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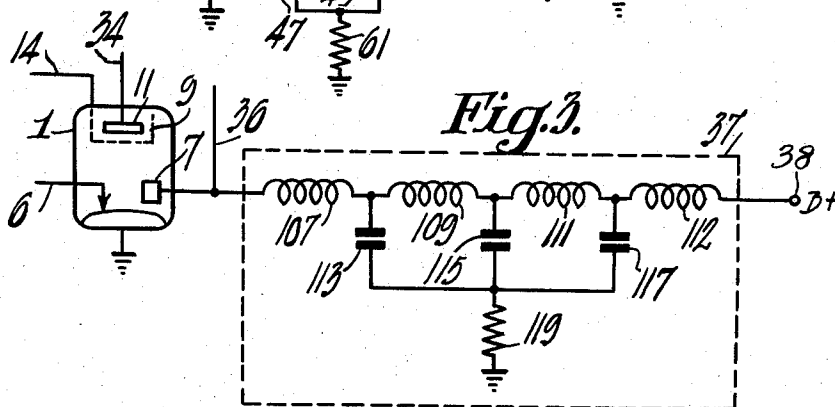
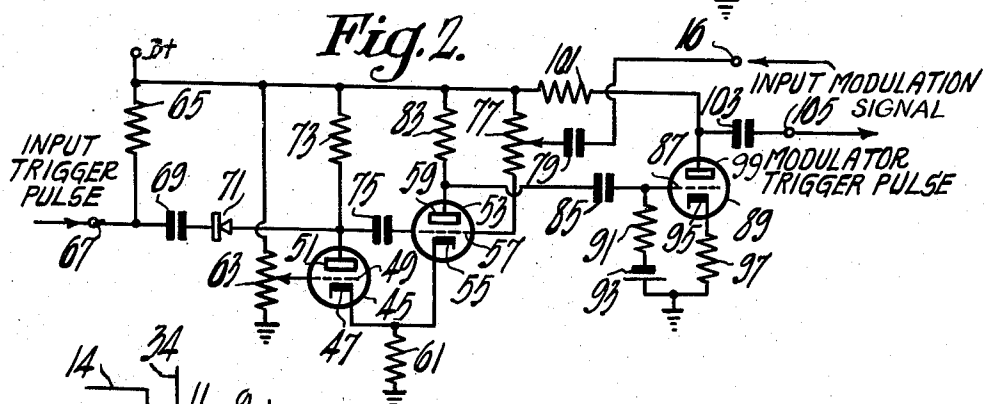
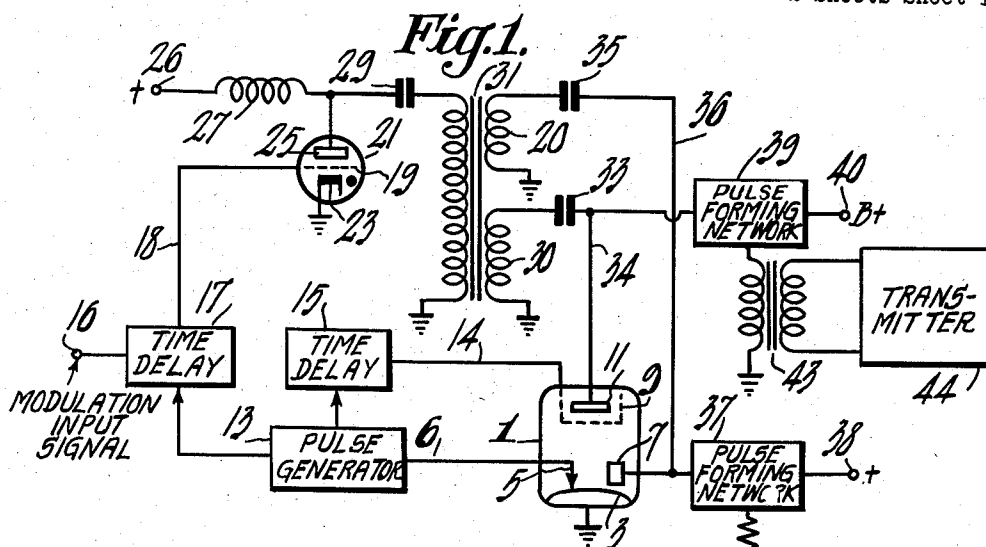
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2,874,355

