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## ELECTRICAL CONTROL SYSTEM

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## UNITED STATES PATENT OFFICE

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## ELECTRICAL CONTROL SYSTEM

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1

This invention relates generally to electrical controlling systems and is especially adapted among other uses for timing the flow of current in a welding mechanism.

Objects of this invention are to provide a new and improved electrical timing system; to provide such a system which may be economically manufactured and which requires a minimum of maintenance; to provide such a system which is accurate in its operation; to provide such a system which requires a minimum of electric valves; to provide such a system utilizing a pair of leading valves and a pair of complementary trailing valves; to provide such an arrangement of leading and trailing valves in which one of the leading valves controls the initiation of the timing period and another of the leading valves controls the termination of the timing period; to generally improve electrical timing systems of the character described.

Other objects of this invention will be apparent from the specification, appended claims and the drawing in which drawing there is illustrated a schematic diagram of an electrical circuit embodying the invention.

Referring to the drawing by characters of reference, alternating current power from a suitable source such as a 60 cycle circuit of suitable voltage is supplied through the line switches LS1 and LS2 and busses L1 and L2. The busses L1 and L2 are connected through suitable networks for energizing a firing network FN comprising the valves V1-V4 inclusive and a timing network TN comprising the valves V5 and V6. Upon closure of the start switch SW, the firing network FN becomes effective to render the main power controlling valves V7 and V8 conductive to supply energy to the welding transformer WT from the busses L3 and L4 which busses are supplied from the same source as are the busses L1 and L2 and which may be of the same voltage or a different voltage in which event transformers would be employed for selecting the relative voltages applied to the busses L1-L2 and L3-L4 from the common source. The firing network FN also initiates the timing function of the timing network TN whereby the firing network FN is rendered ineffective to continue the rendering of the valves V7 and V8 conductive subsequent to the expiration of the timed interval.

More specifically the closure of the switch SW renders the valve V1 conductive to supply anode potential to the series connected valve V3 whereby at the proper point in the voltage wave, as determined by the phase-shifting network PS, the

2

valve V3 will conduct to render valve V7 conductive. Conduction of the valve V1 also establishes a potential across a resistor R1 which is applied as a blocking bias potential to the valve V5 whereby the timing network TN1 immediately starts to time out. Conduction of the valve V3 establishes a potential across the resistor R3 which is applied to the valve V7 and which is sufficient to overcome the direct current blocking bias applied to this valve V7 from the direct current voltage source DC1 thereby effectively removing the blocking bias on the valve V7 rendering it conductive. The potential across resistor R3 is also applied to a transformer T5 whereby a transient bias voltage is applied to the valve V2 for rendering valve V2 conductive during the next half cycle of the alternating voltage following that during which the valve V1 is conductive. Valve V2 will supply anode potential to the valve V4 which like valve V3 is rendered conductive by network PS at a particular point on the voltage wave spaced 180 electrical degrees from the point in which the network PS rendered the valve V3 conductive. Conduction of valve V4 establishes a potential across the resistor R4 which is applied between the grid and cathode of the valve V8 and which overcomes the direct current blocking bias applied to this valve by the direct source DC2 thereby effecting conduction of the valve V8 so that it is operable to conduct each half cycle following that in which the valve V1 conducts. In other words the rendering of valves V1 and V3 conductive in response to closure of switch SW, causes valve V7 to conduct and the valves V2 and V4 to conduct during the following half cycle whereby the valve V8 will conduct as a trailing valve with respect to valve V7. In a general sense, valves V2 and V4 are trailing to the valves V1 and V3 and the valve V8 is a trailing valve to valve V7.

As stated above the conduction of valve V1 rendered the normally conductive valve V5 non-conductive initiating the timing function of the network TN1. When the network TN1 times out, the valve V6 becomes conductive placing a blocking bias potential on a second control grid g2 of valve V3 which overcomes the bias placed on the first control of grid g1 of this valve whereby the valve V3 is held against further conduction so long as the valve V6 continues to conduct. Since the conduction of the valve V3 initiates the conduction of the valve V2 which supplies the anode potential to valve V4 necessary to fire the valve V8, the valves V7 and V8 are

both maintained nonconductive as long as the valve V6 continues to conduct. Valve V6 will continue to conduct as long as valve V1 conducts to set up the blocking potential across the resistor R1 which is until the switch SW is again opened. The opening of the switch SW will render valve V1 nonconductive removing the potential across resistor R1 which will again place the valve V5 in its normally conductive condition for charging the network TN1 and blocking of the valve V6 whereby the blocking potential on the second controlling grid of the valve V3 is removed and the various networks are again in their initial conditions.

