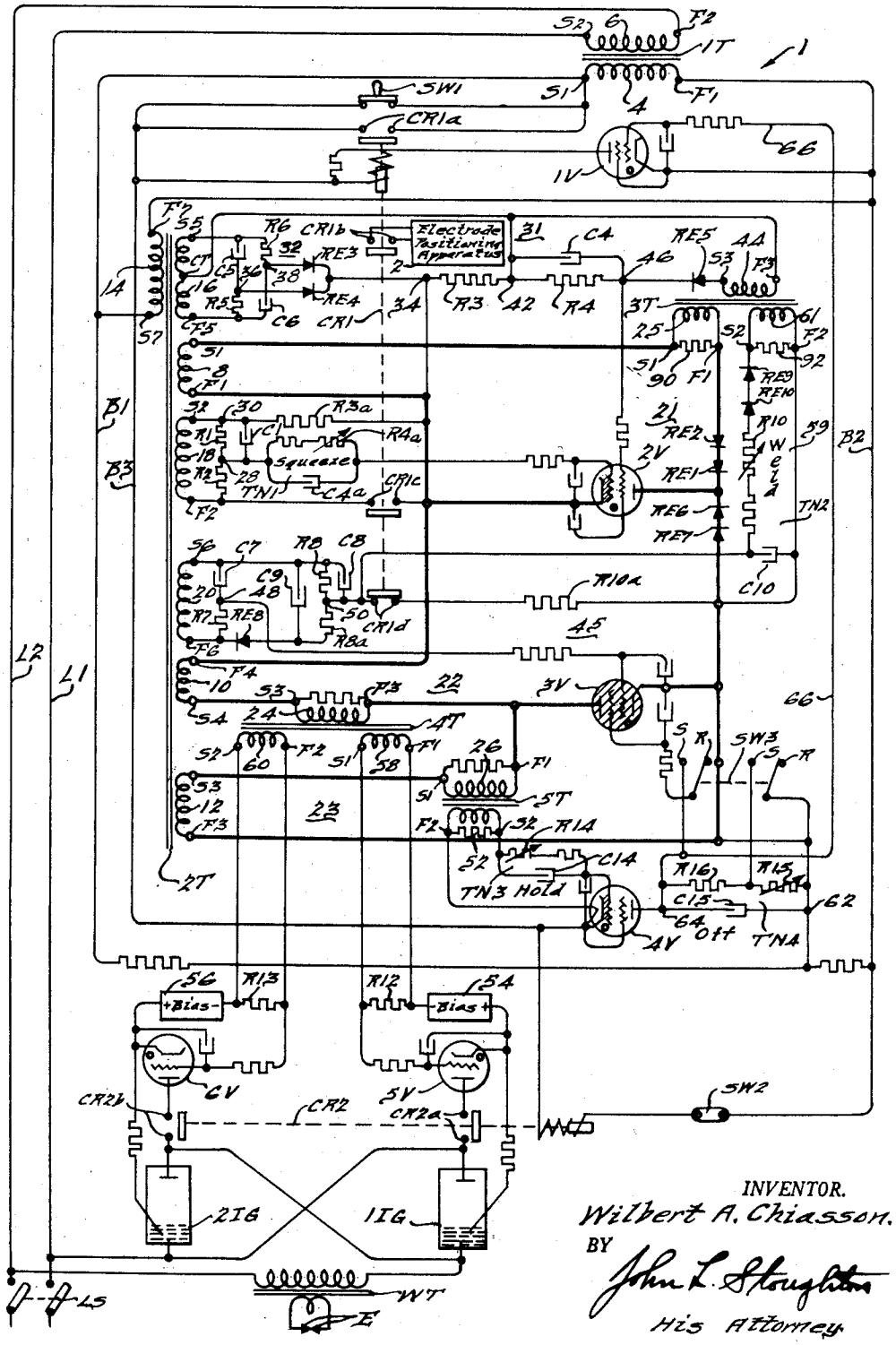
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ELECTRIC TIMER

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ELECTRIC TIMER

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This invention relates generally to Electrical Sequencing Timers and more especially to such a timer which is adapted, among other uses, to time the various sequential operations of a resistance welding machine.

An object of this invention is to provide a new and improved electrical apparatus of the character described.

A further object of this invention is to provide such an apparatus which is economical to manufacture and requires a minimum amount of maintenance.

A further object of this invention is to provide such an apparatus which will dependably control the flow of heating current to an associated machine.

A still further object of this invention is to provide such an apparatus in which the interruption of heating energy flow is not solely dependent upon the initiation of conduction of an electrical valve.

Other and more detailed objects will be apparent from the description, the appended claims, and the drawing, the single figure of which illustrates schematically a preferred embodiment of the invention.

