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J. J. PALEY ET AL
IGNITRON CONTROL CIRCUITS

2,955,233

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2 Sheets-Sheet 1

Fig. 1.

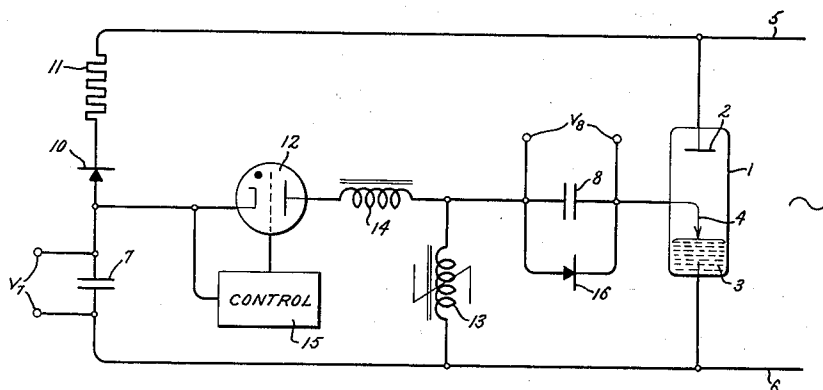


Fig. 2.

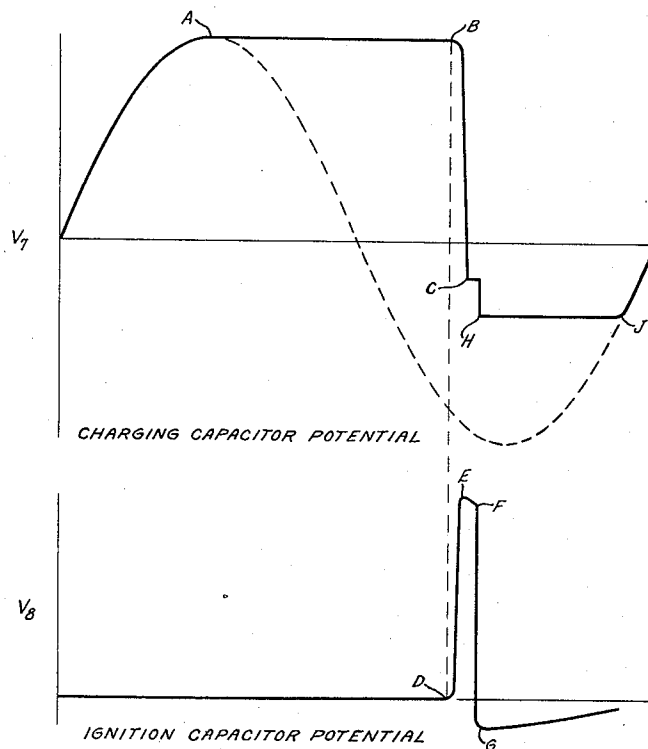
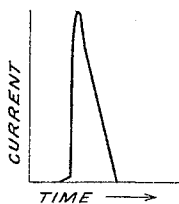


Fig. 2a.



Inventors:
James J. Paley,
Charles E. Rettig,
by *William D. Roberson*
Their Attorney.

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Fig. 3.

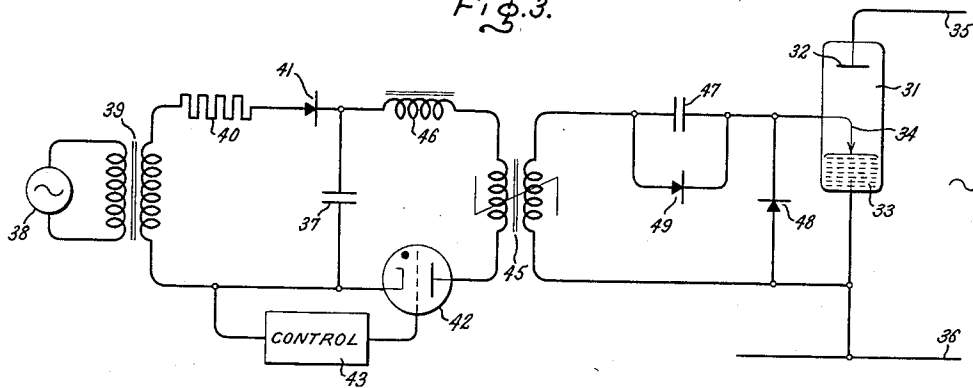


Fig. 4.