Referring to the details of the various networks, the firing network includes the valves V1-V4 inclusive. The anodes of the valves V1 and V2 are connected respectively to opposite ends of the secondary winding of a transformer T1 having its primary winding energized from the lines L1 and L2. The cathodes of each of the valves V1 and V2 are connected through resistors R1 and R2 and neutral bus 2 respectively to the center tap terminal of the secondary winding of the transformer T1. The cathodes of the valves V1 and V2 are respectively connected through resistors R3 and R4 to the anodes of the valves V3 and V4 respectively, the cathodes of these valves V3 and V4 being connected together and to the bus 2. The valve V1 is normally held nonconductive due to a blocking bias applied between its grid and cathode from the negative and positive terminals 4 and 6 of a full wave rectifying network DC3. It will be noted that the positive terminal 6 of this network is directly connected to the cathode of the valve V1 while the negative terminal 4 of this network is connected through the secondary winding of transformer T2 and a current-limiting resistor directly to the grid of the valve V1.

The transformer T2 is energized from the lines L1 and L2 through a voltage phase shifting network PS2 comprising a parallelly connected variable resistor and condenser arranged in series with the primary winding of the transformer T2. Preferably the network PS2 is so adjusted that the secondary winding of the transformer T2 will supply a positive pulse of voltage at the same phase angle with respect to the voltage of the lines L1 and L2 that the current flowing through the welding transformer bears to the voltage appearing across the lines L3 and L4 which of course in this instance is the same as that appearing across the lines L1 and L2. The magnitude of the bias afforded by the network DC3 is substantially greater than that applied by the transformer T2 so that, even though a positive pulse is provided by the secondary winding of the transformer T2 each positive half cycle of the voltage wave, the direct current bias applied by the network DC3 is still effective to maintain the grid negative with respect to the cathode of the valve V1. In order to remove the direct current potential applied between the terminals 4 and 6, the primary winding of the transformer T3 of the network DC3 is center-tapped dividing it into two winding portions 10 and 12. The portion 10 is directly connected across the lines L1 and L2 and is continually energized. The portion 12 is also connected across the lines L1 and L2 oppositely to the connection of the portion 10 but is normally held de-energized due to the normally open position of the starting switch SW. Upon closure of the switch SW, however, the winding 12 is energized and since the energization of the winding 12 creates an effect in the

transformer T3 opposite that of the winding 10, the net result is to substantially remove the direct current voltage appearing between the terminals 4 and 6 so that the positive pulse applied by the transformer T2 will render the grid bias of the valve V1 in a condition to render the valve V1 conductive.

The bias of the grid g1 of the valve V3 with respect to its associated cathode is controlled by the phase shifting network PS whereby the portion of the cycle during which the valve V3 will be rendered in a conductive condition may be selectively controlled. The network PS is disclosed and claimed in my copending application Serial No. 696,945, filed September 13, 1946, for Electrical Control System, now Patent No. 2,523,167.

Briefly this network comprises a transformer T4 having a center-tapped primary winding, the center tap connection of which is directly connected to the line L2. The opposite end terminals of the primary winding of this transformer T4 are connected together through series connected impedance elements comprising a variable resistor 16, a potentiometer-type resistor 17, a condenser 18, and a fixed resistor 19. The movable contact 20 of the resistor 17 is connected to the line L1. The secondary winding of the transformer T4 is of center-tapped construction, one end terminal of which is connected to the grid g1 of the valve V3, the other end terminal of which is connected to the grid of the valve V4 and the center terminal of which is connected to the bus 2. In this manner one half of the secondary winding of the transformer T4 applies control bias between the grid g1 and cathode of valve V3 and the other half of the secondary winding of the transformer T4 applies a control bias between the control grid and cathode of the valve V4. Due to the connection described, the control voltages applied by the network PS to the valves V3 and V4 will be phased 180° with respect to each other. It will be apparent that upon adjustment of the resistor 16 and the resistor 17, a phase-shifted voltage may be applied to the grids of the valves V3 and V4 which may be regulated to cause the valves V3 and V4 to conduct at any desired portion of the voltage wave appearing between the anodes and cathodes of the valves V3 and V4.

It should here be noted that since the anodes of the valves V3 and V4 are connected to opposite ends of the secondary winding of the transformer T1 and the cathodes are each connected through the common bus 2 to the center tap connection thereof the valves V1 and V2 when in a conductive condition will conduct alternate half cycles of the voltage appearing between the busses L1 and L2. For purposes of explanation it will be considered that the valve V1 conducts when L1 is positive with respect to L2 and which condition will be called a positive half cycle and valve V2 conducts when L2 is positive with respect to L1 and which condition will be called a negative half cycle.