Referring to the drawing by characters of reference, the electrical sequencing timer generally designated 1 comprises a plurality of electric valves 1V, 2V, 3V, 4V, 5V, and 6V for controlling the flow of current to, and the relative movement of, a pair of (diagrammatically shown) welding electrodes E. More specifically, the relative movements of the electrodes E may be controlled by means of any of the apparatus well known in the art for such purposes and which is generally designated 2 in the drawing. The apparatus 2 is controlled by a pair of normally open contacts CR1*b* of a controlling relay CR1. The potential applied between the electrodes E is derived from a welding transformer WT, the primary winding of which is connected to a suitable source of alternating potential through a pair of reversedly connected ignitrons 1IG and 2IG.

Whenever valve 1V conducts, the relay CR1 will be energized and the apparatus 2 will be effective to actuate the electrodes E to work engaging position and whenever both of the valves 2V and 3V are conducting, the ignitrons 1IG and 2IG will be fired to energize the electrodes E. The relative conductive conditions of the valves 1V to 6V as determined by the timing networks TN1–TN4 actuate the apparatus 2 and the ignitrons 1IG and 2IG in a timed sequence.

The potential for charging the timing networks TN1–TN4 and for the anode-cathode circuits of the valves 1V–4V is supplied from the secondary winding 4 of a transformer 1T having its primary winding 6 connected by means of the lines L1 and L2 and line switch LS to a suitable source of alternating potential. The busses B1 and B2 are directly connected to the terminals S1 and F1 of the winding 4 and are maintained energized as long as the transformer 1T is energized. The bus B3 is selectively connected to the terminal S1 of winding 4 by the start switch SW1 and/or the contacts CR1*a* of a control relay CR1. During standby operation of the network, both the switch SW1 and the contacts CR1*a* will be open and the bus B3 will be deenergized.

The anode-cathode circuit of the valves 1V and 4V extends between the busses B2 and B3 whereby the valves 1V and 4V will not conduct whenever the bus B3 is deenergized. The anode-cathode potential for the valves 2V and 3V is derived from the secondary windings 8, 10, and 12 of the transformer 2T, the primary winding 14 of which is connected between the continually energized busses B1 and B2. The valve 2V is normally nonconducting anode to cathode because of the bias potential developed across resistor R1 but does conduct grid to cathode to maintain the squeeze time network TN1 charged. The valve 3V is normally conducting anode to cathode to energize transformer 5T which maintains network TN3 energized to maintain a blocking bias on valve 4V which is effective when bus B3 is energized to keep valve 4V nonconducting.

The polarity designations used on the terminals of the windings of transformer 1T, as well as on those of the transformers 2T, 3T, 4T, and 5T is such that all of the S terminals are positive with respect to the F terminals at the same half cycle of the alternating potential supplied to the lines L1 and L2 and vice versa.

The valve 2V has a first anode circuit 21 which includes the winding 8 of transformer 2T and a primary winding 25 of transformer 3T. It also has a second anode circuit 22 which includes the winding 10 of transformer 2T, the anode-cathode of tube 2V, rectifiers RE6 and RE7, the anode-cathode of tube 3V and the primary winding 24 of transformer 4T. The valve 3V, in addition to being included in circuit 22, has another anode-cathode circuit 23 which includes the winding 12 of transformer 2T and the primary winding 26 of transformer 5T. Normally, the valve 3V conducts through the circuit 23 and the valve 2V is nonconducting, keeping the circuits 21 and 22 deenergized. At the end of "squeeze time" the valve 2V conducts to energize the circuits 21 and 22 whereby all of circuits 21–23 are conducting and the ignitrons 1IG and 2IG are rendered conducting. At the end of "weld time" the valve 3V is rendered nonconducting and circuits 22 and 23 are deenergized while circuit 21 remains energized. The deenergization of circuit 22 terminates the firing of the ignitrons 1IG and 2IG while the deenergization of circuit 23 initiates the timing of "hold time."

More particularly, the cathode of valve 2V is connected to the terminal F1 of the secondary winding 8 and its anode is connected through a pair of dry disc type rectifiers RE1 and RE2, the primary winding 25 of the transformer 3T to the S1 terminal of the secondary winding 8. The tube 2V is normally maintained blocked by means of a bias potential established between its grid and cathode from a secondary winding 18 of transformer 2T. The bias circuit extends from the control grid of the tube 2V through a current limiting resistor, the squeeze time network TN1 to the common connection 28 between a pair of resistors R1 and R2 connected across the secondary winding 18. The common connection 30 of the resistor R1 and the S2 terminal of the winding 18 is connected through a resistor R3*a* to the cathode of the tube 2V. The phasing of the winding 18 relative to the winding 8, as indicated from the S and F numerals applied thereto, is such that when the anode of tube 2V is positive with respect to the cathode, the grid will be maintained negative with respect to the cathode due to the alternating potential established across the resistor-capacitor network R1—C1. During the half cycle that the anode of tube 2V is negative with respect to the cathode, its grid will be positive with respect to its cathode and current flows grid to cathode in the tube

2V and through the network TN1 to charge its capacitor C4.

