Jan. 11, 1966 E. G. ANGER 3,229,161

IGNITRON EXCITATION CONTROL CIRCUIT

Filed March 25, 1963

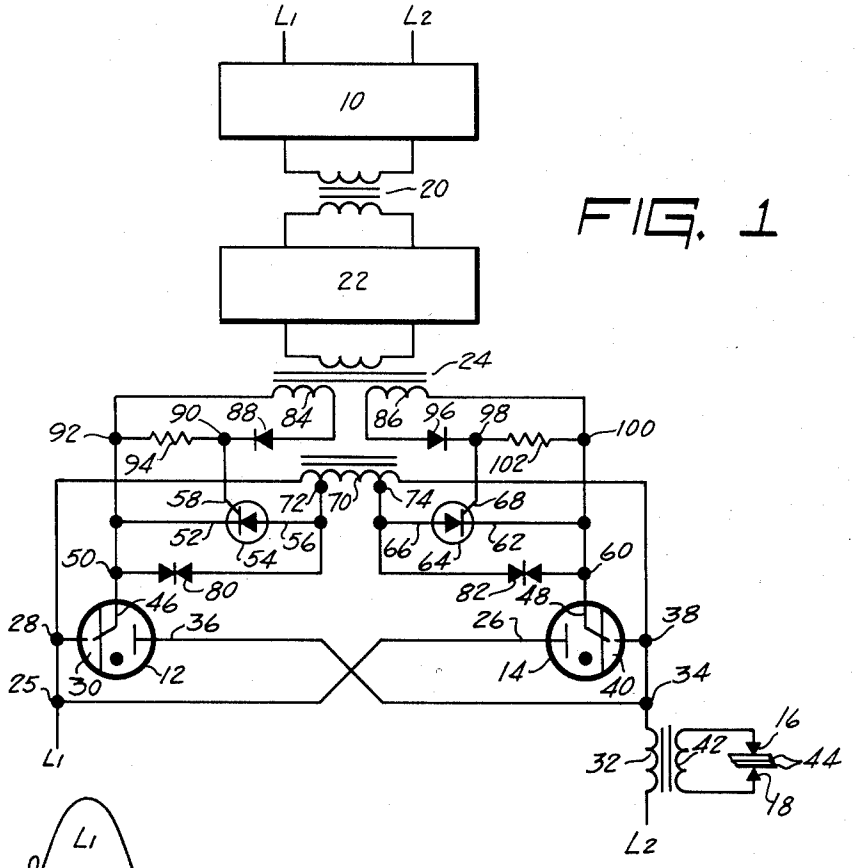


FIG. 1

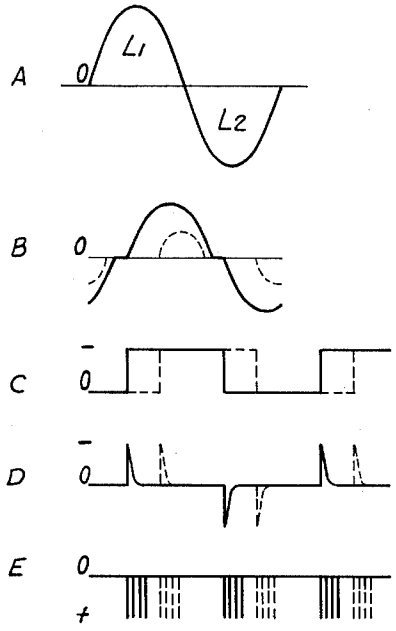


FIG. 2

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United States Patent Office 3,229,161
Patented Jan. 11, 1966

3,229,161

IGNITRON EXCITATION CONTROL CIRCUIT

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Filed Mar. 25, 1963, Ser. No. 267,462
14 Claims. (Cl. 315—196)

This invention relates to the control of electric discharge devices and is more particularly concerned with a system for controlling the ignition current through the ignition electrode of mercury pool cathode-type electronic discharge devices commonly known as ignitrons.