PULSE WIDTH MODULATION SYSTEM

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2 Sheets-Sheet 1



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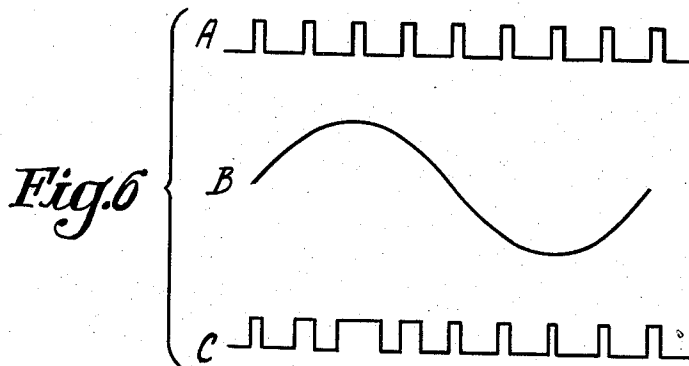
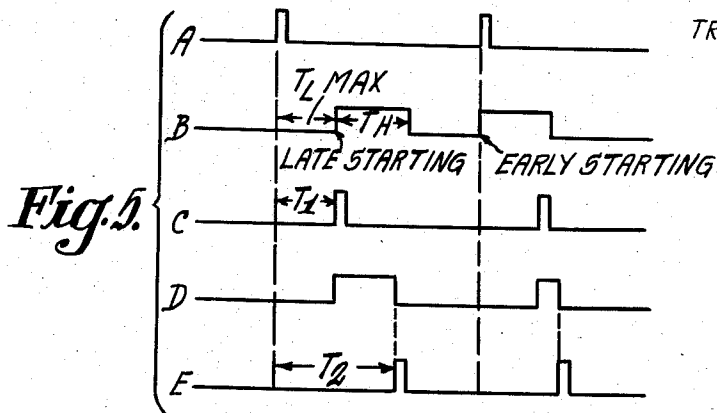
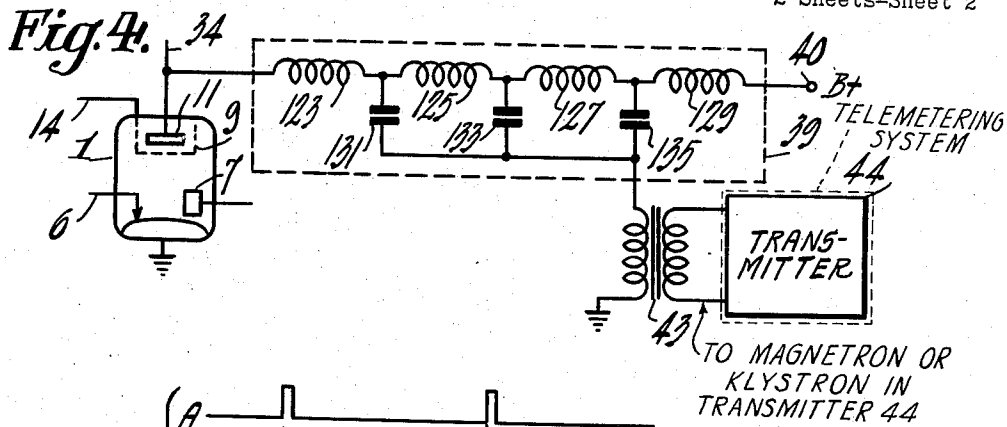
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PULSE WIDTH MODULATION SYSTEM

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2 Sheets-Sheet 2



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1

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PULSE WIDTH MODULATION SYSTEM

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Application January 2, 1957, Serial No. 632,081

18 Claims. (Cl. 332-8)

This invention relates to a pulse system, and particularly to a novel method of and means for controlling the generation of pulses useful in modulation and radar systems.

An object of the invention is to provide a pulse communication system which makes use of the fast switching action of an ignitron type tube.

Another object of the invention is to provide a switching device which will handle a large amount of power and also provide pulses of controllable width at relatively high repetition rates for modulation purposes.

Still another object of the invention is to provide an improved means for the generation of pulses of sufficient power suitable for the modulation of a radar transmitter, or for use in telemetering applications.