The valve 2V has a second biasing network 31 connected between its shield grid and cathode. The network 31 causes the valve 2V to initiate its conduction at a predetermined point in the anode-cathode voltage wave. The network 31 provides a phase shifted raw rectified pulsating unidirectional blocking bias potential across the resistor R3 which approaches zero value twice each cycle. The resistor R3 is connected in series with resistor R4 between the shield grid and cathode of the valve 2V. Since the resistor R4 will not become energized until valve 2V conducts the voltage across resistor R3 will prevent valve 2V from becoming conductive except at or substantially at the point in the anode voltage wave of valve 2V at which the potential across the resistor R3 is substantially zero. This point may be adjusted to occur at any desired phase angle, but in resistance welding I prefer to have it occur substantially at 85°. The resistor R3 is energized from a phase shifting network 32 in which there is provided a pair of series connected resistors and capacitors R6—C6 and R5—C5 connected oppositely across the end terminals S5 and F5 of a secondary winding 16 of transformer 2T. The common points 36 and 38 of the series connected capacitors and resistors are individually connected through rectifiers RE3 and RE4 to the terminal 34 of the resistor R3. The center terminal CT of the winding 16 is connected to the other end terminal 42 of the resistor R3 which is also one terminal of resistor R4. The phase shifted voltage provided between the center tapped terminal CT and each of the common terminals 36 and 38 is phase shifted approximately 85° behind the anode-cathode voltage applied to the tube 2V from the winding 20 and it is only when the voltage across the resistor R3 is approximately zero that the tube 2V can commence to fire.

Once, however, the tube 2V fires, a swamping voltage established across the resistor R4 from the winding 44 of the transformer 3T overcomes the blocking bias potential established across the resistor R3 so that the tube 2V will thereafter fire substantially completely throughout the half cycle of applied voltage in which its grid is positive with respect to its cathode. More particularly, the terminal S3 of the winding 44 is connected through a rectifier RE5 to one terminal 46 of the resistor R4. The common terminal 42 between the resistors R3 and R4 is connected to the terminal F3 of the transformer 3T. A capacitor C4 is connected in shunt with the resistor R4 so as to smooth out the rectified voltage from the winding 44.

Conduction of the tube 3V is controlled by a biasing circuit 45 and is normally biased into a conducting condition by a potential established from the winding 20 of the transformer 2T. Connected between terminals S6 and F6 of the winding 20 are series connected capacitor C7 and resistor R7, having a common terminal 48. Also connected between the terminal S6 and F6 of winding 20 are a pair of series connected resistors R8 and R8*a* having a common terminal 50. A rectifier RE8 is connected between the lower end terminal of resistor R8*a* and the terminal F6 and capacitors C8 and C9 are respectively connected in shunt with resistor R8 and the series connected resistors R8 and R8*a*. The grid of the valve 3V is connected through a current limiting resistor to the common terminal 48 while the terminal 50 is connected through a capacitor C10 to the cathode of valve 3V. During standby, the capacitor is maintained discharged through a shunt circuit comprising normally closed contacts CR1*d* and resistor R10*a*. The potential across resistor R8 provides a substantially constant unidirectional conducting bias while that across the capacitor C7 provides an alternating potential which leads that across the anode of valve 3V by approximately 150° so that "full cycle" firing of valve 3V will occur.

Capacitor C10 is charged from the transformer 3T during the intervals in which valve 2V conducts. The rate of increase in charge of capacitor C10 is primarily controlled by the resistor R10. When this charge on capacitor C10 is above a critical value, it overcomes the conducting bias provided by the resistor R10 and capacitor C7, and valve 3V blocks to terminate weld time.

As mentioned above, the valve 4V is normally held blocked by the charge across the hold timing network TN3 and the potential developed in the winding 52 of transformer 5T. For this purpose, it will be noted that the grid of the thyratron 4V is connected through the secondary winding 52 of the transformer 5T and through the heater of the tube 4V to the cathode thereof. For purposes of simplicity, the heater circuit for the valve 4V is not shown but it is to be understood that it is suitably energized with the proper magnitude of alternating potential which, in the case of 2050 type valves, would be slightly over 6 volts. This A. C. voltage applied in the grid-cathode circuit of the valve 4V is of no effect when the network TN3 is fully charged. However, it does provide a superimposed source of alternating voltage on the bias circuit so that the firing of the tube 4V upon timing out of the network TN3 is more precise.

Since the tube 2V during standby is normally held nonconductive, it will be appreciated that the transformer 4T is normally deenergized which, as will be explained below, maintains the firing thyratrons 5V and 6V, and consequently the ignitrons 1IG and 2IG, blocked so that no current is flowing to the welding transformer WT.

