

June 1, 1937.

J. W. DAWSON

2,081,987

ELECTRICAL CONTROL SYSTEM

Filed Jan. 16, 1936

2 Sheets-Sheet 1

Fig. 1.

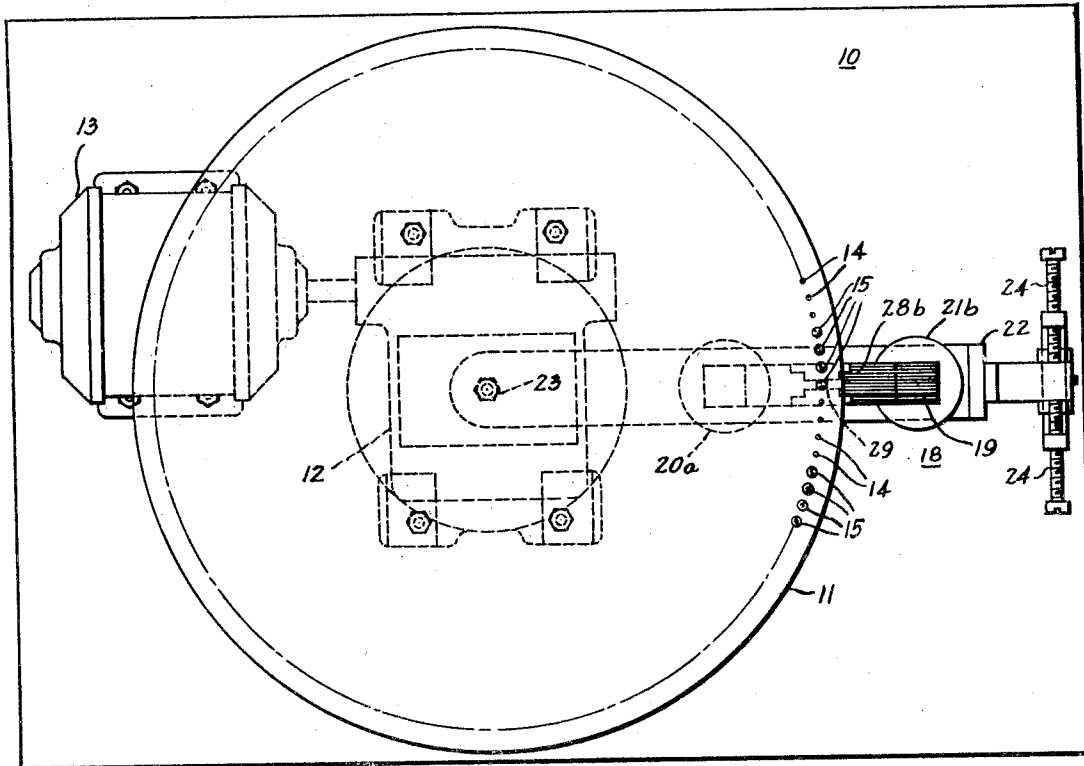


Fig. 2.

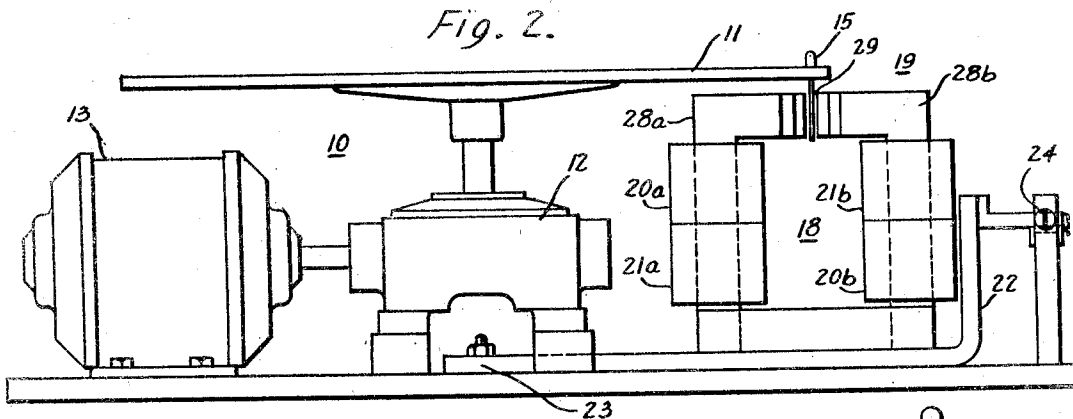


Fig. 3.