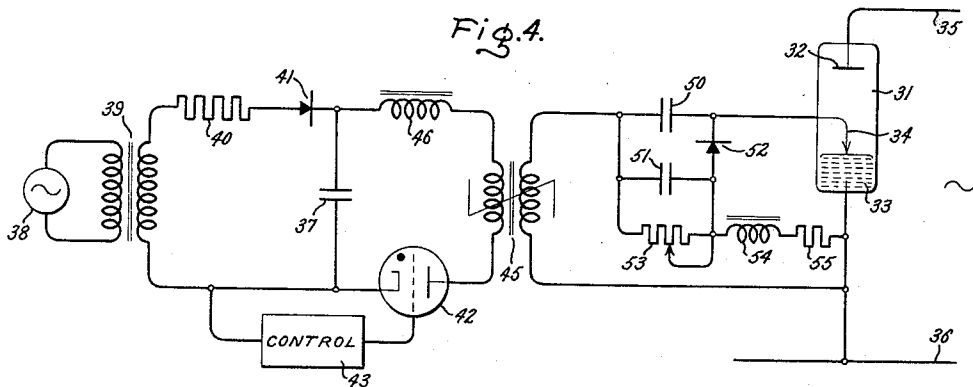
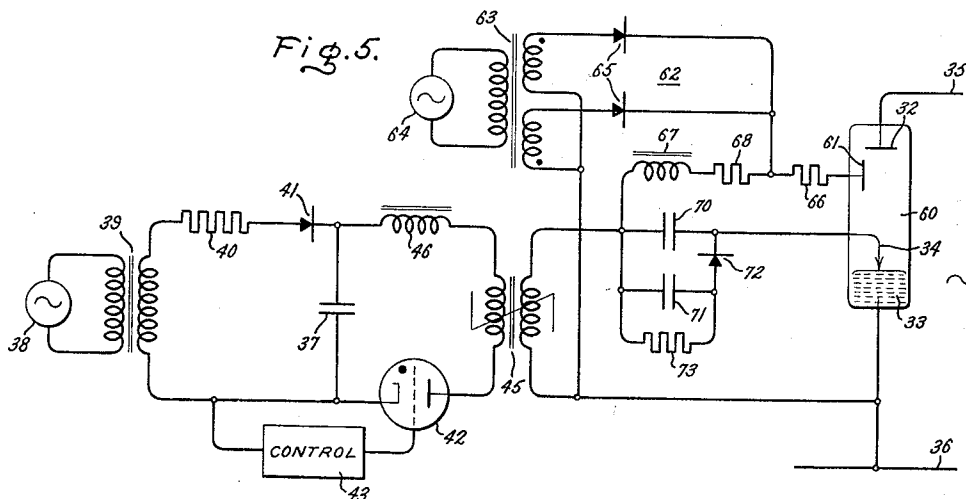


Fig. 5.



Inventors:
James J. Paley,
Charles E. Rettig,
by *William D. Roberson*
Their Attorney.

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IGNITRON CONTROL CIRCUITS

James J. Paley, Albany, N.Y., and Charles E. Rettig, Havertown, Pa., assignors to General Electric Company, a corporation of New York

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9 Claims. (Cl. 315—234)

This invention relates to control circuitry and, more particularly, to control circuits for applying periodic pulses to the ignitor electrode of an ignitron to control its conduction periods.

By the word "ignitron" we means specifically a discharge tube of the type having a reconstructable cathode such as mercury in which is dipped an ignitor rod such as a rod of silicon carbide or boron carbide. To fire an ignitron current is transmitted through the ignitor electrode and the cathode to produce ionization in the region of the ignitor electrode. By reason of the ionization an arc is ignited between the anode and the cathode, if the anode potential is of the proper magnitude at the instant of ionization.

In the operation of ignitrons it has been customary to charge a capacitor from a source of direct current and to discharge the capacitor through the ignitor electrode to provide an ignitron pulse starting the conduction. Now the resistance characteristics of an ignitor electrode is subject to change due to many factors such as temperature, agitation of the mercury pool and the depth of immersion of the ignitor electrode in the pool. For reliability of ignition it is therefore necessary to provide an excess of energy storage on the ignition capacitor. In most conventional circuits the surplus energy, that remaining after firing the ignitron, appears as a potential on the ignition capacitor of opposite polarity to the initial potential. This remaining energy causes certain random variations in the next ignition pulse, both in the amplitude of the pulse and the time during the cycle when the pulse is delivered.