It is believed that the remainder of the details of construction may best be understood by a description of operation of the apparatus, which is as follows:

The apparatus is initially conditioned for operation by closure of the line switch LS which energizes the line conductors L1 and L2 from a suitable source of alternating potential of an available voltage which normally would be either 220 or 440 volts. Energization of the line L1 and L2 energizes the control potential supplying transformer 1T whereby the secondary winding 4 thereof is effective to place an alternating potential between the busses B1 and B2 of the desired potential for the control network, which normally would be 115 volts. Due to the nonconducting condition of the ignitrons 1IG and 2IG, the welding transformer WT will, of course, not be energized.

Energization of the busses B1 and B2 energizes the transformer 2T and other transformers not shown for supplying heating potential to the heaters not shown of the valve 1V, 2V, 3V, 4V, 5V, and 6V, whereby their anodes may be brought up to operating potential.

If desired, a time delay switch, not shown, may be inserted in series with the starting switch SW1 to prevent the initiation of operation of the control apparatus prior to a desired warm up time period to prevent damage to the various control tubes which might be caused by premature firing thereof.

The bias producing devices 54 and 56 shown in block form may also be energized through rectifying devices energized upon closure of the lines L1 and L2 in a manner well known in the art. The heater windings for the tubes, the energizing circuits therefor, as well as the details of the bias devices 54 and 56 and their energizing circuits are not shown for the purposes of simplifying these drawings, since their structure is well known. It is sufficient to state, however, that the devices 54 and 56 in the absence of the energization of the transformer 4T will bias the firing tubes 5V and 6V nonconductive. As is usual in the art, the firing tubes 5V and 6V are connected in series between the anode and igniter of the discharge devices 1IG and 2IG which preferably are ignitrons. During standby operation, when B3 is deenergized, the anode circuits of the tubes 5V and 6V are open circuited by the normally open contacts CR2*a* and CR2*b* of relay CR2.

During standby operation, the relay CR1 is deenergized and its normally open contacts CR1*a* and the normally open starting switch SW1 maintain the bus B3

deenergized. Thus, the anode circuit of the valve 1V is open so that, although not biased nonconductive, it can not conduct and energize the relay CR1. The open condition of the contacts CR1*c* connects the bias circuit of the valve 2V to prevent it from conducting. The valve 2V, however, does conduct grid to cathode to charge the squeeze time network TN1. The valve 3V is normally conducting and the circuit 23 is energized. This causes the hold time network TN3 to become charged due to grid to cathode conduction of the valve 4V. The bias voltage applied to the valve 4V holds this valve nonconducting but the anode circuit of 4V is also open.

The transformer 4T is not energized because of the blocked condition of valve 2V and the bias devices 54 and 56 are effective to maintain the firing thyratrons 5V and 6V blocked. The blocked condition of the thyratrons 5V and 6V as well as the open condition of the contacts CR2*a* and CR2*b* of the relay CR2 insures that the ignitrons 1IG and 2IG will be held nonconducting to prevent energization of the welding transformer WT. The relay CR2, under control of the switch SW2, provides a weld no-weld control. Under usual conditions, the switch SW2 is kept closed so that the relay CR2 is energized and its contacts CR2*a* and CR2*b* are closed whenever the bus B3 is energized but if, for some reason, it is desired to cycle the timer 1 without energizing the electrodes E, the switch SW2 may be opened to prevent the firing tubes 5V and 6V from firing the ignitrons 1IG and 2IG.

When it is desired to initiate a weld, the starting switch SW1, which may be the usual foot switch, is closed thereby energizing the bus B3. This completes the anode-cathode circuit of the valves 1V and 4V and the energizing circuit of the relay CR2. The relay CR2, thereby energized, closes its contacts CR2*a* and CR2*b* to prepare the anode circuits of the firing tubes 5V and 6V, but because of the deenergized condition of the transformer 4T, the tubes 5V and 6V remain nonconductive due to the biasing devices 54 and 56. Upon closure of the anode circuit of the valve 1V, it immediately conducts to energize the relay CR1 causing its normally open contacts CR1*a*, CR1*b* and CR1*c* to close and its normally closed contacts CR1*d* to open. Closure of the contacts CR1*a* completes a maintaining circuit in parallel with the switch SW1, which may now be opened, without interrupting the sequence of operation which has just been initiated. Closure of the contacts CR1*b* energizes the electrode positioning apparatus 2 causing the electrodes E to be moved against the work placed therebetween. Closure of the contacts CR1*c* connects the cathode of the valve 2V to the F2 terminal of the winding 18 of the transformer 2T and due to the presence of resistor R3*a*, effectively disconnects the cathode from the terminal S2. This interchange of connections removes the alternating bias formerly supplied by the resistor R1 and capacitor C1 and substitutes therefor the smaller oppositely polarized potential supplied by the resistor R2. In this regard, the value of resistor R2 is much smaller than that of resistor R1. This interchange terminates further charging of the squeeze time network TN1, which then commences to discharge. At the end of a predetermined time interval as determined by the relationship of the values of resistor R4*a* and capacitor C4*a*, the potential across the squeeze time network TN1 will have been reduced sufficiently so that the potential across the resistor R4*a*, when coupled by the alternating potential across the resistor R2, will be sufficient to render the valve 2V conducting at a point in the anode voltage wave determined by the biasing network 31. When valve 2V conducts, it completes the circuits 21 and 22. Completion of circuit 21 energizes the primary winding 25 of the transformer 3T from the secondary winding 8 of the transformer 2T which is the source of anode potential. Energization of the transformer 3T causes the winding 44 thereof to impress a potential across the resistor-capacitor network R4—C4 so that the potential thereacross is of a polarity and magnitude to render the shield grid ineffective to block the valve 2V. Valve 2V thereupon remains fully conducting until subsequently blocked upon the opening of the contacts CR1*c*, as will be described below.