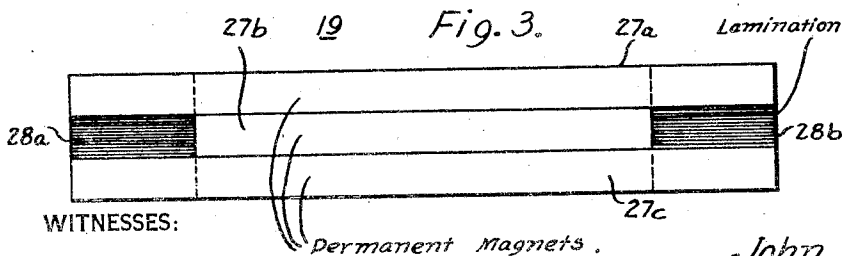
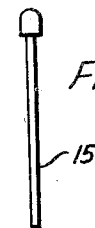


Fig. 4.



WITNESSES:

Permanent Magnets.

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2 Sheets-Sheet 2

Fig. 5.

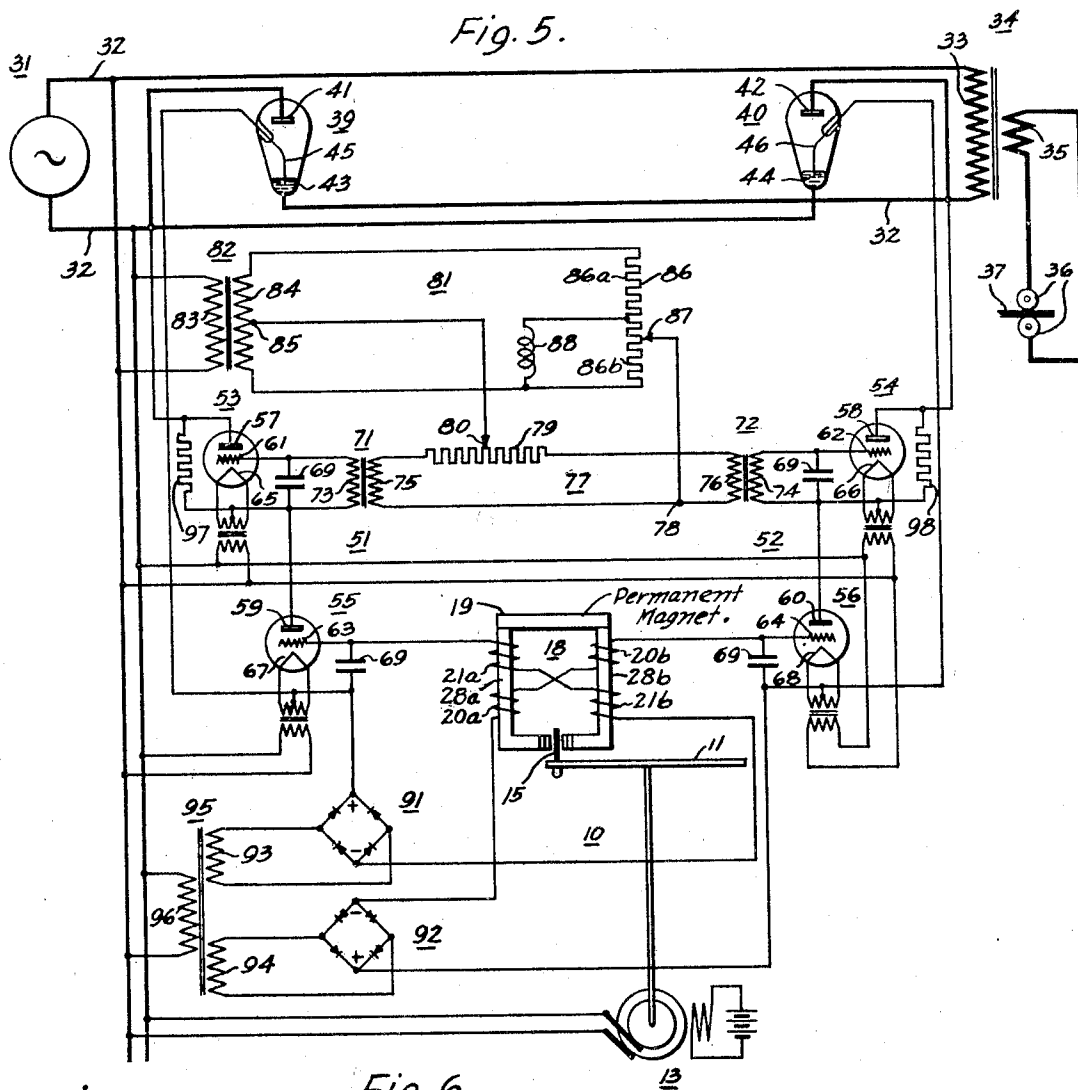


Fig. 6.

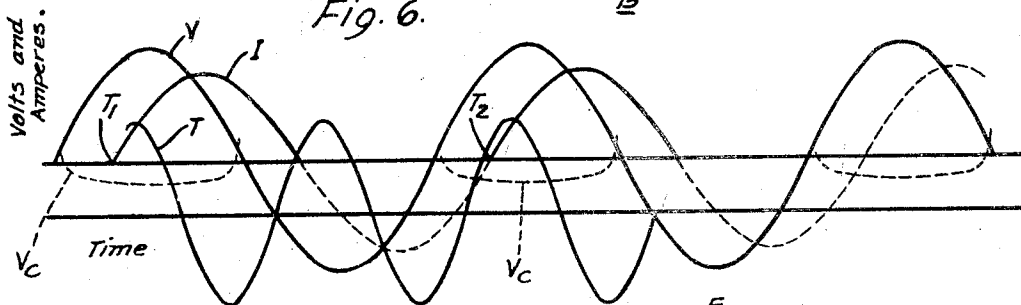
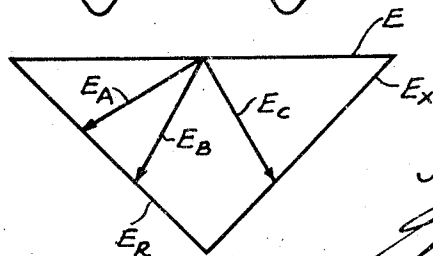


Fig. 7.



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ELECTRICAL CONTROL SYSTEM

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Application January 16, 1936, Serial No. 59,402

14 Claims. (Cl. 250—27)

My invention relates generally to electrical control systems, and it has particular relation to such systems when employed for controlling the flow of current to a load device.

5 The object of my invention, generally stated, is to provide an electrical control system which shall be simple and efficient in operation and which may be readily and economically manufactured and installed.

10 An important object of my invention is to provide for periodically changing the flow of alternating current in a circuit.

Another important object of my invention is to provide for permitting alternating current to

15 intermittently flow to a load device.
Still another important object of my invention is to provide for employing magnetic impulses to determine the particular cycles during which alternating current is permitted to flow in a circuit.

20 A further object of my invention is to provide for periodically varying the reluctance of a magnetic circuit to control the functioning of an electric valve in controlling the flow of current in a circuit.