It is an object of the present invention to provide improved ignitron firing circuits in which practically all of the energy stored on the ignition capacitor is delivered to the ignitor electrode during each ignition pulse so that all pulses are of more uniform amplitude and the pulse timing is more accurate.

It is another object of the present invention to provide improved ignitron firing circuits in which the power supply is required to deliver capacitor charging currents at relatively low rates and in which, therefore, the size and cost of the total control circuit may be considerably reduced.

Since this invention does not contemplate a sacrifice in the performance of the control circuit in its function of governing the conduction periods of an ignitron, it is a further object of the invention to provide an ignitron control circuit of comparatively small size which is nevertheless capable of delivering very high peak currents to the ignitor electrode.

It has often been assumed that the ignition pulse to the ignitor electrode should be maintained as long as possible to preserve the ignitor electrode. We have found this assumption to be only partially true, since our observations have tended to confirm that it is the wave shape of most short ignition pulses which tends to destroy the ignitor electrode and not the duration of the pulse.

It is therefore still another object of the present inven-

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tion to provide an ignitron control circuit whose ignition pulses to the ignitor electrode possess a novel wave shape conducive to prolonged ignitor electrode life.

By way of a brief summary of but one embodiment of the present invention, an ignitron control circuit is provided in which an ignition capacitor receives its charge from another capacitor connected to be charged at a comparatively leisurely rate. Periodically a conducting path is established through a low-rated thyatron tube connected in a common circuit loop with the two capacitors to permit the energy on the charged capacitor to transfer onto the ignition capacitor. Shortly after receiving its full charge the potential on the ignition capacitor causes a saturable reactance connected in closed series circuit with it and the ignitor electrode of an ignitron tube to saturate, thereby providing a low reactance discharge path through the ignitor electrode which causes the formation of a cathode spot and initiates the conduction period of the ignitron. The firing of the thyatron is done at intervals which are phase-related to the alternating potentials impressed across the ignitron to control the average current therethrough. Across the ignition capacitor is connected a free-wheeling rectifier which permits the accumulation on the ignition capacitor of a potential of the proper polarity to form a cathode spot, but which prevents the acquisition of any substantial reverse polarity by the ignition capacitor. The effect of this rectifier in combination with the residual inductance in the saturated reactor is to continue to pass currents through the ignitor electrode after the ignition capacitor has been substantially discharged. With such a circuit, the ignition pulse through the ignitor electrode is found to have a very sharp wave front, which contributes to the precision of control exercised over the firing of the ignitron, and a gradual decay of current following the ignition, which we have found greatly increases the life of the ignitor electrode and improves the precision of control which may be exercised over the ignitron.

Further details of the invention as well as additional objects and advantages will be more readily apparent with reference to the following more complete description taken in connection with the accompanying drawings wherein:

Fig. 1 is a schematic circuit diagram of a simplified version of an ignitron control circuit constructed in accordance with this invention;

Fig. 2 is a graphical representation of potentials appearing across certain circuit elements of Fig. 1;

Fig. 2a is a graphical representation of the ignition current pulse through the ignitor electrode; and

Figs. 3 to 5 are schematic circuit diagrams of alternate embodiments of this invention incorporating certain variations and refinements in accordance with these teachings.

With reference to Fig. 1 there may be seen an ignitron 1 having an anode 2, a cathode 3 in the form of a pool of mercury, and an ignitor electrode 4 in contact with the cathode. While but one ignitron is shown it should be realized that the more usual case will include multiple ignitrons connected in polyphase circuit relationship, either full or half wave. Since polyphase circuit connections themselves are not part of the present invention and because many forms of them are well known in the art, the showing of other ignitrons and their interconnections have been omitted to avoid unnecessary duplication of parts and to simplify the description. The alternating current potential source illustrated symbolically as connected across conductors 5 and 6 should therefore be understood to represent one phase of a single phase or multiple phase electrical system.

