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PULSE FORMER USING GAS TUBE WITH SUBSTANTIALLY GROUND
SUPPRESSOR AND NEGATIVE PULSE FOR RAPID DEIONIZATION

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FIG. 1.

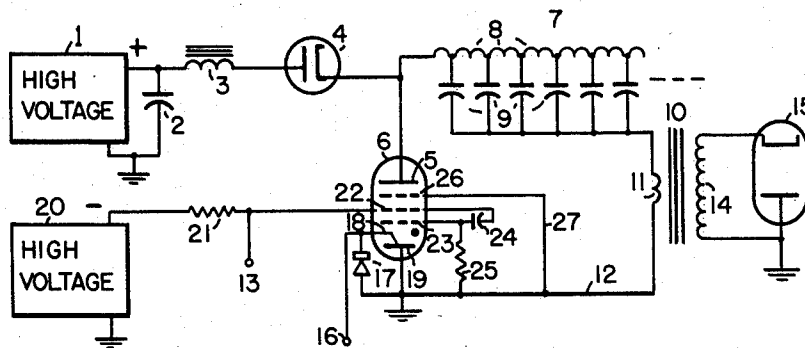
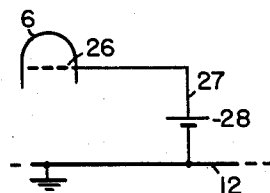


FIG. 2.



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AGENT

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PULSE FORMER USING GAS TUBE WITH SUBSTANTIALLY GROUNDED SUPPRESSOR AND NEGATIVE PULSE FOR RAPID DEIONIZATION

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9 Claims. (Cl. 328—67)

My invention relates to high power pulse-forming apparatus and particularly to an electrical circuit for a switch tube in such apparatus.

In apparatus of the class described the switch tube acts to periodically short a delay line structure in order that a pulse be formed. An important requisite of the switch tube is that it deionize rapidly, in a time interval of the order of fifty microseconds, so that when voltage is again automatically applied to charge the delay line the switch tube will not immediately conduct again and thus cause the apparatus to malfunction.

Apparatus capable of producing pulse power in the hundred megawatt class requires a gaseous ionizable switch tube employing a metallic vapor, as for example, mercury in the type known as an ignitron. In the conventional operation of such tubes, as the type GL 6228, the deionization time is of the order of one thousand microseconds. While certain circuit arrangements are possible that reduce this time these are not sufficiently effective to provide an operative apparatus of the pulse-forming type. The inherent characteristics of the charging circuit of such apparatus require additional measures to be taken. One such measure is to provide an additional high power high vacuum tube and an accompanying circuit to withhold the charging voltage from the anode of the switch tube until that tube has deionized.

I have found that an unusual circuit connection of an ionizable tube such as an ignitron reduces the deionization time thereof sufficiently to dispense with a tube and additional circuitry concerned with deionization time and that my circuit connection results in apparatus performance with a reliability heretofore not realizable.

Briefly, I provide two intra-electrode volumes with electrode potentials effective in accomplishing deionization. Previously, only one such volume has been considered possible for accomplishing this process. This has been a "last step" that has brought both simplicity of apparatus and reliability of operation to devices of this class in spite of the previously considered inherent characteristic of ionizable tubes.

An object of my invention is to simplify the circuit of a switch tube.

Another object is to increase the reliability of operation of such a tube.

Another object is to shorten the deionization time of a multi-electrode ionizable tube.

Other objects will become apparent upon reading the following detailed specification and upon examining the accompanying drawing, in which is set forth by way of illustration and example an embodiment and an alternate embodiment of my invention.

FIG. 1 shows an electrical circuit for a pulse-producing apparatus employing a switch tube, and

FIG. 2 shows an alternate circuit for the same.

In FIG. 1, numeral 1 indicates a high voltage source of direct current, the positive terminal of which is connected to the apparatus and the negative terminal is grounded. In high power apparatus of the class in which rapid deionization is a problem, the voltage of this source is of the order of twenty kilovolts and the current capability is in the range of several amperes. Capacitor 2 is connected across this source to act in the nature of a filter reservoir, and may have a capacitance of the order

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of twenty microfarads. Inductor 3 is the charging inductor and typically has an inductance of one and one-half henrys. The plate, or anode, of high vacuum diode 4 is connected to one terminal of inductor 3, while the other terminal of the inductor is connected to the positive terminal of source 1. The cathode of diode 4 is connected to the anode 5 of ionizable tube, or ignitron, 6, and also to the input section of the artificial transmission line, or delay line, generally indicated at 7.