25 Still another object of my invention is to provide for relatively adjusting the time in half cycles of alternating current at which inversely connected electric valves are rendered conducting.

30 Another object of my invention is to provide for maintaining a voltage obtained from a phase shifting circuit at a substantially constant magnitude regardless of the phase relationship of the voltage.

35 A still further object of my invention is to provide for periodically generating magnetic impulses in the control circuit of an electric valve.

Other objects of my invention will in part be

40 obvious and in part appear hereinafter.
Accordingly, my invention is disclosed in the embodiment hereof shown in the accompanying drawings and comprises the features of construction, combination of elements and arrangements

45 of parts which will be exemplified in the construction hereinafter set forth and the scope of the application of which will be indicated in the appended claims.
For a more complete understanding of the nature and scope of my invention, reference may

50 be had to the following detailed description taken in connection with the accompanying drawings, in which:

55 Figure 1 is a top plan view of the impulse timer,

Fig. 2 is a view, in side elevation, of the impulse timer shown in Fig. 1,

Fig. 3 is an enlarged bottom plan view of the composite yoke or core shown in Figs. 1 and 2,

Fig. 4 is a view in side elevation of one of the pins which is employed in the impulse timer,

Fig. 5 illustrates diagrammatically the circuit connections which may be employed in practicing my invention,

Fig. 6 shows a number of curves which demonstrate the functioning of my invention, and

Fig. 7 is a vector diagram showing the functioning of the phase shifting circuit illustrated in Fig. 5.