The control circuit shown in Fig. 1 includes a first capacitor 7 and a second capacitor 8, the latter of which functions as an ignition capacitor. During the

half cycle of the applied alternating current potentials when the conductor 6 is positive and the ignitron 1 is therefore non-conductive the first capacitor 7 is free to assume a charge. The current for this purpose flows through a charging circuit including rectifier 10 and current limiting resistor 11. The charging of capacitor 7 takes place during an entire quarter cycle of the applied alternating current potentials, and the capacitor maintains its charge after reaching its peak potential. The rectifier 10 prevents the charge on the capacitor from following line potential after the peak potential is reached, and the switching means represented by normally non-conducting thyatron 12 prevents the capacitor 7 from draining through the discharge circuit until the desired phase angle occurs.

The discharge circuit for capacitor 7 in Fig. 1 includes on the one hand a saturable reactor 13 and, connected across it, an ignition capacitor 8 in series circuit with the ignitor electrode 4 and the cathode 3 of the ignitron. The thyatron 12 and linear reactor 14 govern the manner in which the capacitor 8 is permitted to discharge through either of these circuit paths. When the thyatron 12 is triggered into conduction by a pulse signal applied to its control grid through the medium of a phase controllable circuit 15, a current begins to flow in the discharge circuit, resulting in transferring most of the energy on capacitor 7 to the ignition capacitor 8. Most of the discharge current for capacitor 7 will flow through the ignitor electrode 4 in the opposite direction from that required to fire the ignitron and will develop a potential on the ignition capacitor 8. Because the saturable reactor 13 is, as yet, unsaturated it presents a high impedance to the discharge currents and only a small, initial magnetizing current will exist in it. Since the tendency of the reactor 14 is to maintain current flowing through the thyatron 12, more charge is transferred to ignition capacitor 8 than was actually on the capacitor 7. Consequently, before the thyatron 12 ceases to conduct because of the decline and reversal of the potential across it, the capacitor 7 will actually acquire a reverse charge.

When the potential on the ignition capacitor 8 reaches its peak the only discharge path open to it is back through the ignitor electrode 4 and the saturable reactor 13. These elements together constitute the ignition circuit. It should be noted that this direction of current flow through the saturable reactor 13 is the same as that occasioned during the discharge of capacitor 7. After a brief time interval the magnetizing current in the saturable reactor 13 succeeds in saturating its magnetic core. Consequently the reactance of this element drops to a very low value and the ignition capacitor is effectively short circuited through the ignitor electrode. The current which then flows through the ignitor electrode is of sufficient magnitude and in the proper direction to cause the formation of a cathode spot, rendering the ignitron conducting to current flowing from conductor 5 to conductor 6.

In Fig. 1 the free-wheeling or bypass rectifier 16 connected across the ignition capacitor 8 has two functions. One of its purposes is to permit the flow of follow-up currents in the same direction after the ignition capacitor has discharged. It should be realized that, although the saturable reactor 13 presents a comparatively low impedance after saturation, its impedance is nevertheless appreciable and, in this case, significant. After saturation the reactor 13 possesses a certain amount of inductively stored energy and has substantially the characteristics of an air core inductor which tends to keep current flowing in the same direction therethrough. Without the rectifier 16 connected in circuit this tendency on the part of the reactor 13 would bring about a peaking of the reverse potential on capacitor 8, an effect which can have destructive consequences on the ignitor electrode. Rectifier 16 prevents such an effect by short-circuiting

the current about capacitor 8, and in doing so causes a comparatively gradual decline in the ignition pulse currents instead of an abrupt termination or sudden reversal of the ignition pulse currents. As a result, substantially all the energy stored in the ignition circuit is dissipated after each ignition pulse.

Another function of the rectifier 16 in this particular example is to reset the flux in the magnetic core of the saturable reactor 13 and for this purpose it is selected to have a comparatively high threshold voltage. By this is meant that it will stand off a few volts in a forward direction before beginning to conduct. Such a rectifier may conveniently be provided by connecting a number of individual selenium cells in series until a composite rectifier possessing the desired threshold voltage is achieved. Because of its threshold voltage the rectifier 16 actually permits the accumulation of some reverse charge on the ignition capacitor 8 before it begins to conduct. But this is small compared to its full charge. The effect of the parallel combination of the rectifier 16 and capacitor 8 is therefore similar to a battery in supplying the reset voltage to the reactor 13 to drive the flux in the magnetic core in the opposite direction on the hysteresis loop, thereby to prepare the reactor for the next cycle of operation.