Ignitron tubes are frequently used to control the magnitude of alternating currents to electrical loads which require frequent switching. While the control which will hereinafter be described may be used in various electrical systems, it is particularly suited for use in a resistance welder apparatus to control the flow of welding current through the primary winding of the welding transformer.

An ignitron has a pool of liquid mercury, as a cathode, and is provided with an ignition electrode known as the ignitor to initiate conduction of the ignitron. The ignitor may consist of a tapered piece of boron carbide that extends down into the mercury pool without being wet by the mercury. When a sufficient potential is impressed between the ignitor and cathode of an ignitron, a small arc is developed. If the current forming the arc has a sufficient intensity, electrons are released which ionize the mercury vapor within the ignitron. If the anode of the ignitron has a positive polarity relative to the cathode and sufficient ionized mercury vapor is present, the ignitron switches from a nonconductive high impedance state to a conductive state presenting practically no impedance between the anode and cathode.

In a welding apparatus the ignitrons are usually connected in inverse parallel pairs between an alternating current supply and the primary winding of a welding transformer to supply alternate half cycles of alternating current to the primary winding. A weld timer determines the conduction interval of the ignitrons by supplying an appropriate signal to a means for initiating conduction of the ignitrons at adjustable instants during the half cycle interval when the anodes of the ignitrons have a positive polarity.

One of the most commonly used circuits for initiating the conduction of ignitrons is known as an anode firing circuit wherein a grid controlled gaseous electrode tube, such as a thyratron, is connected between the anode and control electrode of the ignitron. When this arrangement is employed, current flow at the anode of the ignitron is conducted by the thyratron to the ignition electrode. Another form of control which may be employed to initiate the conduction of the ignitron comprehends an arrangement whereby a separate source is connected through a thyratron across the control electrode and cathode of the ignitron. In this arrangement the separate source provides the exciting current to initiate the conduction of the ignitron. The disadvantage of the separate excitation arrangement is that relatively large components are required and proper synchronization of the current flow through the ignitor with the anode voltage of the ignitron is difficult to control. A distinct advantage of the anode firing arrangement, other than the use of less expensive components, is that it inherently causes a continued flow of ignition current until the ignitron becomes conductive, at which time the low impedance drop of the ignitron effectively shorts out the excitation circuit to the ignition electrode. Thus, as soon as the ignitron becomes conductive, the ignition current ceases to flow and will not cause premature failure of the ignition electrodes. It has also

been found that anode firing, because of the lower energy requirements necessary for proper ignition of the ignitrons, will cause the ignitrons to operate at a lower temperature than is possible with separate excitation firing. The circuit according to the present invention retains all of the advantages of an anode firing circuit for ignitrons without incurring the disadvantages presented by the thyratrons which have a relatively short life and thus require frequent replacement. The anode firing circuit for ignitrons according to the present invention uses static semiconductor devices, such as silicon controlled rectifiers, which are known to have practically an indefinite life span when properly applied. The circuit is arranged so the silicon controlled rectifiers will not be subjected to the full line voltage which is impressed across the ignitrons. This will permit the silicon controlled rectifiers to be used in a circuit which is normally beyond their rated capacity to provide an ignitron contactor which is low in cost as it can be assembled with standard components and which will provide troublefree operation so as to reduce the maintenance cost and the high down-time costs which heretofore occurred in modern factories when an ignitron contactor is rendered inoperative because of a failure of a thyratron tube in the firing circuit.

It is an object therefore of the present invention to provide a circuit for initiating conduction of a pair of inversely connected ignitrons which includes a transformer means connected in circuit with the anode and cathode of the ignitrons for supplying anode to cathode current to a pair of unidirectional conducting devices.

Another object of the present invention is to provide an anode firing circuit for a pair of inversely connected ignitrons, which firing circuit is subjected to a substantially lower voltage than the load circuit of the ignitrons.

A further object of the present invention is to provide an anode firing circuit for an ignitron which includes a semiconductor and a transformer means which is connected in a circuit parallel with the ignitron and in series with the semiconductor.