Briefly stated, the invention comprises a pulse generating system including an ignitron type tube employed to control the duration of the pulses used for modulation purposes. In the operation of the system, the ignitron is started or fired at the beginning of a control pulse, and then cut off or extinguished by applying a negative pulse both to the main anode and the holding anode of the ignitron type tube. The precise time of occurrence of the negative pulse is controlled by an input modulating signal, thus enabling the ignitron to generate pulses of controlled duration.

The ignitron type tube allows a more rapid rate of switching to take place in the system of the invention than can be achieved with the conventional gas tube, and hence, the generation of pulses having a higher repetition rate. This may be appreciated from the fact that a mercury pool arc such as used in an ignitron tube can be extinguished in a period of from 10^{-8} to 10^{-9} seconds.

The ignitron type tube used in the modulation system of the invention contains a starting probe, an arc holding anode, a main anode, a control grid shielding the main anode, and a mercury pool or liquid cathode. An arc is joined from the mercury pool cathode to the holding anode by feeding a positive pulse from a generator to the starting probe. The pulse generator also feeds a trigger pulse to first and second time delay circuits. The first time delay circuit feeds a trigger pulse to the control grid of the ignitron type tube after a predetermined period of time from the firing of the tube to draw the arc from the holding anode to the main anode. In one embodiment of the invention, the second time delay circuit serves to combine an input modulating signal with the pulse fed to it from the pulse generator in order to send a modulated trigger pulse to the grid of a thyatron tube. The thyatron tube provides a discharge path for a storage condenser through the primary winding of a transformer. When the storage condenser is discharged, a negative pulse is generated in two secondary windings on the transformer. One secondary winding feeds the negative pulse through a coupling condenser to the main anode of the ignitron tube to extinguish the arc to the main anode. At the same time the other secondary winding of the transformer feeds a negative pulse through a

2

coupling condenser to the holding anode of the ignitron tube to extinguish the arc to the holding anode. The holding anode is connected to the positive terminal of a source of unidirectional potential through a first pulse forming network. Output of the ignitron tube in the form of pulses is fed from the main anode through a second pulse forming network to an output transformer. The output transformer is connected to the tube in a transmitter to be modulated, for example, a magnetron or a klystron.

The leading edge of the output pulse from the system (derived from the main anode of the ignitron) is defined by the application of the trigger pulse to the control grid of the ignitron tube while the trailing edge of the output pulse is defined by the application of a negative pulse to the anode of the ignitron tube which extinguishes the mercury arc. The period of pulse duration is varied in accordance with an input modulation signal fed to the system.

In another embodiment of the invention, the width of the output pulse is varied manually by adjusting the tap on a voltage divider in the delay circuit controlling the discharge of the storage condenser, rather than by applying an input modulating signal to the second time delay circuit.

A more detailed description of the invention follows in conjunction with the drawing, wherein:

Figure 1 is a schematic presentation of a pulse width modulation system in accordance with one embodiment of the invention.

Figure 2 is a schematic diagram of the time delay circuit controlling the grid of the thyatron tube, including means to provide a modulated trigger pulse.

Figure 3 is a schematic diagram of the pulse forming network connected to the holding anode of the ignitron type tube, which may be used in the embodiment of the invention shown in Figure 1.

Figure 4 is a schematic diagram of the output pulse forming network which may be connected to the main anode of the ignitron type tube in the embodiment of Figure 1.

Figure 5 is a chart of the waveforms generated in the pulse width modulation system illustrating the time sequence in the operation of the system.

Figure 6 is a graph illustrating the variation in output pulse width of the modulation system for a sine wave input modulation signal.

Referring to Figure 1 in detail, there is shown an ignitron type tube 1 having a cathode composed of a liquid or mercury pool 3 at ground potential, a starting probe 5, a holding anode 7, a control grid 9 and a main anode 11. The starting probe 5 is connected to a pulse generator 13 over lead 6. Pulse generator 13 feeds a positive pulse to the starting probe 5 to vaporize the mercury pool 3 and start an arc between pool 3 and holding anode 7. Pulse generator 13 also feeds a positive trigger pulse to a first time delay circuit 15 and also to a second time delay circuit 17. The first time delay circuit 15 sends a positive trigger pulse over lead 14 to the control grid of the ignitron type tube 1 after a period of time T measured from the firing of the tube, in order to draw the arc from the holding anode 7 to the main anode 11. The first time delay circuit 15 is of the conventional type. The second time delay circuit 17 is composed of a multivibrator arrangement which will be described in greater detail in connection with Figure 2.