Completion of the circuit 22 causes the transformer 4T to become energized whereby its secondary windings 58 and 60 thereof apply alternating potentials across the resistors R12 and R13 in the bias circuits of the firing valves 5V and 6V. The potential applied to the resistors R12 and R13 is of such phase and magnitude as to overcome the blocking bias devices 54 and 56 to fire the firing thyratrons 5V and 6V. When conductive, the valves 5V and 6V periodically fire the ignitrons 1IG and 2IG to energize the welding transformer with alternating current in a manner well known in the art.

Energization of the transformer 3T also initiated the timing out of the weld time network TN2, which determines the time the welding transformer is energized. Current from the winding 61 flows through a circuit 59 comprising a pair of series connected rectifiers RE9 and RE10, and the resistor R10 to the capacitor C10. It should be recalled that during standby condition capacitor C10 is normally maintained discharged by the normally closed contacts CR1*d* of the relay CR1. When, however, the tube 2V conducts, the relay CR1 will be energized and its contacts CR1*d* will be open. As valve 2V conducts, to keep the transformer 3T energized as described above, the charge on the capacitor C10 gradually increases at a rate determined by the magnitude of the resistance of the resistor R10. After a predetermined time interval, the capacitor C10 will have received a predetermined charge such that the potential thereacross will become sufficient to overcome the conducting potential derived from the winding 20 and a blocking bias will be applied to the valve 3V to terminate further conduction thereof.

The valves 1V, 2V, 3V, 5V, and 6V continued to conduct as described until the weld timing network TN2 placed a blocking bias between the control grid and cathode of the valve 3V.

When the valve 3V blocks, the transformer 4T will no longer be energized to energize the resistors R12 and R13 and the bias devices 54 and 56 will become effective to maintain the firing thyratrons 5V and 6V blocked and thereby prevent any further conduction of the ignitrons 1IG and 2IG and consequently any further energization of the welding transformer WT. Blocking of the valve 3V also deenergized the transformer 5T to initiate the timing of the hold timing network TN3. At the end of its timing period (the time required for capacitor C14 to discharge to a predetermined low value through resistor R14), the potential across the timing network TN3 will have reduced sufficiently to permit the valve 4V to conduct. As stated above, a low voltage alternating potential wave is applied in series with the potential across the network TN3 due to the fact that the heater winding is connected in this biasing circuit. This is a well known expedient in the art and tends to render accurate the time interval provided by the network TN3.

At the end of hold time, the valve 4V conducts to energize the off timing network TN4 in its anode circuit. It will be appreciated that the cathode of the valve 1V is connected through the bus B2 and the resistor R2 to the positive terminal 62 of the charged timing network TN4. The negative terminal 64 of this network TN4 is connected by the conductor 66 through the usual current limiting resistor to the control grid of the valve 1V. The valve 1V therefore becomes blocked upon energization of the network TN4. Blocking of the valve 1V deenergizes the control relay CR1 causing its contacts CR1*a*, CR1*b*, and CR1*c* to open and its contacts CR1*d* to close.

Assuming that the switch SW1 is being held closed,

opening of the contacts CR1*a* will be without effect. Opening of the contacts CR1*b* will deenergize the electrode positioning apparatus of the electrodes E to cause the electrodes E to be moved away from each other, permitting the work to be repositioned for a subsequent welding operation. Opening of the contacts CR1*c* effectively disconnects the cathode of the valve 2V from the F2 terminal of the winding 18 and connects it to the S2 terminal thereof, whereby the resistor R1 is effective to apply a blocking portion between the grid and cathode of the valve 2V to block the same, as well as to provide for recharging of the squeeze time network TN1 .

