigger electrode-cathode discharges are not initiated and for applying a triggering potential for a period less than the operating time of the electro-magnetic switching devices but greater than the time required to fire one of the valves to all the trigger electrodes when it is required to operate any one of the electro-magnetic switching devices; contact means associated with each electro-magnetic switching device for effecting a desired operation; and means associated with each electro-magnetic switching device for maintaining its contacts in the operated condition until the said required operation is completed.

2. An electric switching circuit according to claim 1, in which, in each of the series connected combinations, the contacts and the operating winding are connected in that order between the anode of the corresponding valve and the positive terminal of the source of direct current potential, and the resistance is connected between the cathodes of all the valves and the negative terminal of the source.

3. An electric switching circuit according to claim 1, in which, in each of the series connected combinations, the contacts and the operating winding are connected in that order between the cathode of the corresponding valve and the negative terminal of the source of direct current potential, and the resistance is connected between the anodes of all the valves and the positive terminal of the source.

4. An electric switching circuit according to claim 1, in which the means, associated with each electro-magnetic switching device for maintaining its contacts in the operated condition until the required operation is completed, includes a further contact means associated with each said device, for completing an operating circuit through the operating winding when said device is operated, and a further switching device associated with said device and having at least one normally closed contact connected in series in said operating circuit for said device, the further switching device being operated momentarily to open the contact when the said desired operation is completed.

5. An electric switching circuit according to claim 1 in which the means for normally maintaining, in operation, the potential of the trigger electrodes at a value such that trigger electrode-cathode discharges are not initiated, includes a common terminal, high resistance means connected between the trigger electrodes of all the valves and said common terminal, and means for applying a potential of less than said value across said common terminal and the negative terminal of said source of direct current potential.

6. An electric switching circuit according to claim 5 in which the means for applying triggering potentials to all the trigger electrodes consists of a pulse generator for generating positive voltage pulses of the required duration and amplitude, and means for applying an output from the pulse generator to said common terminal.

7. An electric switching circuit according to claim 6 in which said pulse generator includes means for providing said positive voltage pulses with appreciably sloping leading edges.

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8. An electric switching circuit according to claim 6 in which the resistance means comprises a plurality of high resistances associated one with each of the valves, one terminal of each of said resistances being connected to said common terminal, and in which each of the electro-magnetic switching devices has an additional contact which is opened when the device is operated, and is connected between the other terminal of the high resistance associated with the same valve as the switching device and the trigger electrode of that valve.

9. An electric switching circuit according to claim 6 in which the resistance means comprises a plurality of high resistances associated one with each of the valves

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and each connected between the common terminal and the trigger electrode of the associated valve.

10. An electric switching circuit according to claim 9 including a plurality of capacitances, each connected between the trigger electrode of a corresponding one of the valves and the negative terminal of the potential source, the time constant of the resistance-capacitance combinations in the trigger electrode circuits of the valves being such that on successive application of triggering potentials to the common terminal, the valves will fire in an order predetermined by the magnitudes of the time constants.

No references cited.