The output of the second time delay circuit 17 is connected to the grid 19 of a thyatron gas tube 21. The time delay circuit 17 combines an input modulation signal from an input terminal 16 with the positive pulse from the pulse generator 13 to provide a modulated trigger pulse for the thyatron tube 21. The cathode 23 of the

thyatron tube is at ground potential. The anode 25 of the thyatron tube is connected through a current limiting coil 27 to the positive terminal 26 of a unidirectional source of high positive potential. Anode 25 is also connected through a storage condenser 29 to the primary winding of a transformer 31.

Transformer 31 has two secondary windings. One secondary winding 30 is connected through a coupling condenser 33 to the anode 11 of the ignitron type tube 1 over lead 34. The other secondary winding 20 is connected through a coupling condenser 35 to the holding anode 7 over lead 36. A pulse forming network 37 is connected to the holding anode 7 at one end and to the positive terminal 38 of a source of unidirectional potential at the other end. A detailed description of pulse forming network 37 will be given in connection with Figure 3.

After a period of time T_2 from the firing of the ignitron type tube the time delay circuit 17 sends a modulated trigger pulse to the grid 19 of thyatron tube 21. The thyatron tube fires, allowing storage condenser 29 to discharge through the primary winding of transformer 31. The discharge of storage condenser 29 forms a negative pulse in the two secondary windings 20 and 30 of transformer 31. One secondary winding 30 sends a negative pulse to the main anode 11 of the ignitron type tube 1 to extinguish the arc to the main anode. The other secondary winding 20 sends a negative pulse to the holding anode 7 to extinguish the arc to the holding anode.

The anode 11 of the ignitron type tube is connected through a pulse forming network 39 to B+ which is at the positive terminal 40 of a source of unidirectional potential. Pulse forming network 39 is connected to the primary winding of an output transformer 43. The secondary winding of the output transformer 43 is connected to the tube to be modulated in the transmitter 44. The output pulse repetition rate may, for example, be of the order of 40 kc. The pulse forming network 39 will be described in greater detail in connection with Figure 4.

Figure 2 is a schematic diagram of the time delay circuit 17 showing a multivibrator arrangement composed of regeneratively intercoupled vacuum tubes 45 and 53. The cathode 47 of tube 45 is connected to ground through a resistor 61 which is common to cathode 55 of tube 53. Grid 49 of tube 45 is connected to a movable tap on voltage divider 63. Voltage divider 63 is connected between positive terminal B+ and ground. A resistor 65 is connected from B+ to the input trigger pulse terminal 67. The positive input trigger pulse supplied to terminal 67 from the pulse generator 13 is fed through a coupling condenser 69 and a crystal rectifier 71 to the junction of anode 51 of tube 45 and resistor 73. The other end of resistor 73 is connected to B+. Anode 51 is also connected through a coupling condenser 75 to the grid 57 of tube 53. A voltage divider 77 is also connected to grid 57 at one end and to the positive terminal B+ at the other end. The center tap of the voltage divider 77 is connected through a coupling condenser 79 to the input modulating signal terminal 16. Anode 59 of tube 53 is connected to B+ through a resistor 83. The output of tube 53 is fed from the anode 59 through a coupling condenser 85 to grid 87 of an amplifier vacuum tube 89. Grid 87 is connected through resistor 91 and a bias battery 93 to ground. Cathode 95 is connected through resistor 97 to ground. The anode 99 of tube 89 is connected to B+ through resistor 101. The output trigger pulse is fed through coupling condenser 103 to terminal 105 which connects with the grid 19 of thyatron 21 over lead 18. The pulse generator 13 supplies a trigger pulse having a constant repetition rate to the free running multivibrator. When an input modulation signal is fed to the multivibrator via terminal 16 and the voltage divider 77, the modulation signal either adds or subtracts from the amplitude of the trigger pulse applied

via terminal 67, resulting in a corresponding variation in pulse output width of the multivibrator. The variation in pulse output width varies the instant or starting of conduction of the thyatron tube 21 by virtue of a differentiation action on the leading and trailing edges of the output pulses from the multivibrator and hence varies the width of the pulse output of the ignitron type tube 1.