According to my invention, I have provided for 15 controlling the flow of alternating current to a load device, such as a resistance welder, by means of a pair of inversely connected electric valves of the arc discharge type. Each of these valves is provided with a control electrode which, on being properly energized, is effective to render the valve individual thereto conducting during the half cycle which it is adapted to conduct. It is desirable to periodically render the valves conducting, so that the flow of alternating current to the load device may be intermittent when the load device constitutes a welding circuit. For this purpose, a control circuit is provided which is arranged not only to select the particular half cycles of the alternating current during which it is desired to render the valves conducting, but also it is effective to render the valves conducting at a predetermined instant in any half cycle.

The control circuit which is employed for effecting this operation is divided into two parts or systems. One of these systems is effective to select the particular half cycles during which the valves are rendered conducting while the other part or system is effective to select the particular instant each half cycle at which the valves are rendered conducting. According to my invention, I have provided a magnetic impulsing system for selecting the particular half cycles. This system comprises a plate or disk which is driven by means of a synchronous motor that is connected for energization to the alternating current source. The plate is provided with a plurality of transverse holes or openings in which magnetic pins may be inserted, the number depending upon the number of half cycles which it is desired to permit to flow to the load device. A sufficient number of openings are provided so that when each of them has a pin positioned therein, the valves will be rendered conducting during each half cycle of the alternating current.

In order to render the valves conducting intermittently, certain of the pins may be removed, each pin corresponding to a half cycle of the alternating current.

5 The time in each half cycle at which the valves are rendered conducting is controlled by means of a phase shifting circuit which is arranged to apply a dephased voltage to a common control circuit for a pair of control valves, each of which is individual to one of the inversely connected
10 valves which conducts the line current. The common control circuit includes a voltage divider by means of which it is possible to relatively adjust the time in each half cycle during
15 which the control valves are rendered conducting for the purpose of balancing out or compensating for different operating characteristics thereof. The phase shifting circuit that is employed for applying the dephased voltage comprises an impedance network which is arranged
20 to be energized from the alternating current source. By means of a second voltage divider, it is possible to obtain from the phase shifting network a control voltage which is substantially
25 constant in magnitude regardless of its phase position.

Referring now particularly to Figs. 1 and 2 of the drawings, it will be observed that the reference character 10 designates generally a timing device which comprises a plate or disk 11
30 that is arranged to be driven through a gear reducer 12 by means of a motor 13 which is preferably of the synchronous type. The plate 11 is provided with a plurality of transverse
35 holes 14 in which a plurality of pins 15, shown in detail in Fig. 4, may be positioned. As shown, the pin 15 is provided with a reduced section and an enlarged head. The openings 14 are
40 provided with a minimum of clearance, so that the pins 15 may be readily positioned therein but will have a comparatively tight fit.

The pins 15, as moved by the plate 11, are arranged to control the functioning of a magnetic
45 impulsing device, shown generally at 18, which is arranged, as will be set forth in detail hereinafter, to select the particular half cycles during which electric valves in a circuit are caused to become conducting. The magnetic
50 impulsing device 18 comprises a composite yoke or core 19 on which control windings 20a, 20b and 21a and 21b are disposed. The control windings 20a and 20b are connected in series circuit relation, as are control windings 21a and 21b, for the purpose of balancing out any irregular characteristics of the functioning of the magnetic
55 impulsing device 18.

The magnetic impulsing device 18 is mounted on a bracket or arm 22 which is pivoted along an axis 23, that coincides with the axis of rotation of the plate 11. The bracket 22 may be
60 rotated about the axis 23 by means of adjusting screws 24 in order to adjust the position of the core 19 relative to the pins 15.

As illustrated in detail in Fig. 3 of the drawings, the composite core 19 comprises permanent
65 bar magnets 27a, 27b and 27c. The permanent magnets have interfitting with the ends thereof laminated members 28a, and 28b around which the control windings 20a, 20b, and 21a, 21b are
70 disposed. The opposite faces of the laminated members 28a and 28b are stepped, as shown more clearly in Fig. 1 of the drawings, in order to provide a flux concentration across a gap 29 through which the pins 15 pass on rotation of
75 the plate 11.