Blocking of the valve 2V terminates further energization of the transformer 3T and the capacitor C4 quickly discharges through the resistor R4 removing the conducting potential applied thereby between the shield grid and cathode of the valve 3V. Closure of the contacts CR1*d* discharges the capacitor C10 of the weld timing network TN2 through a current limiting resistor placing the valve 3V again in a conducting condition under control of the potential supplied by the capacitor C7 and resistor R8. The valve 3V again commences to conduct to energize the transformer 5T for reenergizing the hold time network TN3 to reblock the valve 4V and terminate further charging of the network TN4 which then starts to time out.

At the end of a predetermined off time, as determined by the relative values of the capacitor C15 and resistor R15 thereof, the blocking bias will be removed from the valve 1V permitting it to reconduct and thereby permit a repeat operation as described above, provided, however, that the switch SW1 had been held closed.

If the switch SW1 is open at the time that the valve 1V is blocked by the off timing network TN4, opening of the contacts CR1*a* deenergizes the bus B3 which immediately results in blocking of the valve 4V and initiating the timing out of the network TN4 directly as a consequence of the opening of the contacts CR1*a* rather than as a result of reenergization of the hold time network TN3 and further operation will cease.

If, however, a repeating operation as described is not desired and it is desired to provide only for a single energization of the electrodes E for each closure of the switch SW1 irrespective of the time that the switch SW1 is held closed, the single-repeat switch SW3 is moved from its shown position in which the poles thereof are in engagement with the R contacts to a position in which the poles are in engagement with the S contacts. This position of the switch SW3 disconnects the shield grid of the valve 3V from the cathode and reconnects it to the terminal 64 of the network TN4. Since the cathode of the valve 3V is connected to the terminal 62 of the network TN4, the potential across the network TN4, due to conduction of the valve 4V, will establish a blocking bias between the shield grid and cathode of the valve 3V. This blocking bias will prevent reenergization of the transformer 5T of the hold time network TN3 as long as the valve 4V conducts and, since the valve 4V will block only if the network TN3 is reenergized, which is not possible, or its anode circuit is interrupted, valve 4V will continue to conduct until the anode circuit is interrupted. This interruption will occur when, but not until, the switch SW1 is opened. Movement of the switch SW3 from the R to the S position also shorts out the resistor R16 so that when the valve 4V is rendered nonconducting by opening of its anode circuit, the capacitor C16 will quickly discharge through the current limiting resistor R16 so that the timer 1 is rapidly put in condition for a subsequent operation.

If desired, the resistors 90 and 92 could be omitted and the phasing of windings 8 and 28 could be reversed. In such event, the valve 2V would conduct through 3T during one half cycle of the supply voltage and through 4T during the opposite half cycle. With this arrangement, the swamping portion of the biasing circuit 31 (the portion energized from winding 44) could be eliminated. With this arrangement, tube 2V would continue to conduct fully until the capacitor C10 of the weld time network TN2 was fully charged and valve 3V blocked. Thereafter valve 2V would conduct only during the half cycles that winding 8 maintains its anode positive with respect to its cathode, thus maintaining the charge on the capacitor C10 above the critical value at which it maintains tube 3V blocked.

The embodiments of this invention are shown in accordance with the provisions of the patent statutes, and it will be appreciated that such embodiments are illustrative only and that the limits of the invention are to be determined by the scope of the hereinafter appended claims.

What is claimed and is desired to be secured by United States Letters Patent is as follows:

1. In a timing apparatus, a plurality of electric valves each having an anode and a cathode and a control means, a first transformer having a primary winding, a first anode circuit for a first of said valves and including said anode and said cathode of a first of said first valves and said primary winding of said first transformer, a second anode circuit for said first valve and including said anode and said cathode of said first valve and a rectifying device and said anode and said cathode of a second of said valves, a second transformer having a primary winding and a secondary winding, a third anode circuit for said second valve and including said anode and said cathode of said second valve and said primary winding of said second transformer, a first bias circuit for said second valve including said secondary winding of said second transformer and connected between said cathode and said control means of said second valve, an energy storage device and a rectifier means in said bias circuit, said energy storage device being connected through said rectifier means to said secondary winding, said rectifier means being connected to provide for charging said storage device in such polarity as to render said second valve conducting, said second transformer having a second secondary winding, a second bias circuit including an energy storage device connected between said cathode and said control means of said first valve, circuit means energized by said second secondary winding and connected to unidirectionally charge said last-named storage device in such polarity as to render said first valve nonconducting, and means responsive to a change in energization of said first transformer for controlling the conductive condition of said second valve.