Fig. 2 is a graphic illustration of the potentials V7 and V8 appearing across capacitors 7 and 8 respectively. Both curves are drawn on the same time scale with the dotted line representing, for reference purposes, the sinusoidal potential appearing across conductors 5 and 6. It can be seen that during the initial 90 degrees of the applied alternating current potential the potential on capacitor 7 follows the sinusoidal potential to a maximum or peak potential at point A. When the alternating potential declines, however, the charge on capacitor 7 remains constant until at a pre-determined point B the thyatron 12 is triggered into conduction. The potential on capacitor 7 does not drop off immediately because of the effect of the inductor 14, but rolls off gradually, its rate of discharge increasing more and more rapidly. As the capacitor 7 discharges from point B to point C, the potential on the ignition capacitor 8 rises correspondingly from point D to a maximum at point E. Thereafter the capacitor 8 does not maintain a constant charge, since there is some drain on it to provide the magnetizing current for the saturable reactor 13. This drain results in the slope of the ignition capacitor potential from point E to point F, which represents the instant at which the saturable reactor 13 saturates.

Immediately on the occurrence of this event the potential on the ignition capacitor drops very sharply as the capacitor supports an ignition pulse through the ignitor electrode. The potential on capacitor 8 swings negative by a small amount until at point G the threshold potential of rectifier 16 is exceeded. After this time the reverse potential on the ignition capacitor 8 leaks off gradually resetting the core of saturable reactor 13. When the reactor 13 saturates the drop in potential across it permits the inductor 14 to pass some additional current through itself before the thyatron ceases to be conducting. For this reason the potential on capacitor 7 goes even more negative as evidenced by the jog in its potential curve between points C and H. This negative potential is maintained by capacitor 7 until point J, at which time the applied sinusoidal potential catches up with it, as it were, and begins to reverse the charge again.

Fig. 2a shows on a different time scale the wave shape of the ignitor current, i.e. it shows the ignition pulse. This pulse is characterized by a very sharp rise in current represented by the almost vertical leading edge of the curve. It can be shown that from the initiation of this pulse to just past its peak the curve is substantially sinusoidal. However, just past the peak the nature of the pulse changes abruptly and instead of falling off as

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sharply as it had risen, a follow-up current flows causing the current pulse to decline gradually to zero. As a consequence, almost all of the energy stored in the ignition circuit is delivered to the ignitor electrode, leaving the ignition capacitor in substantially identical conditions at the beginning of each cycle. This results in more uniform ignition pulses precisely timed to give accurate and reliable control over the operation of the ignitron. Furthermore, we have found that the gradual decline of the ignition pulse to zero is more conducive to prolonged ignitor electrode life than are current pulses which decline abruptly or reverse their direction suddenly in an oscillatory manner.

In the embodiment of this invention illustrated in Fig. 3 there may be seen certain variations which, among other things, permit the insulation of the charging capacitor circuit from the ignition capacitor circuit. As in the previous example the ignitron 31 is possessed of an anode 32, a cathodic pool of mercury 33, and an ignitor electrode 34, the ignitron being connected across conductors 35 and 36 having an alternating current potential impressed upon them. The charging capacitor 37 in this example is charged from a separate source 38 of alternating current power related in phase to the alternating current potential on conductors 35 and 36. The coupling between the source 38 and charging capacitor 37 is effected through transformer 39, current limiting resistor 40 and the rectifier 41, the latter element permitting the charging capacitor 37 to hold the peak potential applied to it by the alternating current source.

As in the Fig. 1 embodiment the charging capacitor is discharged through a thyatron 42 triggered into conduction by a pulse signal applied to its control grid through the medium of a phase controllable circuit 43. When the thyatron is thus rendered conductive the charge on capacitor 37 drains off through the primary of saturable transformer 45 and through the linear reactor 46, which provides a transfer inductance. This action produces a current flow in the secondary circuit of the unsaturated transformer 45 to charge the ignition capacitor 47. Most of the current required to charge the ignition capacitor 47, instead of passing in a reverse direction through the cathode 33 and the ignitor electrode 34, is shunted through another circuit branch including a bypass rectifier 48, which is poled to permit flow of the charging current but to block the discharge current. The addition of rectifier 48 reduces the total current required to be passed through the ignitor electrode and tends to prolong the life of the ignitron still further.