The permanent magnets 27a, 27b and 27c are provided in order to generate a constant flux across the air gap 29. It will be understood, however, that any other suitable source of magnetomotive force may be provided for causing flux to cross the air gap 29. As the pins 15 enter and leave the gap 29, the flux linking the control windings 20a, 20b and 21a, 21b is increased and decreased, as a result of which voltages are induced in these windings which may be used to effect certain control functions that will be described in detail hereinafter. The plate 11 is preferably provided with one-hundred and twenty holes 14 and is rotated by the synchronous motor 13 at the speed of one revolution per second. Each of the openings 14 then corresponds to a half cycle of 60-cycle alternating current. By placing the pins, as illustrated, in alternate sets of four openings 14 an effect to control the conductivity of certain electric valves
20 is produced during four successive half cycles of the alternating current which may be utilized to cause alternating current to flow in a circuit during these four half cycles. During the next four half cycles if none of the pins 15 are positioned in the next four openings 14, the valves
25 will be unaffected and, therefore, during these four half cycles no current will flow in the circuit.

Referring now to Fig. 5 of the drawings, it will be observed that the circuit connections are there shown which may be employed in connection with the timer 10 shown in Figs. 1 and 2 and described hereinbefore. As here shown, an
30 alternating current source 31, such as a 60-cycle source, is provided which is arranged to energize conductors 32. The conductors 32 are connected across the terminals of a primary winding 33 of a transformer shown generally at 34, having a secondary winding 35 which may be connected to a load device such, for example, as a resistance welder represented by the electrodes 36
40 between which work 37 may be positioned on which a welding operation is to be performed.

With a view to controlling the flow of current through the conductors 32 to the transformer 34,
45 a pair of inversely connected valves of the arc discharge type, shown generally at 39 and 40, is provided and is connected between one terminal of the primary winding 33 and one terminal of the generator 31. Each of the valves 39, 40 comprises, respectively anodes 41, 42, mercury pool
50 cathodes 43, 44 and control electrodes 45, 46. When current is caused to flow from the anodes 41, 42 through the control electrodes 45, 46 into the mercury pool cathodes 43, 44, cathode spots are formed on the latter which will cause the
55 valves 39 and 40 to become conducting when thus ignited provided that the proper polarity for which they are adapted to be conducting is applied thereto. In other words, each of the valves 39, 40 will become conducting on the application of the proper polarity or half cycle thereto provided that the cathode spot is formed in the
60 half cycle for which either of them is adapted to become conducting. The valves 39, 40 will remain in the conducting state until the end of the half cycle and will not again become conducting unless during a succeeding half cycle of the alternating current a cathode spot is again
65 formed.

In order to energize the control electrodes 45, 46 for the purpose of forming the cathode spots in the valves 39, 40, control circuits, shown generally at 51, 52 individual respectively thereto, are provided. The circuits 51, 52 comprise electric
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valves 53, 54, respectively, which are controlled by means of a phase shifting circuit and valves 55, 56 which are disposed to be controlled by the timer device 10 employing the magnetic impulsing device 18 described hereinbefore. The valves 53, 54, 55, 56 are preferably of the gas filled arc discharge type, and, as illustrated, they are, respectively, provided with anodes 57, 58, 59, 60, control electrodes or grids 61, 62, 63, 64, and hot cathodes 65, 66, 67, 68. A capacitor 69 is connected between each of the control electrodes 61, 62, 63, 64 and its respective cathode 65, 66, 67, 68, in order to maintain the former at a predetermined potential relative to the latter.

The valves 53, 54 are arranged to control the particular instant in each half cycle at which the valves 39, 40 are to be rendered conducting. Each of the valves 53, 54 has an individual transformer 71, 72, the secondary windings 73, 74 of which are connected, respectively, between the control electrode 61 and the cathode 65 and the control electrode 62 and the cathode 66. The transformers 71, 72 are provided, respectively with primary windings 75, 76 which are connected into a common control circuit 77 having a common terminal 78 and a voltage divider 79 provided with a variable tap 80. The voltage divider 79 and the variable tap 80 therealong is provided in order to control the relative time in each half cycle at which the valves 53, 54 are rendered conducting. Due to slight variations in manufacture, the valves 53, 54 and the associated valves may not have identical operating characteristics. In order, therefore, to provide for making a compensation for different operating characteristics of the valves 53, 54, the voltage divider 79 may be adjusted by moving the variable tap 80 to the desired position.

