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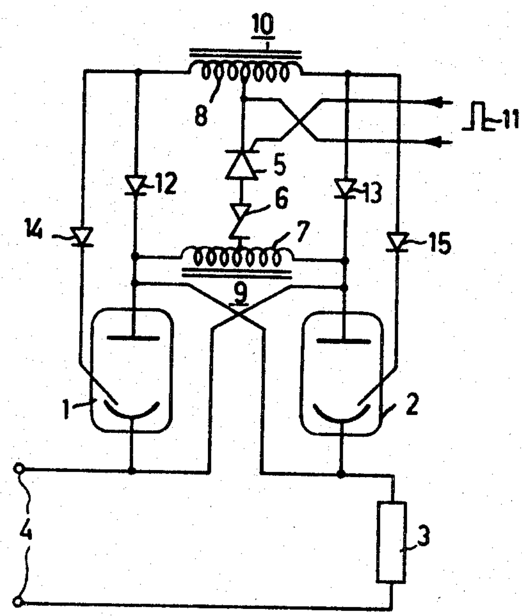

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IGNITION CIRCUIT FOR INVERSE-PARALLEL CONNECTED IGNITRONS UTILIZING A SINGLE SEMICONDUCTOR CONTROLLED RECTIFIER

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ABSTRACT OF THE DISCLOSURE

A circuit for supplying power to a load includes two inverse-parallel connected ignitrons in series with a source of AC voltage and the load. A first center-tapped winding is connected between the anodes of the ignitrons. A second center-tapped winding is connected to the anodes and ignitors of the ignitrons by means of a plurality of diodes. A semiconductor controlled rectifier is connected between the center taps of the two windings and is pulsed to control the current flow in the circuit. The circuit operates so that the full anode voltage is applied to the ignitors yet the maximum voltage produced across the controlled rectifier is at most equal to one half of the ignitron anode voltage.

The invention relates to a circuit arrangement for the alternate ignition of two anti-parallel connected ignitrons by means of a single controllable element.

Such an arrangement is known from French patent specification 1,282,577, particularly from FIG. 2. In this patent the controllable element is a switch contact conducting in both directions, for example, the contact of a relay.

The invention has for an object to provide a circuit arrangement in which this switch contact is replaced by the main current electrode circuit of a rectifying semiconductor switch, for example, a controllable semiconductor rectifier. This gives rise to the difficulty that, for obtaining a satisfactory operation of the ignitrons within an ample current and/or voltage range, it is necessary to have a possibility of applying the full anode voltage of each ignitron to the ignition electrode thereof, whilst the voltage operative across the semiconductor switch may then be inadmissibly high for said element.

The invention provides a solution of this problem so that the full anode voltage can be applied to the ignition electrode of each ignitron, whilst the maximum voltage operative across the semiconductor switch is at most equal to one half of said anode voltage.

The circuit arrangement according to the invention is characterized in that the controllable element is a rectifying semiconductor switch, the main current electrode circuit of which is connected between the central tappings of the windings of two auto-transformers. The central tapping of the winding which is connected to the anode of the semiconductor switch is connected between the anodes of the two ignitrons. Each side of the other winding is connected to the anodes of two diodes, the cathodes of which are respectively connected to the anode and to the ignition electrode of one of the two ignitrons.

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When phase control of the ignition of each ignitron is not desired, the rectifying semiconductor switch may be a power rectifier, for example, a p-n-p-n diode having a well determined threshold voltage, in series with which a mechanical on-off switch can be connected.

The arrangement according to the invention is, however, particularly suitable when a phase-control of the ignition is desired. The rectifying semiconductor switch is then a controllable semiconductor rectifier.

As described in my copending United States application, Ser. No. 395,384, filed Sept. 10, 1964, it is frequently useful and often necessary to connect, in series with the rectifying semiconductor switch, in the circuit between the anode of each ignitron and the ignition electrode thereof, an element having a strongly voltage-dependent resistance and which only becomes strongly conducting when the voltage across it exceeds the anode-cathode arc voltage of each of the two ignitrons, or one half thereof. This element may be a voltage-dependent resistor (VDR). However, use will preferably be made of a diode connected in the reverse direction and having a Zener voltage exceeding the anode-cathode arc voltage of each of the two ignitrons, or one half thereof.

The invention will be described more fully with reference to the drawing, which shows a diagram of an embodiment of the circuit arrangement according to the invention.