As the charge on the ignition capacitor 47 builds up and even after it has reached its highest point, a magnetizing or exciting current flows in the transformer 45 until after a certain interval determined by the constants of the system the core of the transformer saturates. Thereupon the secondary of the transformer 45 becomes a low impedance path for the discharge of the ignition capacitor. A cathode spot-forming ignition pulse of the general wave shape shown in Fig. 2a is therefore passed through the ignitor electrode and the cathode, the free-wheeling rectifier 49 functioning, as before, to permit the flow of a follow-up current causing a gradual decay of the ignition current pulse following its initial sharp rise. Rectifier 49 is preferably constructed as was rectifier 16 in the Fig. 1 example to possess a relatively high threshold potential which, in combination with capacitor 47, connected across it, aids in resetting the flux in the core of transformer 45 to prepare it for the next cycle of operation.

For ease of identification of the respective components many of those elements of Figs. 4 and 5 corresponding to their functional counterparts in Fig. 3 have been assigned the same reference number. In the Fig. 4 modification one of the principal differences resides in the use of a pulse-shaping circuit combination connected across ignition capacitor 50. This pulse-shaping circuit includes by-

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pass capacitor 51, bypass rectifier 52, and an adjustable resistor 53. This circuit combination permits a measure of control to be exercised over the width of the ignition pulse. We have found that with values of three microfarads for capacitor 50 and 200 microfarads for capacitor 51 and a residual inductance of about 300 microhenries in the secondary winding of saturable transformer 45, an ignition pulse which would have lasted two electrical degrees at sixty cycles is stretched to approximately 5 electrical degrees. Thus the final rate of change of current in the ignition pulse is greatly decreased with a consequent decrease in the duty on the ignitor electrode.

After the ignition pulse is completed it is necessary to return the flux in the core of transformer 45 to its original unsaturated condition. To do this a voltage must be applied across the secondary of the transformer with a polarity opposite to that which appeared during saturation. Such a voltage is obtained from the reset circuit elements including inductor 54 and resistor 55. As a result of the fact that a portion of the ignition pulse current flows through the reset reactor 54, following the termination of the ignition pulse this reactor tends to keep a current flowing through it in the same direction, and this results in a reset current flowing through resistor 53 and through the secondary of transformer 45 in a reverse direction, resetting it. With a separate reset circuit of this nature rectifier 52 does not have to be of a type which possesses a high threshold potential, since the potential across the bypass rectifier is not employed to reset the saturable reactor.

In Fig. 5 is shown an alternative ignitron control circuit in which the ignitron 60 is supplied with a holding anode 61. The holding anode is supplied with a holding potential in a known way through a rectified D.C. supply 62 which is represented in the drawing by a filament transformer 63 coupled to a source 64 and providing full-wave rectified potentials to the holding anode through rectifiers 65 and resistor 66. In this example the potential to reset the core of saturable transformer 45 is obtained from the holding anode circuit through an inductor 67 and a resistor 68. The inductor 67 serves to isolate the ignition capacitor 70 from the holding anode circuit during the time the ignition capacitor is being charged. As might be expected, the reactor 67 does draw some current from the ignition capacitor and decreases the charge upon it. For this reason reactor 67 should be as large as practical and the saturation of transformer 45 should occur as soon as possible after the voltage across the ignition capacitor reaches its peak. As in the previous example, a pulse-shaping circuit comprising bypass capacitor 71, bypass rectifier 72 and resistor 73 is connected across the ignition capacitor to shape and stretch the ignition pulse applied to the ignitron through the ignitor electrode 34.

As can be seen each of the embodiments of this invention described above may employ a comparatively inexpensive thyatron to initiate the firing pulse. The saturable reactor permits the rise time of the ignition pulse to be very brief, which results in precision of control and also avoids the waste of the ignition power on initial ignition currents which would be insufficient in magnitude to form a cathode spot. Coupled with the sharp rise of current in the ignition pulse is a comparatively gradual decay of the ignition current which prevents oscillation of the current through the ignition electrode and inhibits large reverse currents which might otherwise flow through the ignition electrode. This greatly prolongs the useful life of the ignition electrode and enhances the precision of control by returning the ignition capacitor to the same condition after each ignition pulse. In addition, since the peak currents and inverse potential in the charging circuit are so low, the energy levels involved in the accumulation of charge from the source circuit are conducive to a long useful life of the thyatron.

It should be appreciated that the potential and current curves described herein are not identical for each of the

circuits depicted, but are primarily representative. They are intended to illustrate the general principles characterizing the operation of this invention rather than to show precise wave forms. It is therefore to be expected that certain variations will be noted in particular circuits.