2. In a timing apparatus, a plurality of electric valves each having an anode and a cathode and a control means, a first anode circuit for said first valve and including said anode and said cathode of a first of said valves and a rectifying device and said anode and said cathode of a second of said valves, a transformer having a primary winding and a secondary winding, a second anode circuit for said second valve and including said anode and said cathode of said second valve and said primary winding of said transformer, a first bias circuit for said second valve including said secondary winding of said transformer and connected between said cathode and said control means of said second valve, an energy storage device and a rectifier means in said bias circuit, said energy storage device being connected through said rectifier means to said secondary winding, said rectifier means being connected to provide for charging said storage device in such polarity as to render said second valve conducting, said transformer having a second secondary winding, and a second bias circuit including an energy storage device connected between said cathode and said control means of said first valve, and circuit means energized by said second secondary winding and connected to unidirectionally charge said last-named storage device in such polarity as to render said first valve nonconducting.

3. In a timing apparatus, a plurality of electric valves

each having an anode and a cathode and a control means, a first anode circuit for said first valve and including said anode and said cathode of a first of said valves and an asymmetrical current conducting device and said anode and said cathode of a second of said valves, a second anode circuit for said second valve and including said anode and said cathode of said second valve and an impedance device, a first bias circuit for said second valve including a portion of said impedance device and connected between said cathode and said control means of said second valve, an energy storage device and a second asymmetrical current conducting device in said bias circuit, said energy storage device being connected through said second asymmetrical device to said impedance device, said second asymmetrical device being connected to provide for charging said storage device in such polarity as to render said second valve conducting, and a second bias circuit including an energy storage device connected between said cathode and said control means of said first valve, and circuit means energized by said impedance device and connected to unidirectionally charge said last-named storage device in such polarity as to render said first valve nonconducting.

4. In an electrical apparatus, a first and a second and a third terminal adapted to be energized from an alternating potential source such that the phase of the potential appearing between said first and said second terminal is displaced 180 electrical degrees from the potential appearing between said second and said third terminals, a first electric valve having a pair of main electrodes and control means, a first circuit connecting one of said main electrodes of said second terminal, a second circuit connecting the other of said main electrodes to said first terminal and including a first translating means, a third circuit connecting said other main electrode and said third terminal and including a second translating means, a second valve having a pair of main electrodes, said third circuit including said main electrodes of said second valve, a fourth circuit including said main electrodes of said second valve and including a third translating means, and circuit means actuated by said third translating means and connected between said control means and one of said main electrodes of said first electric valve.

5. In an electrical apparatus, a plurality of terminals adapted to be energized from an alternating potential source such that the phase of the potential appearing between a first and a second terminal of said terminals is displaced 180 electrical degrees from the potential appearing between a third and a fourth of said terminals, a first electric valve having a pair of main electrodes and control means, a first circuit connecting one of said main electrodes to said second terminal, a second circuit connecting the other of said main electrodes to said first terminal and including a first translating means, a third circuit connecting said other main electrode and said third terminal and including a second translating means, a second valve having a pair of main electrodes, a fourth circuit including said main electrodes of said second valve and connecting said one electrode to said fourth terminal, a fifth circuit including said main electrodes of said second valve and including a third translating means, and circuit means actuated by said third translating means and connected between said control means and one of said main electrodes of said first electric valve.

6. In a sequence timer, a plurality of electric valves, each said valve having a pair of main electrodes and control means, a pair of current supplying busses, an electromagnetic relay having an energizing winding and circuit controlling contacts, a first circuit connected between said busses and including in series said winding and said pair of electrodes of a first of said valves, a first transformer having a primary winding and a secondary winding, first unidirectional current flow means, a second circuit energized from said busses and including in series said main electrodes of a second of said valves and said primary winding of said first transformer and said unidirectional means, a second transformer having a primary winding and secondary winding means, a second unidirectional current flow means, a third circuit energized from said busses and including in series said main electrodes of a third of said valves and said primary winding of said second transformer and said second unidirectional means and said main electrodes of said second valve, a third transformer having a primary winding and a secondary winding, a fourth circuit energized from said busses and including said primary winding of said third transformer and said main electrodes of said third valve, a plurality of timing networks, a first and a third and a fourth of said timing networks including an energy storage device and a resistor connected in parallel, a second of said timing networks including an energy storage device and a resistor connected in series, a fifth circuit energized from said busses and including in series said first timing network and said control means and one of said main electrodes of said second valve and a first pair of said contacts of said relay, a sixth circuit energized from said second secondary winding of said first transformer connected between said control means and one of said main electrodes of said third valve and including said second timing network, a seventh circuit energized from said secondary winding of said third transformer connected between said control means and one of said main electrodes of a fourth of said valves and including said third timing network, an eighth circuit connected in series with said main electrodes of said fourth valve and including said fourth timing network, a ninth circuit connected between said control electrode and one of said main electrodes of said first valve and including said fourth timing network, means actuated when said first valve is nonconductive to discharge said storage device of said second network, and a first control circuit energized by said secondary winding means of said second transformer.