The embodiment shown comprises two anti-parallel connected ignitrons **1** and **2**, through which a load **3**, for example, a welding transformer, is energized by an alternating-voltage source **4**, for example, an A.C. supply of 50 c./s. The circuit for igniting the ignitrons **1** and **2** includes a rectifying semiconductor switch **5**, formed by a controllable n-p-n-p-type semiconductor rectifier, the main current electrode circuit of which is connected in series with a semiconductor diode **6**, connected in the reverse direction, between the central tappings of the windings **7** and **8** of two autotransformers **9** and **10**. The anode of the controllable rectifier **5** is connected to the anode of the diode **6** and the cathode of said diode is connected to the central tapping of the winding **7**. Winding **7** is connected between the anodes of the two ignitrons **1** and **2**. The n-type emitter of the controllable rectifier **5** is connected to the central tapping of the other winding **8** and to a terminal of a source **11** of phase-controllable control-pulses having a repetition frequency of, for example, 100 c./s. The control-electrode of the controllable rectifier **5** is connected to the other terminal of said source so that positive control-pulses are applied to said control-electrode. Each end of the other winding **8** is connected to the anodes of two diodes **12, 14** and **13, 15**, respectively. The cathodes of these diodes are respectively connected to the anode and to the ignition electrode of the associated ignitrons **1** and **2**, respectively.

If, for example, the upper terminal of the voltage source **4** of, for example, 220 v. becomes positive, the ignitron **2** is still non-conducting, whereas the ignitron **1** is already extinguished because the passing current has become lower than its holding current. The voltage of the source **4** is therefore operative across the series combination of the load **3** and the winding **7**. The impedance of said winding is high as compared with that of the load **3**, so that substantially the whole voltage of the source **4** is operative across the winding **7**.

At the chosen instant, when a forward pulse is applied by the source **11** between emitter and control-electrode of the controllable rectifier **5**, this rectifier is rendered conducting and the voltage across the left-hand half of the winding **7** produces a current through this half of said winding, the diode **6**, the controllable rectifier **5**, the left-hand half of the winding **8** and the diode **12**. Across the whole winding **8** this current produces a voltage which is substantially equal to the voltage across the whole winding **7** and to the instantaneous value of the voltage of the source **4**. This voltage is applied to the ignition electrode of the ignitron **2** through the diode **15**. As a result of said voltage, an arc is struck between ignition electrode and cathode of the ignitron **2**. This arc forms a cathode spot on the surface of the mercury pool so that the mercury vapour in the ignitron is ionised and an arc is struck between its anode and cathode. This arc carries the main current through the load **3** and forms a strong damping across the winding **7**. For the remainder of the half period concerned of the supply voltage, the voltage across said winding, and hence also across the winding **8**, is at most equal to the anode-cathode arc voltage of the ignitron **2**, of, for example, 20 v.

In accordance with the characteristics of the employed ignitrons, the voltage of the source **4** and the impedance of the load **3**, the discharge between ignition electrode and cathode of the ignitron **2** is extinguished immediately after the ignition of the main discharge between its anode and cathode. It may, however, occur that the voltage which is still applied between ignition electrode and cathode after the ignitron of the main discharge is not sufficiently reduced for ensuring the extinction of the ignition arc. A strong current then continues to flow through the ignition electrode for the remainder of the half period concerned, so that this electrode finally burns down or is seriously damaged. A current of equal value also continues to pass through the diode **12** and twice this current passes through the controllable semiconductor rectifier **5**, so that particularly the latter element is soon overloaded. This is prevented by the diode **6**, which extinguishes as soon as the voltage across the left-hand part of the winding **7** becomes smaller than its Zener break-down voltage of, for example, 12 v. The controllable rectifier **5** is then immediately cut off and any further current supply to the ignition electrode of the ignitron **2** is interrupted.