Figure 3 is a schematic diagram of the pulse forming network 37 connected to the holding anode 7 of ignitron type tube 1. The pulse forming network includes four serially connected current limiting inductance coils 107, 109, 111 and 112. Coil 107 is connected to the holding anode 7 of the ignitron type tube 1. Coil 112 is connected to a source of relatively low positive potential at terminal 38 with respect to the positive potential available at terminal 40. A first condenser 113 is connected from the junction of coils 107 and 109 to a resistor 119. The other end of resistor 119 is connected to ground. A second condenser 115 is connected from the junction of coils 109 and 111 to the junction of condenser 113 and resistor 119. A third condenser 117 is connected from the junction of coil 111 and coil 112 to the junction of condenser 113 and the resistor 119. Condensers 113, 115 and 117 and resistor 119 form a delay network which dissipates the negative pulse fed to the holding anode 7. The current limiting coils of pulse forming network 37 limit the current surge which takes place when holding anode 7 strikes an arc.

Figure 4 is a schematic diagram of the output pulse forming network 39 connected to the main anode 11 of the ignitron type tube 1. The pulse forming network 39 supplies B+ voltage to the main anode 11 of the ignitron type tube 1 and prevents a current surge when an arc is struck to the main anode 11. The pulse forming network is composed of four serially connected current limiting inductance coils 123, 125, 127 and 129. Coil 123 is connected to the main anode 11 of the ignitron type tube 1. Coil 129 is connected to a source of high positive potential B+ at terminal 40. A first condenser 131 is connected from the junction of coils 123 and 125 to the primary winding of transformer 43. A second condenser 133 is connected from the junction of coils 125 and 127 to the junction of condenser 131 and the primary winding of transformer 43. A third condenser 135 is connected from the junction of coils 127 and 129 to the junction of condenser 133 and the primary winding of transformer 43. The condensers 131, 133 and 135 provide a delay network for the output pulse of the system. The amount of delay provided by pulse forming network 39 must be greater than the pulse duration of the output pulse of the ignitron type tube 1.

Figure 5 is a chart of the waveforms generated in the pulse width modulation system showing the time sequence in the operation of the system. Waveform A represents the starting voltage pulse applied to the starting probe 5 of the ignitron type tube 1 by pulse generator 13 as shown in Figure 1. Waveform B represents the current flowing through the holding anode of the ignitron type tube. Depending on the time lag TL in starting an arc, the holding anode 7 will pick up the arc at approximately the time TL after the application of the starting voltage. The time constant T_h of the pulse forming network 37 must be larger than the maximum expected starting time lag TL max. Waveform C represents the trigger pulse from pulse generator 13 which is fed through the time delay circuit 15 to the control grid 9 of the ignitron type tube 1 and which causes the arc to transfer from the holding anode 7 to the main anode 11. The time delay T_1 of time delay circuit 15 must be larger than TL max but less than T_h to insure that a holding arc is burning at the time the trigger pulse is applied to the control grid 9 to draw the arc to the main anode 11 of the ignitron type tube 1. Under these conditions it is possible to reduce the starting time of the arc to the main anode 11

5

to below 20 millimicro seconds. Waveform D represents the main anode current of the ignitron type tube 1. The time constant of pulse forming network 39 must be larger than the largest pulse output width of the ignitron type tube 1. Waveform E represents the positive trigger voltage pulse fed by the pulse generator 13 through the time delay circuit 17 to the grid 19 of the thyatron tube 21. The time delay T_2 of time delay circuit 17 is varied with the modulation signal and determines the time of cessation or the pulse width of the main anode current represented by the waveform D.

Figure 6 is a graph illustrating the variation in pulse output width of the modulation system for a sine wave input modulating signal. Waveform A represents a series of output pulses from the transmitter 44 when they are not modulated by a message or intelligence applied to terminal 16 of Figure 1. Waveform B represents the sine wave input modulating signal applied to the time delay circuit 17 of the pulse width modulation system. Waveform C represents the variation in output pulse width when the pulse width modulation system is used to modulate the transmitter output pulses represented by the waveform A.