Another object of the present invention is to provide an anode firing circuit for initiating the conduction of an ignitron which includes a silicon controlled rectifier and a transformer means which is shorted by the ignitron when the ignitron is conductive and which is arranged to supply the rectifier with current at a voltage substantially lower than the voltage of the supply for the ignitron.

A still further object of the present invention is to provide an anode firing circuit for initiating conduction of a pair of ignitrons connected in inverse parallel between an alternatng current supply and a primary winding of a welding transformer in a resistance welder apparatus which circuit, in response to a signal from a weld timer of the welder apparatus, causes a pair of silicon controlled rectifiers to become conductive at adjustable instants during the half cycles after voltage zero of the voltage wave of the supply and wherein the silicon controlled rectifiers are connected in series with the ignitor electrode of the ignitrons and with a transformer means which is connected in a circuit with the anodes of the ignitrons so the rectifiers are supplied with a portion of the anode voltage of the ignitrons during the intervals when the ignitrons are nonconductive.

Further objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawing illustrating certain preferred embodiments in which:

FIG. 1 diagrammatically shows a resistance welding apparatus including a schematic showing of an anode firing circuit for a pair of ignitrons incorporating the features of the present invention.

FIG. 2 illustrates a series of curves of one form of

the firing pulse which may be provided to cause conduction of the ignitrons in FIG. 1.

In the drawings, a firing circuit for an ignitron type contactor is illustrated which may be used to control the flow of current from an alternating current source to an alternating current load. While the alternating current load shown is a resistance welding transformer in FIG. 1, it is understood that laternating current flow to other type loads may be controlled by the ignitron contactor employing the firing scheme according to my invention.

In FIG. 1, an alternating current source, not shown, is connected to supply two sets of input leads L1 and L2. A weld timer indicated by the numeral **10** is provided to supply a suitable signal to initiate conduction of a pair of ignitrons **12** and **14** in a manner which will be hereinafter set forth. The weld timer shown will provide a suitable signal at the beginning and during the weld interval to govern the flow of energy to a pair of welding electrodes **16** and **18** and may be any suitable well known type, such as the timer shown in Patent 3,015,067, issued December 26, 1961, to C. W. Porter and assigned to the assignee of the present invention, or a timer as shown in application Serial No. 129,828, filed August 7, 1961, which has been assigned to the assignee of the present invention by the inventors C. F. Meyer and J. J. Eckl.

The timer shown in the Porter patent includes gaseous electronic tubes and the timer shown in the Meyer and Eckl application utilizes static switching devices, such as transistors, and is arranged to supply signals as shown on curve C in FIG 2 of the drawings.

The weld timer **10** is energized from the source through the leads L1 and L2 and is connected through a pulsing transformer **20** to a signal pulser **22**. In FIG. 2, a curve A illustrates the voltage wave of the source which is connected to the leads L1 and L2. Because of the inductive characteristics of the welding transformer, the voltage of curve A will cause a lagging current flow in the welding transformer circuit as shown in curve B. The timer **10** is arranged at the beginning and during the weld interval to supply a signal as shown by curve C in FIG. 2; that is, a series of voltage pulses which occur as shown during the respective half cycles of current shown by the curve B. It will be seen from curve C that at the beginning of the weld interval during periods of L1 polarity, the output of the weld timer **10** will provide a negative polarity voltage which exists throughout the current half cycle L1. At the beginning of the L2 half cycle, the output signal from the timer **10** changes from a negative polarity voltage to a zero voltage. This signal continues throughout part of the L2 half cycle. The pulsing transformer **20** is arranged so that if the voltage through its primary winding changes it will provide an output signal consisting of sharp voltage spikes, as shown in curve D. The voltage output pulses of transformer **20** are impressed as inputs to the signal pulser **22** which in response thereto provides an output as shown on curve E which consists of a series of sharp voltage spikes. The output of the signal pulser **22** is impressed across a primary winding of a transformer **24**.