The semiconductor diode **6** may be replaced by another element having a strongly voltage-dependent resistance and which only becomes highly conducting when the voltage across it exceeds one half of the anode-cathode arc voltage of each of the two ignitrons, for example, by a so-called voltage-dependent resistor (VDR). Instead of using a semiconductor diode or a VDR, use may be made of two corresponding elements, for example, in the connections between each end of the winding **7** and the anode of the ignitron **1** or **2**, respectively, or in the connections between each end of the winding **8** and the anodes of the diodes **12** and **14** or **13** and **15**, respectively, or in series with the diodes **12** and **13** or with the diodes **14** and **15**. In accordance with the point in the circuit chosen for these elements, they must have a threshold voltage for becoming conducting which exceeds one half of the anode-cathode arc voltage of each ignitron, or which exceeds the full arc voltage. In some cases, for example, with semiconductor diodes or VDR's in series with the diodes **14** and **15**, the extinction or the decrease in conductivity of these elements does not necessarily involve the blocking of the controllable semiconductor rectifier. A circulation current may, for example, continue to flow for the remainder of the half period concerned through the left-hand or right-hand halves of the windings **7** and **8**, the diodes **12** or **13** and the controllable rectifier **5**.

Finally, it should be noted that if a particularly strong ignition of the ignitrons **1** and **2** is desired, it is also possible to step up the voltage across the winding **8**, and hence the voltage applied to the ignition, electrode of each ignitron by a ratio of more than 1:2, for example, for compensating for the voltage loss across the diode **6** or across corresponding elements. For this purpose it is sufficient to connect the anode of each of the diodes **12** and **13** to a tapping of the winding **8** lying between the end thereof connected to the diodes **14** and **15**, respectively, and the central tapping of said winding.

What is claimed is:

1. An ignitron ignition circuit comprising, a source of AC voltage, an electric load, first and second ignitrons each having an anode, cathode and ignitor electrode, means connecting said first and second ignitrons in inverse-parallel relationship in series with said voltage source and said load, first and second center-tapped transformer windings, means connecting said first transformer winding between the anodes of said ignitrons, first, second, third and fourth diodes, means connecting said first and second diodes between one side of said second transformer winding and the ignitor and anode of said first ignitron, respectively, means connecting said third and fourth diodes between the other side of said second transformer winding and the ignitor and anode of said second ignitron, respectively, a semiconductor rectifying element having first and second electrodes defining a current path therein and a control electrode for controlling the current in said path, means connecting said semiconductor element between the center taps of said first and second windings, and means for applying control pulses to said control electrode in synchronism with said AC voltage so as to ignite said ignitrons during alternate half cycles of said AC voltage.

2. A circuit as defined in claim **1** wherein said first and third diodes are poled to conduct current into their respective ignitor electrodes and wherein said second and fourth diodes are poled to allow current to flow in opposite directions in the corresponding halves of said first and second transformer windings.

3. A circuit as defined in claim **2** wherein said semiconductor element comprises a controlled rectifier.

4. A circuit as defined in claim **1** further comprising a zener diode having a zener threshold voltage that exceeds one half of the anode-cathode arc discharge voltage of the ignitrons, and means connecting said zener diode in series with the current path of said semiconductor rectifying element.

5. A circuit as defined in claim **1** wherein said first and third diodes are connected to opposite end terminals of said second transformer winding and said second and fourth diode, are symmetrically connected to intermediate taps on said second transformer winding between each end terminal and the center tap.

6. A circuit for coupling a source of AC voltage to an electric load comprising, first and second ignitrons each having an anode, cathode and ignitor electrode, means connecting said first and second ignitrons in inverse-parallel relationship in series with said voltage source and said load, first and second center-tapped transformer windings, means connecting said first transformer winding between the anodes of said ignitrons, first, second, third and fourth diodes, means connecting the anode electrodes of said first and second diodes to one end of said second winding and the cathode electrodes to said ignitor and anode electrodes, respectively, of said first ignitron, means connecting the anode electrodes of said third and fourth diodes to the other end of said second winding and the cathode electrodes to said ignitor and anode electrodes, respectively, of said second ignitron, a semiconductor rectifier element having anode, cathode and control electrodes, means connecting the anode and cathode of said rectifier element to the center taps of said first and second windings, respectively, and means for applying a control voltage to said control electrode at given instants of time during each half cycle of said AC voltage to initiate current flow in said rectifier element.

7. A circuit as defined in claim **6** further comprising

a zener diode having a zener voltage that is greater than one half of the anode-cathode arc discharge voltage of said ignitrons, means connecting said zener diode in series with the anode and cathode of said semiconductor rectifier element between the center taps of said first and second winding, and wherein said voltage applying means includes a source of voltage pulses having a frequency that is twice the frequency of said AC voltage.

8. A circuit as defined in claim **6** further comprising a voltage-dependent resistor connected in series with said rectifier element.

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JAMES W. LAWRENCE, *Examiner.*

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