At this point it will have become apparent that the various specific embodiments described herein are offered as purely illustrative in nature and that they should not necessarily be taken as limiting on the invention disclosed herein. Many other modifications within the true spirit and scope of these teachings in addition to those already depicted will doubtless occur to those skilled in the art to which this disclosure pertains.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In combination: an ignitron having an ignitor electrode in contact with a cathodic pool of mercury; means for impressing a source of alternating current potential across said ignitron; an ignition capacitor; a saturable reactor; a closed series circuit connecting said capacitor and said saturable reactor in mutual series relationship with said ignitor electrode through said cathodic pool of mercury; means for periodically storing a charge on said capacitor and for periodically discharging said capacitor through said series circuit to cause the flow of an arc-igniting current pulse through said ignitor electrode in response to saturation of said reactor; and a current conducting path connected across said ignition capacitor and containing a rectifier poled to effect resetting of the flux of said saturable reactor following discharge of said capacitor and permit the flow of inductively caused follow-up currents through said ignitor electrode after the discharge of said ignition capacitor.

2. In combination: an ignitron having an ignitor electrode in contact with a cathodic pool of mercury; means for impressing a source of alternating current potential across said ignitron; an ignition capacitor; a saturable reactor; a closed series circuit connecting said reactor and capacitor in mutual series relationship with said ignitor electrode through said cathodic pool of mercury; means for storing a charge on said capacitor of a polarity to cause the flow of an arc-igniting current pulse through said ignitor electrode in response to saturation of said reactor; a current conducting path connected across said ignition capacitor containing a rectifier poled to effect resetting of the flux of said saturable reactor following discharge of said capacitor and permit the flow of follow-up currents through said ignitor electrode after the discharge of said ignition capacitor.

3. In combination: an ignitron having an ignitor electrode in contact with a cathodic pool of mercury; means for impressing a source of alternating current potential across said ignitron; a first capacitor; means for storing energy in the form of a charge on said first capacitor during the half cycle of said alternating current when said ignitron is non-conductive; a second capacitor; means for transferring the energy represented by the charge on said first capacitor onto said second capacitor at pre-selected intervals related to the phasing of said alternating current source; inductance means having saturable magnetic material associated therewith to cause said inductance means to operate at different levels of reactance; said inductance means being connected in closed series circuit with said second capacitor and said ignitor electrode to provide a discharge path for the charge on said second capacitor, said magnetic material saturating a predetermined time interval following the charging of said second capacitor to cause the impedance of said discharge path to decrease thereby to form an arc-igniting cathode spot in said ignitron by the sudden discharge of said second capacitor; and a circuit branch including a rectifier connected across said second capacitor and poled to permit the saturated inductance means to continue to force currents therethrough after the discharge of said second capacitor.

4. In combination: an ignitron having an ignitor electrode in contact with a cathodic pool of mercury; means for impressing a source of alternating current potential across said ignitron; a charging circuit including a first capacitor connected to receive and store an electrical charge; an ignition circuit including a second capacitor connected in series with said ignitor electrode, a discharge circuit including switching means periodically coupling said charging circuit with said ignition circuit to periodically transfer energy represented by the charge on said first capacitor onto said second capacitor; and saturable reactance means in said ignition circuit adapted to saturate a predetermined time interval after said second capacitor assumes its charge, thereby converting said ignition circuit into a low impedance discharge path permitting flow of an ignition current pulse to said ignitor electrode.

5. In combination: an ignitron having an ignitor electrode in contact with a cathodic pool of mercury; means for impressing a source of alternating current potential across said ignitron; and means for periodically applying through said ignitor electrode current pulses to form cathode spots in predetermined phase relationship with said alternating current potentials comprising: a saturable reactance device having high and low impedance states and an ignition capacitor connected to form with said ignitor electrode and said cathodic pool of mercury a closed series-connected ignition circuit, means for periodically placing a charge on said ignition capacitor thereby permitting said charge to support a magnetizing current through said saturable reactance device causing, after a predetermined time interval, saturation of said device and consequent conversion of said device to its low impedance state, whereby periodic current pulses flow in said ignition circuit, and a bypass circuit branch connected in parallel across said ignition capacitor including a bypass rectifier poled to permit the flow of follow-up currents in the same direction as said current pulse, whereby said current pulses are characterized by a sharp rise of current followed by a relatively gradual decay of current.