7. In a sequence timer, a plurality of electric valves, each said valve having a pair of main electrodes and control means, a pair of current supplying busses, an electromagnetic relay having an energizing winding and circuit controlling contacts, a first circuit connected between said busses and including in series said winding and said pair of electrodes of a first of said valves, a first transformer having a primary winding and at least two secondary windings, first unidirectional current flow means, a second circuit energized from said busses and including in series said main electrodes of a second of said valves and said primary winding of said first transformer and said first unidirectional means, a second transformer having a primary winding and secondary winding means, a second unidirectional current flow means, a third circuit energized from said busses and including in series said main electrodes of a third of said valves and said primary winding of said second transformer and said second unidirectional means and said main electrodes of said second valve, a third transformer having a primary winding and a secondary winding, a fourth circuit energized from said busses and including said primary winding of said third transformer and said main electrodes of said third valve, a plurality of timing networks, a first and a third and a fourth of said timing networks including an energy storage device and a resistor connected in parallel, a second of said timing networks including an energy storage device and a resistor connected in series, a fifth circuit energized from said busses and including in series said first timing network and said control means and one of said main electrodes of said second valve and a first pair of said contacts of said relay, a sixth circuit energized from one of said second secondary windings of said first transformer connected between said control means and one of said main electrodes of said third valve and including said second timing network, a seventh circuit energized from a second of said secondary windings of said first transformer and connected between said control means and a first and said

main electrodes of said first valve, an eighth circuit energized from said secondary winding of said third transformer connected between said control means and one of said main electrodes of said fourth valve and including said fourth timing network, a ninth circuit connected in series with said main electrodes of said fourth valve and including said fourth timing network, a tenth circuit connected between said control electrode and one of said main electrodes of said first valve, means actuated when said first valve is nonconductive to discharge said storage device of said second network, a first control circuit energized by said secondary winding means of said second transformer, and a second control circuit actuated by a second pair of said contacts of said relay.

8. In a controlling network for an electric valve having a pair of main electrodes and a control electrode, a timing network including an energy storage device and a discharge means therefor, a source of bias potential comprising at least three terminals adapted to be energized from a source of alternating potential such that the potential between a first and a second of said terminals is less than the potential between said second and a third of said terminals, means connecting said timing network between said control electrode and said second terminal, and switch means for selectively connecting one of said main electrodes to said first or said third terminals.

9. In a controlling network for an electric valve having a pair of main electrodes and a control electrode, a timing network including an energy storage device and a discharge means therefor, a source of bias potential comprising at least three terminals adapted to be energized from a source of alternating potential such that the potential between a first and a second of said terminals is less than and phased 180 degrees from the potential between a third of said terminals and said second terminal, means connecting said timing network between said control electrode and said second terminal, means including an impedance connecting said third terminal to one of said main electrodes, and means including switch means for connecting said first terminal to said one main electrode.

10. In a controlling network for an electric valve having a pair of main electrodes and a pair of control electrodes, a timing network including an energy storage device and a discharge means therefor, a source of bias potential comprising at least three terminals adapted to be energized from a source of alternating potential such that the potential between a first and a second of said terminals is less than and phased 180 degrees from the potential between a third of said terminals and said second terminal, means connecting said timing network between a first of said control electrodes and said second terminal, switch means for selectively connecting one of said main electrodes to said first or said third terminals, a translating means connected in series with said main electrodes, a first and a second impedance device connected in series with each other between the second of said control electrodes and said one main electrode, means energized by said translating means including a storage device for unidirectionally energizing said first impedance device, and means for pulsatingly energizing said second impedance device.

11. The combination of claim 10 in which said last-named means includes a source of alternating potential having end taps and an intermediate tap, a first and a second series circuit connected between said end taps, each said series circuits including a primarily resistive element and a primarily reactive element, means including a first unidirectional current flow device connecting the common point between said elements of said first series circuit to one terminal of said second impedance device, means including a second unidirectional current flow device connecting the common point between said elements of said second series circuit to said one terminal of said second impedance device, and means connecting the other terminal of said second impedance device to said intermediate tap.

12. The combination of claim 11 in which the said first and second unidirectional current flow devices are poled to provide a potential across said second impedance device in a direction tending to render said valve nonconducting, the magnitude of and the polarity of the potential across said first impedance device when said translating means is energized is such as to provide a potential across said first impedance device in a direction to render said valve conducting.

13. In combination, a first and a second and a third circuit, a first electric valve common to said first and said second circuits, a second electric valve common to said second and said third circuits, a pair of controlling circuits, means responsive to an energized condition of said first circuit for controlling one of said pair of circuits, means responsive to an energized condition of said second circuit for controlling the other of said pair of circuits, and control means for first rendering one of said valves conducting and thereafter rendering both said valves conducting and thereafter rendering said one valve nonconducting while maintaining the other of said valves conducting.

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