The line is composed of a number of series-connected inductors 8 and shunt-connected capacitors 9. In a typical embodiment the individual section inductors each have an inductance of less than one microhenry and each capacitor has a capacitance of the order of five one-hundredths of a microfarad. More sections of the line are usually employed than have been shown, so that the total shunt capacitance is of the order of a half microfarad. The characteristic impedance is low, usually less than ten ohms.

A pulse transformer 10 has line 7 in series with primary 11 to ground plane 12. Secondary 14 of transformer 10 is connected to the anode and to the cathode of klystron 15, which klystron illustrates a typical load requiring pulse energization. Ignitron switch tube 6 is connected (anode to cathode) across the series connected combination of line 7 and primary 11. It serves to create a short across this circuit for a brief interval measured in microseconds and to repeat this shorting at a selected repetition rate. This action discharges the electrical energy accumulated by the line between shorts through the primary of the transformer and so to produce the modulating (energizing) pulses for the klystron.

Ignitron 6 is typically ignited to ionization just before each pulse is required by the application of a considerable amount of power, such as a current of two hundred amperes at two hundred volts. This power is applied between terminal 16 and ground by known means which have not been illustrated. Diode 17 is connected from igniter electrode 18 to ground 12 to prevent a reverse potential upon the ignitor and possible damage thereto, as known in the practice governing this type of tube. The typical ignitron has three grids, or control electrodes, in addition to an anode and a cathode 19.

A second high voltage source 20 is provided to furnish a negative voltage with respect to ground. This typically has a magnitude of 2,000 volts and a momentary current capability is of the order of two hundred milliamperes. A resistive impedance, or resistor, 21 is connected in series between the negative output terminal of source 20 and the second (middle) shield grid 22 of ignitron 6. The triggering pulse for producing the shorting action by the ignitron is supplied at terminal 13 from external known means of substantial driving power. Resistor 21 has a resistance of the order of 250 ohms.

The ignitron is actually triggered by an appreciable pulse on the third control electrode from the anode, or control grid, 23. This pulse is supplied thereto through the internal capacitance between grids 22 and 23, or additionally, by means of a small capacitance capacitor 24 connected between the two. Grid 23 is connected to ground 12 through resistive impedance, or resistor, 25, which has a resistance of the order of five hundred ohms.

It will be understood that in the mechanism of deionizing a multielectrode tube the establishment of one deionizing space in the previously active discharge path serves, to a first approximation, to accomplish deionization of the tube. In the instant structure, the large negative voltage upon grid 22 serves to attract the positive (Hg) ions and thus to deionize the volume between grids 22 and 23. The three grids in such tubes are usually planar structures, but as long as a definite volume is en-

closed between the grids in and beyond the ionizing path, the shapes of the grids is not controlling.

It has been invariable, heretofore, to connect the first grid away from the anode (i.e., the "gradient" grid) grid 26, to an intermediate voltage approximately half way between the potential of the anode and that of the cathode of ignitron 6. Thus energized, it could play no part in deionization.

I discovered that if this grid 26 was connected directly to ground, as by conductor 27, that this allowed desired operation of the ignitron when ionized and that this provided a second deionized volume after the shorting pulse per se had ceased. This additional deionized volume had the marked effect of decreasing the deionizing time to the order of fifty microseconds and of increasing the stability of operation of the apparatus.

In this relatively early developmental period of high power pulse modulators, malfunctioning due to marginal deionization has been common. Malfunctioning has often occurred every two or three minutes of operation. With my connections, malfunctioning has been so greatly reduced as to occur only once every two or three hours. While my invention is of the nature of a novel simplification, numerous other known expedients to decrease deionization time have been ineffective and certain work in this field is known to have been abandoned because of the inability of accomplishing stable operation with this type of apparatus.

My connection to, or substantially to, cathode potential for grid 26 introduces a relatively negative potential electrode into the region in the ignitron where the gradient has thus far been quite positive. This is again effective in removing positive ions and provides the now recognized highly effective second deionized volume in the tube.

Not only was this new arrangement of connections effective on each apparatus of a limited group that was manufactured, but it was also effective upon another apparatus of the same general type but one which had been differently fabricated by other parties. Thus, the new structure is shown to be of fundamental effectiveness and not a particular arrangement effective upon only one embodiment, which one embodiment could have possessed a unique idiosyncrasy.

While the range of operation over which this type of apparatus functions is reasonably broad, the embodiments concerned operated with a pulse duration of a few microseconds and with an interval between pulses of the order of 2700 microseconds. The average power was of the order of one hundred megawatts and the peak pulse current of the order of five thousand amperes.