The time in each half cycle at which the valves 53, 54 are rendered operative depends upon the phase relationship of the voltage which is impressed between the common terminal 78 and the variable tap 80 relative to the voltage of the alternating current source 31. This relative phase relationship may be altered in order to vary the amount of energy which is supplied to the load device or the heat supplied to perform a welding operation, by rendering the valves 39, 40 conducting either earlier or later in their individual half cycles to correspondingly increase or decrease the amount of energy which is supplied to the load device. The desired phase relationship of the control voltage for the valves 53, 54 may be obtained from a phase shifting circuit, shown generally at 81. The phase shifting circuit 81 is energized by means of a transformer, shown generally at 82, having a primary winding 83 connected for energization across the conductors 32 and a secondary winding 84 having a tap 85 which may be located midway between the terminals thereof. A voltage divider 86 is provided comprising sections 86a, 86b, and having a variable tap 87 movable therealong. An inductor 88 is provided and connected in shunt circuit relation with the section 86b. It will be observed that two impedances are provided by this impedance network. That is, the impedance represented by the section 86a of the voltage divider 86 and the impedance having a different phase angle represented by the section 86b of the voltage divider 86 and the inductor 88 connected in shunt circuit relation therewith.

It will also be observed that the variable tap 80 of the voltage divider 79 is connected to the tap 85 of the secondary winding 84 and that the

common terminal 78 is connected to the variable tap 87. By adjusting the position of the variable tap 87 along the voltage divider 86, it is possible to vary the phase relation of the voltage applied between the common terminal 78 and the variable tap 80 of the common control circuit 77 as may be desired. This relationship is illustrated in a vector diagram shown in Fig. 7 of the drawings. The vector E represents the voltage across the terminals of the secondary winding 84 while the vectors E_R and E_x represent, respectively, the voltage drop across the section 86a of the voltage divider 86 and the voltage drop across the impedance represented by the section 86b of the voltage divider 86 and the inductor 88. As illustrated, it is preferable to so proportion the voltage divider 86 and the inductor 88 that the voltage drops across each of the sections will be equal. For various positions of the variable tap 87, different voltages represented by the vectors E_A , E_B and E_C will be applied to the common control circuit 77.

It will be observed that the control voltages represented by the vectors E_A , E_B and E_C will be substantially constant in magnitude regardless of their phase position relative to the voltage represented by the vector E due to the fact that the current which flows through the impedance network is substantially constant and also that no change is made in the length of the vectors E_R and E_x . The control voltage of substantially constant magnitude is obtained by connecting the common control circuit 77 between a point represented as midway along the vector E, corresponding to the tap 85, and some point, corresponding to the variable tap 87, along either the vector E_R or the vector E_x . In this manner, it is possible to provide a substantially constant value of control voltage over the entire portion of each half cycle during which it may be desirable to render the valves 39, 40 conducting.

As stated hereinbefore, the timer 10 is provided to determine the particular half cycles during which the valves 39, 40 will be rendered conducting. It will be observed that the control windings 21a, 21b of the magnetic impulsing device 18 are connected in series circuit relation and to the control electrode 63 of the valve 55, and that the windings 20a, 20b of this device are also connected in series circuit relation and to the control electrode 64. Normally, a negative biasing potential is applied to the electrodes 63, 64 by means of rectifiers 91, 92, respectively. The rectifiers 91, 92 may be connected for energization, respectively, to secondary windings 93, 94 of a transformer, shown generally at 95, having a primary winding 96 which may be connected across the conductors 32.