If desired, the weld timer may be also provided with an arrangement for phase shifting the occurrence of the signals in FIG. 2. This arrangement will provide heat control in the resistance welder and is achieved by shifting the occurrence of the signals of curve C in timed relation to the source voltage as indicated by a broken line in curve C and a corresponding shift of the pulses in curves D and E which will cause the conduction of the ignitrons to be initiated at adjustable instants after voltage zero of the source voltage as shown by the broken line curve of curve B.

As shown in FIG. 1, the lead L1 is connected through a junction **25** to an anode **26** of ignitron **14** and through a junction **28** to a cathode **30** of ignitron **12**. The lead L2 is connected through a primary winding **32** of a welding transformer to a junction **34** which is connected to an anode **36** of the ignitron **12** and through a junction **38** to a cathode **40** of ignitron **14**. The primary winding **32** of the welding transformer supples energy to a secondary winding **42** which is connected to the welding electrodes **16** and **18** to cause welding current to flow through a pair of parts **44** which are to be welded together.

The ignitron **12** has an initiating electrode known as an ignitor **46** and the ignitron **14** has an initiating electrode known as an ignitor **48**. The ignitor **46** is connected through a junction **50** to a cathode electrode **52** of a unidirectional conducting device, such as a silicon controlled rectifier **54**, which has an anode **56** and a control electrode known as a gate **58**. The ignitor **48** of the ignitron **14** is connected through a junction **60** to a cathode **62** of another unidirectional conducting device, such as a silicon controlled rectifier **64**, which has an anode **66** and control electrode, known as a gate **68**.

A transformer winding **70** is connected between the junction **28** and **38**. In the embodiment shown, the transformer winding **70** is provided with a pair of intermediate taps **72** and **74**. The tap **72** is connected to the anode **56** of the rectifier **54**. The tap **74** is connected to the anode **66** of the rectifier **64**. Back-to-back rectifiers **80** and **82** are connected as surge suppressors between the anodes and the cathodes of the rectifiers **54** and **64**. These back-to-back rectifiers **80** and **82** act as transient voltage suppressors in the circuits associated therewith to protect the rectifiers **54** and **64** from damage due to transient voltages.

The transformer **24** has a pair of secondary windings **84** and **86**. One of the output terminals of the winding **84** is connected through a suitable diode **88** and a junction **90** to the gate **58** of the rectifier **54**. The other output terminal of the winding **84** is connected through a junction **92** to the cathode **52** of the rectifier **54**. A bias resistor **94** is connected between junctions **90** and **92**. Similarly, one of the output terminals of the winding **86** is connected through a diode **96** and a junction **98** to the gate **68** of the rectifier **64**. The other output terminal of the winding **86** is connected through a junction **100** to the cathode **62** of the rectifier **64**. A resistor **102** is connected between junctions **98** and **100**.

The operation of the circuit above described is as follows: if it be assumed that the ignitrons **12** and **14** are both nonconducting, current will flow through the winding **70** and the winding **32**. The winding **70** is shown as connected as an auto-transformer and during intervals when the secondary circuits connected to taps **72** and **74** are open, will provide a high impedance path for current flow through primary winding **32**. During periods when lead L1 is positive, the portion of the winding **70** between terminal **74** and junction **38** will cause the anode **66** of the rectifier **64** to have a positive polarity relative to its cathode **62**. Similarly, when lead L2 is positive, the portion of the winding **70** between terminal **72** and junction **28** will cause the anode **56** of the rectifier **54** to have a positive polarity relative to its cathode **52**. As previously explained, when the ignitrons are nonconducting, they present a high impedance which changes to a low impedance as they change to their conductive states. Thus, when either of the ignitrons **12** or **14** becomes conductive, a short circuit path is formed across winding **70** to remove the supply for the anode to cathode voltage of the rectifiers **54** and **64**.