The invention may be used in any application where it is required to vary the pulse duration as in communications, interrogation radar and telemetering systems. As indicated in Figure 4, the secondary winding of transformer 43 may be connected to the input circuit of a magnetron or a klystron in the transmitter 44, the transmitter 44 being included in a telemetering or other pulse system.

The term "ground" used herein is not limited to an actual earth connection but is deemed to include any point of reference potential.

What is claimed is:

1. A pulse width modulation system comprising in combination an ignitron type tube having a mercury pool cathode, a starting probe, a holding anode, a control grid and a main anode, means for applying a positive potential to said holding anode, means for applying a positive potential to said main anode, a pulse generator, said pulse generator being coupled to said starting probe to supply a pulse of positive potential thereto for vaporizing said mercury pool to cause an arc from said pool to said holding anode, a first delay circuit coupled between said pulse generator and said control grid, said pulse generator being adapted to feed a trigger pulse through said first delay circuit to said control grid of sufficient magnitude to draw an arc to said main anode, means including a second delay circuit to apply a negative pulse to said main anode and said holding anode for extinguishing the arc to said main anode and said holding anode, means for applying an input modulating signal to said second delay circuit for varying the time of occurrence of said negative pulse, and means for deriving an output pulse from said ignitron, the output pulse varying in width in accordance with said input modulating signal.

2. A pulse width modulation system comprising in combination an ignitron type tube having a mercury pool cathode, a starting probe, a holding anode, a control grid and a main anode, a first current limiting means for applying a positive potential to said holding anode, a second current limiting means for applying a positive potential to said main anode, a pulse generator, said pulse generator being coupled to said starting probe to supply a pulse of positive potential thereto for vaporizing said mercury pool to cause an arc from said pool to said holding anode, a first delay circuit coupled between said pulse generator and said control grid, said pulse generator being adapted to feed a trigger pulse through said first delay circuit to said control grid of sufficient magnitude to draw an arc to said main anode, means including a second delay circuit to apply a negative pulse to said main anode and said holding anode for extinguishing the arc to said main anode and said holding anode, means

6

for applying an input modulating signal to said second delay circuit for varying the time of occurrence of said negative pulse, and means for deriving an output pulse from said ignitron, the output pulse varying in width in accordance with said input modulating signal.

3. A pulse width modulation system as claimed in claim 2, wherein said first and second current limiting means comprise first and second pulse forming networks, said first pulse forming network being connected to the positive terminal of a unidirectional source of low potential, said second pulse forming network being connected to the positive terminal of a unidirectional source of high potential.

4. A pulse width modulation system comprising in combination an ignitron type tube having a mercury pool cathode, a starting probe, a holding anode, a control grid and a main anode, a first pulse forming network, said first pulse forming network being connected at one end to the positive terminal of a unidirectional source of low potential and at the other end to said holding anode, a second pulse forming network, said second pulse forming network being connected at one end to the positive terminal of a unidirectional source of high potential and at the other end to said main anode, a pulse generator supplying a pulse of positive potential to said starting probe for vaporizing said mercury pool to cause an arc from said pool to said holding anode, a first delay circuit coupled between said pulse generator and said control grid, said pulse generator being adapted to feed a trigger pulse through said first delay circuit to said control grid of sufficient magnitude to draw an arc to said main anode, means to apply a negative pulse to said main anode and said holding anode for extinguishing the arc to said main anode and said holding anode, a second delay circuit, said second delay circuit being coupled between said pulse generator and said means, said pulse generator being adapted to feed a trigger pulse to said second delay circuit for controlling said means, means for applying an input modulating signal to said second delay circuit for varying the time of said negative pulse applied by said first-mentioned means, and means for deriving an output pulse from said ignitron, the output pulse varying in width in accordance with said input modulating signal.

5. A pulse width modulation system comprising in combination an ignitron type tube having a mercury pool cathode, a starting probe, a holding anode, a control grid and a main anode, a first pulse forming network, said first pulse forming network being connected at one end to the positive terminal of a unidirectional source of low potential and at the other end to said holding anode, a second pulse forming network, said second pulse forming network being connected at one end to the positive terminal of a unidirectional source of high potential and at the other end to said main anode, a pulse generator, said pulse generator supplying a pulse of positive potential to said starting probe for vaporizing said mercury pool to cause an arc from said pool to said holding anode, a first delay circuit coupled between said pulse generator and said control grid, said pulse generator being adapted to feed a first trigger pulse through said first delay circuit to said control grid of sufficient magnitude to draw an arc to said main anode, a thyatron tube connected serially with storage means, said storage means being adapted upon the triggering of said thyatron tube to apply negative pulses to said main anode and said holding anode for extinguishing the arc to said main anode and said holding anode, a second delay circuit, said second delay circuit being coupled between said pulse generator and the grid of said thyatron tube, said pulse generator being adapted to feed a second trigger pulse to said second delay circuit for triggering said thyatron tube, means for applying an input modulating signal to said second delay circuit for varying the time of the third trigger pulse fed to the grid of said thyatron tube, and means for deriving an output