In operation it will be assumed that it is desired to supply current to the load device during two succeeding half cycles and that a period of two cycles then occurs during which no current is to be supplied. Accordingly, as illustrated in Fig. 1 of the drawings, pins 15 are positioned in each of four of the holes or openings 14 and the next succeeding four openings are left blank. On rotation of the disk or plate 11 by the synchronous motor 13, a voltage is induced in the control windings 21a, 21b, for example, which may be represented by the timer curve T shown in Fig. 6 of the drawings, in which units of time are plotted as abscissa and units of volts and amperes are plotted as ordinates. It will be observed that the curve T is of a frequency which is double that of the voltage of the alternating current

source 31 which may be represented by the curve V. It will be further observed that the axis of the timer wave T is displaced from that of the voltage wave V because of the biasing voltage obtained from the rectifier 91. For the purposes of illustration, the curve I has been plotted to represent the current which flows through the valve 39, for example, the full line portion thereof representing the time during which current flows and the dotted portion representing the flow of current through the other valve 40 and the current which would flow through the valve 39 if it were in the conducting state. The curve V_c represents the critical potential of the valve 55, for example, which if exceeded in a positive sense will cause it to be rendered in the conducting state.

Assuming now that it is desired to render the valve 39 conducting for the full half cycle, it will be necessary to render it conducting at a time T₁. The position of the magnetic impulsing device 18 is then adjusted by the adjusting screws 24, so that the control voltage applied to the control electrode 63, as represented by the curve T will be above the critical voltage, as represented by the curve V_c at this instant. The position of the variable tap 87 is so adjusted that at the time T₁, the control electrode 61 will have applied thereto the proper energizing potential to render the valve 53 conducting. Therefore, at this instant current will flow through the control electrode 45 from the anode 41 through the valves 53 and 55 in series to the cathode 43. The cathode spot for igniting the valve 39 will then be formed and current will flow as indicated by the curve I. The same sequence of functioning will take place at a time T₂. While the functioning of the control of the valve 39 has been described in detail, it will be understood that the functioning of the valve 40 will be identical except that it will be rendered conducting in the half cycle of the alternating current which is of a polarity opposite to that conducted by the valve 39.

In order to obtain the full range of heat control provided by rendering the valves 39, 40 conducting either earlier or later in the half cycles of the alternating current disposed to be conducted by them, the phase relation of the timer wave T₁ may be altered by shifting the impulsing device 18 and by changing the position of the variable tap 87. The position of the impulsing device 18 may be preset once for all if resistors 97, 98 are connected in shunt circuit respectively with valves 53, 54. The resistances of the resistors 97, 98 may be such that once the valves 55, 56 are rendered conducting in their respective half cycles, they will remain in the conducting state during the remainder of the half cycles due to current flow through resistors 97, 98. This current flow, however, is not sufficient to cause the formation of the cathode spots on the cathodes 43, 44. They will be formed at the time, as determined by the position of the adjustable tap 87, when the valves 53, 54 are rendered conducting.

Since certain changes may be made in the foregoing construction and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter shown in the accompanying drawings or described herein shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. An electric control system comprising, in combination, circuit means for connecting a load

device to a source of alternating current, electric valve means interposed in said circuit means to control the flow of current to said load device, and magnetic impulsing means disposed to increase the conductivity of said valve means during a predetermined number of cycles of the alternating current and to produce substantially no effect on the conductivity of said valve means during a predetermined number of cycles of the alternating current.

2. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, electric valve means interposed in said circuit means to control the flow of current to said load device, and magnetic impulsing means synchronized with the frequency of the alternating current and disposed to render said valve means conducting during a predetermined number of cycles of the alternating current.

3. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, electric valve means interposed in said circuit means to control the flow of current to said load device, control means for said valve means, a control winding operatively connected to said control means, means for causing flux to interlink said control winding, and means disposed to alter the magnitude of said flux during each of a predetermined number of cycles of the alternating current to induce a voltage in said control winding, thereby changing the state of conduction of said valve means during said cycles.

4. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, electric valve means interposed in said circuit means to control the flow of current to said load device, control means for said valve means, a core composed of magnetic material having a gap therein, a control winding on said core and operatively connected to said control means, means for applying a magnetomotive force to said core, and magnetic means disposed to change the reluctance of said gap during each cycle of the alternating current to effect induction of a voltage in said control winding, thereby changing the state of conduction of said valve means.

5. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, electric valve means interposed in said circuit means to control the flow of current to said load device, a support member, means for moving said support member, and a plurality of magnetic members carried by said support member and disposed to be moved relative to said gap to vary the reluctance thereof, thereby causing a voltage to be induced in said control winding to change the state of conduction of said valve means.

6. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, electric valve means interposed in said circuit means to control the flow of current to said load device, control means for said valve means, a core composed of magnetic material having a gap therein, a control winding on said core and operatively connected to said control means, means for applying a magnetomotive force to said core, a rotatable plate, means for rotating said plate, and a plurality of pins of magnetic material carried

by said plate and disposed to be moved relative to said gap to vary the reluctance thereof, thereby causing a voltage to be induced in said control winding to change the state of conduction of said valve means.

7. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, electric valve means interposed in said circuit means to control the flow of current to said load device, control means for said valve means, phase shifting means connected to said control means to condition said valve means to be conducting at a predetermined time in a half cycle of the alternating current disposed to be conducted by said valve means, and magnetic impulsing means connected to said control means to render said valve means conducting during a predetermined number of half cycles of the alternating current at a time determined by said phase shifting means.

8. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, a pair of inversely connected electric valves interposed in said circuit means for permitting succeeding half cycles of the alternating current to flow to said load device, and magnetic impulsing means disposed to render said valves conducting during a predetermined number of successive half cycles of the alternating current.

9. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, a pair of inversely connected electric valves interposed in said circuit means for permitting succeeding half cycles of the alternating current to flow to said load device, a control circuit for each of said valves, a control winding operatively connected to each of said control circuits, means for causing magnetic flux to interlink said control windings, and magnetic means disposed to operate in synchronism with the frequency of the alternating current for changing the magnitude of said flux during each of a predetermined number of half cycles of the alternating current to induce a voltage in each of said control windings, thereby changing the state of conduction of said valves during said half cycles.

10. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, a pair of inversely connected electric valves interposed in said circuit means for permitting succeeding half cycles of the alternating current to flow to said load device, a control circuit for each of said valves, a core composed of magnetic material having a gap therein, a pair of control windings on said core, each being individually connected to a control circuit, means for applying a magnetomotive force to said core, and magnetic means disposed to operate in synchronism with the frequency of the alternating current for changing the reluctance of said gap during each of a predetermined number of half cycles of the alternating current to induce a voltage in each of said control windings, thereby changing the state of conduction of said valves during said half cycles.

11. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, a pair of inversely connected electric valves interposed in said circuit means for permitting succeeding

half cycles of the alternating current to flow to said load device, a control circuit for each of said valves, a core composed of magnetic material having a gap therein, a pair of control windings on said core, each being individually connected to a control circuit, means for applying a magnetomotive force to said core, a support member, means for moving said support member in synchronism with the frequency of the alternating current, and a plurality of magnetic members each corresponding to a cycle of the alternating current and disposed to be carried by said support member to be moved relative to said gap to vary the reluctance thereof during each half cycle of the alternating current, thereby effecting the induction of a voltage in said control winding to change the state of conduction of said valves.

12. An electric control system comprising, in combination, circuit means for connecting a load device to a source of alternating current, a pair of inversely connected electric valves interposed in said circuit means for permitting succeeding half cycles of the alternating current to flow to said load device, a control circuit for each of said valves, a core composed of magnetic material having a gap therein, a pair of control windings on said core, each being individually connected to a control circuit, means for applying a magnetomotive force to said core, a plate provided with a plurality of transverse openings near the periphery thereof, means for rotating said plate in synchronism with the frequency of the alternating current, and a plurality of pins of magnetic material each corresponding to a half cycle of the alternating current positioned in said openings and disposed to be moved relative to said gap to vary the reluctance thereof during each half cycle of the alternating current, thereby effecting the induction of a voltage in each of said control windings to change the state of conduction of said valves.

13. In an electric control system, in combination, a pair of inversely connected electric valves disposed to interconnect a load circuit and a source of alternating current, a control electrode for each of said valves, a common control circuit for said control electrodes, phase shifting means disposed to be interconnected between said source of alternating current and said common control circuit for rendering said valves conducting at a predetermined time in each half cycle of the alternating current disposed to be conducted thereby, and means for relatively adjusting the time in each half cycle at which said valves are rendered conducting.

14. In an electric control system, in combination, a pair of inversely connected electric valves disposed to interconnect a load circuit and a source of alternating current, a control electrode for each of said valves, a common control circuit for said control electrodes, phase shifting means disposed to be interconnected between said source of alternating current and said common control circuit for rendering said valves conducting at a predetermined time in each half cycle of the alternating current disposed to be conducted thereby, and adjustable voltage dividing means in said common control circuit for relatively adjusting the time in each half cycle at which said valves are rendered conducting.

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