At the beginning and during the weld interval the transformer **24** causes the windings **84** and **86** to be provided with a series of voltage pulses which occur as shown by curve E of FIG. 2. These voltage pulses are conducted by the diodes **88** and **96** to the junctions **90** and **98** where they appear between the gates **58** and **68** and cathodes **52** and **62** of the rectifiers **54** and **64** to cause the rectifiers to become conductive. When the rectifier **54** con-

ducts, current flows from the junction 72 through the rectifier 54 to the ignitor 46 to cause the ignitron 12 to conduct as previously explained. Similarly, when the rectifier 64 is rendered conductive, current flows from the terminal 72 through the rectifier 64 to the ignitor 46 to cause the ignitron 14 to be rendered conductive.

The winding 70 is preferably wound of a wire of suitable size to provide low resistance and the coil windings thereof are suitably interleaved to provide low leakage reactance so the winding 70 provides a very low short circuit impedance at the terminals 72 and 74. This arrangement will provide the system with a rapid response. The winding 70 as shown is connected in parallel with the ignitrons 12 and 14 so that as the ignitrons 12 and 14 conduct, they effectively provide a short circuit across the winding 70. While the winding 70 is shown as an autotransformer, other transformer arrangements may be used to reduce the anode to cathode voltages of the rectifiers 54 and 64. The arrangement shown makes it possible to use silicon controlled rectifiers having a lower voltage rating than would be required if the anodes of the rectifiers were directly connected to the anodes of the ignitrons as in conventional ignitron anode firing circuits. For example: if the source causes the leads L1 and L2 to have a potential of 440 volts as is conventional in resistance welding practice, then the rectifiers because of the use of the suitable taps of the winding 70, will provide an anode to cathode voltage across the rectifiers of 110 volts which is sufficient to initiate the conduction of the ignitrons without damaging the rectifiers or requiring special costly devices.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. In combination with a source of alternating current having a pair of terminals, a first ignitron having an anode, a cathode and an ignition electrode, a second ignitron having an anode, a cathode and an ignition electrode, means connecting the anode of the first ignitron and the cathode of the second ignitron to one terminal of the source, means connecting the cathode of the first ignitron and the anode of the second ignitron to the other terminal of the source, an autotransformer having a winding interconnecting the anodes of both ignitrons, said transformer having at least one tap dividing said winding into two portions, a first unidirectional conducting device having an anode, a cathode and a control electrode, a second unidirectional conducting device having an anode, a cathode and a control electrode, means connecting in series across one of said winding portions the anode and the cathode of the first device and the ignition electrode and the cathode of the first ignitron, means connecting in series across the other of said winding portions the anode and the cathode of the second device and the ignition electrode and the cathode of the second ignitron, and circuit means connected between the control electrodes and the cathodes of each of said devices for initiating conduction of said devices.

2. For use in supplying current from a source of alternating current to a load, the combination comprising: a pair of ignitrons interposed in a circuit between the source and the load in such a manner so as to conduct alternate half cycles of current from the source to the load, each of said ignitrons having an anode, a cathode and an ignition electrode arranged for switching the ignitrons from a nonconductive to a conductive state, transformer means connected in a circuit parallel with said ignitron circuit, said transformer having a pair of outputs, a first unidirectional conducting device connected in a series with the ignition electrode and the cathode of one of said ignitrons across one of said outputs and a second unidirectional conducting device connected in a series circuit with the ignition electrode and the cathode of the other ignitron across the other of said outputs.

3. For use in supplying current from a source of alternating current to a load, the combination comprising; a pair of ignitrons interposed in a first circuit between the source and the load in such a manner so as to conduct alternate half cycles of current from the source to the load, each of said ignitrons having an anode, a cathode and an ignition electrode arranged for switching the ignitrons from a nonconductive to a conductive state and thereby changing the impedance of said circuit from a high value to a negligible value, a pair of unidirectional conducting devices each having an anode, a cathode and a control electrode arranged for initiating the conduction of the device, transformer means interposed in a circuit between the source and the load in a circuit parallel with said first circuit, said transformer means having an impedance substantially less than the high impedance value of said first circuit and greater than the negligible value of the impedance of said first circuit when the ignitrons are conducting whereby the ignitrons substantially provide a short circuit path for the transformer means, said transformer means having a pair of output portions, a second circuit means connecting the anode and the cathode of one of said devices in a series circuit with one of said output portions and the ignition electrode and the cathode of the first ignitron and a third circuit means connecting the anode and the cathode of the other of said pair of devices in a series circuit with the other output portion and the ignition electrode and the cathode of the second ignitron for initiating conduction of the ignitrons in response to current flow through the transformer means when the ignitrons are nonconductive.