7

pulse from said ignitron, the output pulse varying in width in accordance with said input modulating signal.

6. A pulse width modulation system as claimed in claim 5, said second delay circuit comprising a multivibrator, an amplifier stage, a coupling condenser and a rectifier, said multivibrator being coupled to said amplifier, said coupling condenser being serially connected to said rectifier, said pulse generator being adapted to feed said second trigger pulse through said coupling condenser and said rectifier to said multivibrator, said input modulation signal being applied to said multivibrator, said multivibrator combining said second trigger pulse with said input modulation signal to form said third modulated trigger pulse for triggering said thyratron tube.

7. A pulse width modulation system as claimed in claim 5, said storage means comprising a storage condenser connected in series with the primary winding of a transformer and said thyratron tube, said transformer having two secondary windings, one of said secondary windings being connected through a coupling condenser to said main anode, the other of said secondary windings being connected through a coupling condenser to said holding anode, the discharge of said storage condenser upon the triggering of said thyratron tube forming a negative pulse in said secondary windings, said negative pulse extinguishing the arc to said main anode and said holding anode.

8. A pulse width modulation system as claimed in claim 5 and wherein said means for deriving said output pulse includes an output transformer having a primary and a secondary winding, said primary winding being connected through said second pulse forming network to said main anode and said secondary winding being connected to a load.

9. A pulse width modulation system as claimed in claim 5 and wherein said means for deriving said output pulse includes an output transformer having a primary and a secondary winding, said primary winding being connected through said second pulse forming network to said main anode and said secondary winding being connected to a klystron.

10. A pulse width modulation system as claimed in claim 5 and wherein said means for deriving said output pulse includes an output transformer having a primary and a secondary winding, said primary winding being connected through said second pulse forming network to said main anode, said secondary winding being connected to a magnetron.

11. A pulse width modulation system as claimed in claim 5 and wherein said means for deriving said output pulse includes an output transformer having a primary and a secondary winding, said primary winding being connected through said second pulse forming network to said main anode, said secondary winding being connected to a telemetering system.

12. A pulse width modulation system comprising in combination an ignitron type tube having a mercury pool cathode, a starting probe, a holding anode, a control grid and a main anode, a first pulse forming network, said first pulse forming network being connected at one end to the positive terminal of a unidirectional source of low potential and at the other end to said holding anode, a second pulse forming network, said second pulse forming network being connected at one end to the positive terminal of a unidirectional source of high potential and at the other end to said main anode, a pulse generator, said pulse generator supplying a pulse of positive potential to said starting probe for vaporizing said mercury pool to cause an arc from said cathode to said holding anode, a first delay circuit coupled between said pulse generator and said control grid, said pulse generator being adapted to feed a first trigger pulse through said first delay circuit to said control grid of sufficient magnitude to draw an arc to said main anode, a thyratron tube, a

8

storage condenser and a transformer having a primary and two secondary windings, said thyratron tube being serially connected to said storage condenser and the primary winding of said transformer, first and second coupling condensers, one of said secondary windings being connected through said first coupling condenser to said main anode, the other of said secondary windings being connected through said second coupling condenser to said holding anode, a second delay circuit, said pulse generator being adapted to send a second trigger pulse through said second delay circuit for triggering said thyratron tube to cause said storage condenser to discharge through said primary winding and said thyratron tube, the discharge of said storage condenser forming negative pulses in said secondary windings, said negative pulses extinguishing the arc to said main anode and said holding anode, and an output transformer having a primary and a secondary winding, the primary winding of said output transformer being connected through said second pulse forming network to said main anode for deriving an output pulse from said ignitron for application from the secondary winding of said output transformer to a utilization circuit.