The tubes shown in FIG. 1 are normally water cooled in these high power embodiments. Since this technique is known it has not been illustrated.

Certain modifications may be made in the embodiments shown. The resistance value of resistor 25 was given as five hundred ohms, but this value can be greatly reduced, even to a value of a few ohms, without altering the functioning I secure. It is merely necessary to provide more driving power for the lower resistance values and concomitantly a larger value of capacitance for capacitor 24.

Furthermore, the potential of gradient grid 26 may have a value removed from that of the cathode as long as this is small with respect to the anode-cathode voltage of some twenty kilovolts. The potential may be positive or negative with respect to that of the cathode. The source thereof should be of low impedance, as a few ohms. The source may be a battery 28, inserted in lead 27, as shown in FIG. 2.

The nature of the load 15 may also be changed as desired and transformer 10 may not be required in all instances.

Still other detailed modifications in the characteristics of the circuit elements, aspects of circuit connections and alteration of the coactive relation between the elements

may be taken without departing from the scope of my invention.

Having thus fully described my invention and the manner in which it is to be practiced, I claim:

1. In an electrical modulator having chargeable means, and an ionizable shorting tube connected to said chargeable means, said shorting tube having an anode, a cathode and at least three control electrodes, a rapid deionization circuit for said tube comprising, means to connect said anode to said chargeable means, means to connect that control electrode nearest said anode to said cathode, means to impress a negative voltage upon the next further said control electrode from said anode through a resistive impedance, and a second resistive impedance connected to the third of said control electrodes away from said anode and connected also to said cathode.
2. In an electrical pulse apparatus having an electrical delay line, and electrical energy means to charge said line, a circuit comprising, an ionizable switch tube for periodically shorting said line, said tube having three grids, a cathode and an anode, the grid nearest said anode connected to said cathode, a negative voltage source and a dissipative impedance, the middle grid connected to said source through said impedance, a second dissipative impedance, the grid nearest said cathode connected to said cathode, through said second impedance, and said anode connected to said means to charge said line; the recited circuit effective in minimizing the time required for deionizing said ionizable switch tube.
3. In a pulse modulator having an electrically chargeable line and electrical energy means to charge said line connected thereto, a shorting tube circuit comprising an ionizable tube connected to discharge said line, said tube having an anode, a cathode and three grids therebetween, a source of potential approximating the potential of said cathode, the grid nearest said anode connected to said source of potential, an impedance, a negative voltage source, the middle grid connected to said negative voltage source through said impedance, a second impedance the grid nearest said cathode connected to said cathode through said second impedance, the impedance of said source of potential being small with respect to the value of said second impedance, said anode connected to said line; the recited circuit effective in minimizing the deionization time of said ionizable tube.
4. The modulator of claim 3 in which the potential of said source of potential is positive with respect to the potential of said cathode.
5. The modulator of claim 3 in which the potential of said source of potential is negative with respect to the potential of said cathode.
6. In an electrical pulse-forming apparatus of multi-megawatt capacity having a recurrent rechargeable structure and an ionizable shorting tube connected to said structure, said tube having an anode, a cathode and at least three intervening control electrodes, a rapid deionizing circuit for said tube comprising a source of voltage low with respect to the voltage of the pulse formed by said apparatus,

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said source of voltage connected to said cathode and to the control electrode nearest said anode, a dissipative impedance, a negative voltage source having a voltage less than half of the voltage of said pulse, the second control electrode away from said anode connected to said negative voltage source through said dissipative impedance, a resistive impedance, the third control electrode from said anode connected to said cathode through said resistive impedance, 10

7. The apparatus of claim 6 in which said source of voltage is connected to impose a positive voltage upon said control electrode nearest said anode.

8. The apparatus of claim 6 in which said source of voltage is connected to impose a negative voltage upon said control electrode nearest said anode. 15

9. In a high power pulse modulator having a load, an inductance-capacitance transmission line, a transformer connecting said line to said load, and an inductor and a 20

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diode connected in series between a positive voltage electrical energy supply and said line for charging said line, a multiple grid metallic vapor switch tube circuit comprising

5 an ignitron having three grids, a cathode and an anode, the grid nearest said anode connected to ground, a negative voltage source, a resistor, the middle said grid connected to said negative voltage source through said resistor, 10 a second resistor, the grid nearest said cathode connected to ground through said second resistor, said anode connected to said diode and to said line, and said cathode connected to ground; the recited circuit effective in minimizing the deionization time of said ignitron.

No references cited.