4. In combination; a pair of ignitrons connected in inverse parallel between an alternating current source and a load, each of said ignitrons having an anode, a cathode and an ignition electrode, a pair of unidirectional conducting devices each having an anode, a cathode and a control electrode for initiating conduction of said devices, circuit means connecting the anode and the cathode of one of said unidirectional conducting devices in a series circuit with the ignition electrode and cathode of one of said ignitrons, circuit means connecting the anode and the cathode of the other of said unidirectional conducting devices in a series circuit with the ignition electrode and cathode of the other of said ignitrons, and transformer means connected in a parallel circuit with both of said ignitrons between said source and load and said circuit means including a portion of the transformer means in each of said series circuits for initiating conduction of said ignitrons in response to the conduction of said unidirectional conducting devices.

5. The combination as set forth in claim 4 wherein each of the unidirectional conducting devices is a silicon controlled rectifier.

6. The combination as set forth in claim 4 wherein the transformer means comprises an autotransformer.

7. The combination as set forth in claim 4 wherein each of the unidirectional conducting devices is a silicon controlled rectifier and the transformer means comprises an autotransformer.

8. The combination as set forth in claim 4 wherein each of the unidirectional conducting devices is a silicon controlled rectifier which has a firing circuit connected between the control electrode and the cathode of the rectifier for initiating conduction of the rectifier and wherein the firing circuit includes means for providing a series of pulses between the control electrode and cathode of the devices.

9. The combination as set forth in claim 8 wherein the ring circuit is coupled to a weld timer for controlling the initiation of conduction of the devices and thereby the initiation of conduction of the ignitrons.

10. In combination; a pair of ignitrons connected in inverse parallel between an alternating current source and a load for supplying alternate half cycles of alternating current to the load, each of said ignitrons having an anode, a cathode and an ignition electrode, a pair of unidirectional conducting devices each having an anode, a cathode and a control electrode for initiating conduction of said devices, circuit means connecting the anode and the cathode of one of said unidirectional conducting devices in a series circuit with the ignition electrode and the cathode of one of said ignitrons, circuit means connecting the anode and the cathode of the other of said unidirectional conducting devices in a series circuit with the ignition electrode and the cathode of the other of said ignitrons, transformer means having a portion connected in a parallel circuit with both of said ignitrons between said source and load and a portion of said transformer means in each of said series circuits for initiating conduction of said ignitrons in response to the conduction of said devices, and firing means connecting between the control electrode and cathode of each of said devices for adjustably initiating the conduction of the devices at variable instants during the half cycles of the supply.

11. The combination as set forth in claim 10 wherein the firing means is arranged to supply the devices with a series of current pulses after the instant of initiation of conduction of the devices.

12. In combination: an ignitron having a pair of main electrodes connected between an alternating current supply and a load, and an anode firing circuit for the ignitron including a semiconductor and an autotransformer winding, said winding having a main portion connected to the main electrodes of the ignitron to be in a circuit parallel to the ignitron and said winding having a portion of said main portion connected in a series circuit with a pair of main electrodes of the semiconductor.

13. The combination as recited in claim 12 wherein the semi-conductor is a silicon controlled rectifier.

14. The combination as recited in claim 12 wherein the semi-conductor has a control electrode which is arranged for initiating conduction of the semi-conductor connected in a circuit with a phase shift circuit means for initiating conduction of the semi-conductor at variable instants of a half cycle current pulse of the alternating current supply.

References Cited by the Examiner

UNITED STATES PATENTS

2,175,921	10/1939	Schnarz	315—196 X
3,089,984	5/1963	Randolph	315—199 X
3,112,437	11/1963	Rockafellow	323—24

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