13. A pulse width modulation system as claimed in claim 12 and wherein said second delay circuit is responsive to a modulating input signal applied thereto to vary the time of said second trigger pulse according to the amplitude of said signal, said ignitron being operated according to the triggering time of said thyratron in response to said second trigger pulse to cause said output pulse to be of a width determined according to said amplitude of said signal.

14. A pulse width modulation system comprising, in combination, an ignitron type tube having a liquid cathode, a starting probe, a holding probe, a control grid and a main anode, a first pulse forming network connected at one end to a positive terminal of a unidirectional source of low potential and at the other end to said holding anode, a second pulse forming network connected at one end to a positive terminal of a unidirectional source of high potential and at the other end to said main anode, a pulse generator arranged to supply a positive pulse to said starting probe to cause an arc between said cathode and said holding anode, a first delay circuit, said generator being arranged to supply a first trigger pulse through said first delay circuit to said control grid of sufficient magnitude to cause an arc between said cathode and said main anode, said first delay circuit being arranged to control the time of said first trigger pulse so that said first trigger pulse is applied to said control grid after the arc is made between said cathode and said holding anode, a storage means, a second delay circuit to which a modulating input signal is applied, said generator being arranged to apply a second trigger pulse through said second delay circuit to said storage means, said second delay circuit being arranged to vary the time of said second trigger pulse according to a given parameter of said signal, said storage means being responsive to said second trigger pulse to apply negative pulses to said main anode and said holding anode to extinguish the arc to said main anode and said holding anode, and means connected to said ignitron through said second pulse forming network for deriving an output pulse from said ignitron of a width determined according to said parameter of said signal.

15. A pulse modulation system comprising, in combination, an ignitron type tube having a liquid cathode, a starting probe, a holding anode, a control grid and a main anode, means for applying a positive potential to said holding anode and to said main anode, means for applying a pulse of the proper polarity to said starting probe for starting an arc between said cathode and said holding anode, means for subsequently feeding a trigger pulse to said control grid of sufficient magnitude to draw an arc from said cathode to said main anode, an

input circuit to which a modulating input signal is applied, means connected to said input circuit and responsive to said signal to apply a negative pulse modulated according to a given parameter of said signal to both said main anode and said holding anode for extinguishing the arc to said main anode and to said holding anode, and means connected to said tube for deriving from said tube an output pulse modulated according to said parameter of said signal.

16. A pulse width modulation system comprising, in combination, an ignitron type tube having a liquid cathode, a starting probe, a holding anode, a control grid and a main anode, means for applying a positive potential to said holding anode and to said main anode, means for supplying a pulse of proper polarity to said starting probe to cause an arc between said cathode and said holding anode, means for subsequently applying a pulse of the proper polarity and magnitude to said control grid to draw an arc from said cathode to said main anode, an input circuit to which a modulating input signal is applied, means connected to said input circuit and responsive to said signal to apply a pulse of the proper polarity time modulated according to the amplitude of said signal to both said main anode and said holding anode for extinguishing the arc to said main anode and to said holding anode, and means connected to said tube for deriving from said tube an output pulse of a width determined according to said amplitude of said signal.

17. A pulse modulation system comprising, in combination, an ignition type tube having a mercury pool cathode, a starting probe, a holding anode, a control grid and a main anode, means for applying a positive potential to said holding anode and to said main anode,

a pulse generator connected to said starting probe to apply a first pulse to said starting probe to cause an arc between said cathode and said holding anode, a delay circuit connected to said generator and responsive to said first pulse to apply a second pulse to said control grid after the arc is made between said cathode and said holding anode to draw an arc from said cathode to said main anode, an input circuit to which a modulating input signal is applied, a second means connected to said input circuit and responsive to said signal to apply a negative pulse modulated according to a given parameter of said signal to both said main anode and said holding anode for extinguishing the arc to said main anode and to said holding anode, and a third means connected to said tube for deriving from said tube an output pulse modulated according to said parameter of said signal.

18. A pulse modulation system as claimed in claim 17 and wherein said pulse generator operates simultaneously upon the application thereby of said first pulse to said starting probe to apply a third pulse to said second-mentioned means, said second-mentioned means being operated upon the reception of said third pulse thereby to apply said negative pulse to said main anode and said holding anode.

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