6. In combination: an ignitron having an ignitor electrode in contact with a cathodic pool of mercury; means for impressing a source of alternating current potential across said ignitron; a charging circuit including a first capacitor connected to receive and store an electrical charge; an ignition circuit including a second capacitor connected in series with said ignitor electrode; a discharge circuit including switching means periodically coupling said charging circuit with said ignition circuit to periodically transfer energy represented by the charge on said first capacitor onto said second capacitor; saturable reactance means in said ignition circuit adapted to saturate a predetermined time interval after said second capacitor assumes its charge thereby converting said ignition circuit into a low impedance discharge path permitting flow of an ignition current pulse through said ignitor electrode, and a bypass circuit branch connected across said second capacitor including a bypass rectifier poled to permit the flow of follow-up currents in the same direction as said ignition current pulse, whereby said pulse is characterized by a sharp rise of current followed by a relatively gradual decline of current which dissipates substantially all the energy stored in said ignition circuit.

7. In combination: an ignitron having an ignitor electrode in contact with a cathodic pool of mercury; means for impressing a source of alternating current potential across said ignitron; a charging circuit including a first capacitor connected to receive and store an electrical charge; an ignition circuit including a second capacitor connected in series with said ignitor electrode; a discharge circuit including a saturable transformer coupling said charging circuit with said ignition circuit and periodically operated switching means to periodically transfer the energy represented by the charge of said first

capacitor onto said second capacitor, said saturable transformer being adapted to saturate a predetermined time interval after said second capacitor assumes its charge thereby converting said ignition circuit into a low impedance discharge path permitting the flow of a pulse of ignition current through said ignitor electrode; and a bypass circuit branch connected across said second capacitor including a bypass rectifier poled to permit the flow of follow-up currents caused by the residual inductance of said saturated transformer, whereby said pulse is characterized by a sharp rise of current followed by a relatively gradual decline of current which dissipates substantially all of the energy stored in said ignition circuit.

8. In combination: an ignitron having an ignitor electrode in contact with a cathodic pool of mercury; means for impressing a source of alternating current potential across said ignitron; a charging circuit including a first capacitor connected to receive and store an electrical charge; a discharge circuit including a thyatron and a saturable transformer having a primary winding connected in series with said thyatron across said first capacitor; means for periodically rendering said thyatron conductive thereby to discharge said first capacitor through said discharge circuit; an ignition circuit including a second capacitor connected in series with said ignitor electrode across a secondary winding of said saturable transformer, whereby the periodic current discharge in said discharge circuit supports a periodic current flow in said ignition circuit to place a charge on said second capacitor, said saturable transformer being adapted to saturate a predetermined time interval after said second capacitor assumes its charge thereby converting said ignition circuit into a low impedance discharge path permitting the flow of an ignition current pulse through said ignitor electrode.

9. In combination: an ignitron having an ignitor electrode in contact with a cathodic pool of mercury; means

for impressing a source of alternating current potential across said ignitron; a charging circuit including a first capacitor connected to receive and store an electrical charge; a discharge circuit including a thyatron and a saturable transformer having a primary winding connected in series with said thyatron across said first capacitor; means for periodically rendering said thyatron conductive thereby to discharge said first capacitor through said discharge circuit; an ignition circuit including a second capacitor connected in series with said ignitor electrode across a secondary winding of said saturable transformer, whereby the periodic current discharge in said discharge circuit supports a periodic current flow in said ignition circuit to place a charge on said second capacitor, said saturable transformer being adapted to saturate a predetermined time interval after said second capacitor assumes its charge thereby converting said ignition circuit into a low impedance discharge path permitting the flow of an ignition current pulse through said ignitor electrode; and a bypass circuit branch connected across said second capacitor including a bypass rectifier poled to permit the flow of follow-up currents caused by the residual inductance of said saturated transformer, whereby said pulse is characterized by a sharp rise of current followed by a relatively gradual decline of current which dissipates substantially all of the energy stored in said ignition circuit.

References Cited in the file of this patent

UNITED STATES PATENTS

2,267,398	Edwards	Dec. 23, 1941
2,320,790	Moyer et al.	June 1, 1943
2,517,129	Mulhern	Aug. 1, 1950
2,624,040	Large	Dec. 30, 1952
2,730,659	Hess	Jan. 10, 1956
2,737,612	Sims	Mar. 6, 1956