Normally the valve V2 is held nonconductive due to a blocking potential applied by the secondary winding 22 of a transformer T6 having its primary winding connected across the busses L1 and L2. One terminal of the winding is connected to the control grid of the valve V2 through the usual grid resistor and condenser while the other terminal is connected through the secondary winding of the before-mentioned transformer T5 to the cathode of the valve V2. A condenser

5

24 may shunt the grid and cathode of this valve V2 if desired. The primary winding of the transformer T5 is connected across and is consequently energized in proportion to the potential appearing across the resistor R3.

The energy for the timing network is supplied by a transformer T7 which has its primary winding directly connected across the lines L1 and L2 and has a pair of secondary windings 26 and 28. One end terminal of the winding 26 is connected to the anode of the valve V5 and the other end terminal is connected through the above-mentioned timing network TN1 to the cathode of the valve V5 which is connected to the common bus 2 and therethrough to one end of the resistor R1. The other end of the resistor R1 is connected by bus 30 through the usual grid resistor and condenser to the grid of the valve V5 so that a blocking bias potential will be impressed between the grid and cathode of the valve V5 proportional to the potential appearing across the resistor R1. Therefore, when the valve V1 is nonconductive there will be no blocking bias potential between the grid and cathode of the valve V5 and the valve V5 will be held in a normally conductive condition to maintain the condenser 32 of the timing network TN1 in a charged condition. The anode of the valve V6 is connected to one terminal of the winding 28 while the cathode thereof is connected to the common bus 2 and through a resistor R6 and a condenser C6 parallelly connected therewith to the other terminal of the winding 28 through a bus 29. The grid of the valve V6 is connected by means of a conductor 34 to a movable tap 36 of a potentiometer 38 having its resistance winding connected in series with a resistor 40 across a secondary winding 42 of the transformer T6. A conductor 44 connects the common junction of the resistors 38 and 40 to the portion of the timing network TN1 away from the common bus 2 whereby the network TN1 is effective to provide a blocking bias between the grid and cathode of the valve V6 whereby it is normally held in a nonconductive condition. The bus 29 is also connected to the grid g2 of the valve V3 whereby a blocking bias will be imposed between the grid g2 and cathode of the valve V3 proportional to the potential across the resistor R6. Since the valve V6 is normally nonconductive no current will be flowing through the resistor R6 and the potential of the grid g2 will be substantially that of the cathode of the valve V3 whereby the valve V3 is normally controlled by the phase-shifting circuit 14.

The direct current sources DC1 and DC2 include respectively center-tapped secondary windings 46 and 48 of a transformer T8 having its primary winding energized from the busses L1 and L2. The end terminals of the winding 46 are each connected through rectifying means 50, which may be of the dry disk type as is diagrammatically shown, to a common bus 52, connected to one terminal of the secondary winding of a transformer T9. The other terminal of the secondary winding of the transformer T9 is connected to the control grid of the valve V7. The center tap of the winding 46 is connected by a bus 54 to the cathode of the valve V7. The busses 52 and 54 serve as the negative and positive output busses of the source DC1 and normally act to maintain the valve V7 blocked. The primary winding of the transformer T9 is connected across the resistor R3 and its secondary winding is so phased that the potential induced therein upon

6

conduction of the valve V3 will oppose the normal direct current potential of the busses 52 and 54 sufficiently to unblock the valve V7. Therefore unless current is flowing through the resistor R3 showing that both the valves V1 and V3 are conducting, the valve V7 will be held blocked.

Similarly the secondary winding 48 is connected through rectifiers 56 to positive and negative busses 58 and 60 which are connected between the grid and cathode of the valve V8 whereby a blocking bias potential is normally impressed upon the grid of valve V8 with respect to the cathode thereof to maintain the valve blocked. A transformer T10 has its primary winding connected across the resistor R4 and its secondary winding arranged in series in the bus 60. The valve V8 is therefore normally maintained nonconductive being rendered conductive only upon flow of current through the valve V4. As in the case of valve V7, when current is flowing through the resistors R4, a potential is induced by the transformer T10 sufficient to overcome the direct current negative blocking bias and the valve V8 is rendered conductive.

It will be noted that the valves V1 through V8 are of the gas-filled discontinuous control type and whenever in this specification a valve is referred to as being rendered nonconductive due to the bias being applied between the grid cathode thereof, it is to be understood that this does not mean that the valve will cease conducting prior to the end of the half cycle in which the anode is positive with respect to the cathode but it does mean that after it has once ceased conducting due to the change in voltage relation between the anode and cathode that it will no longer again be placed in a conducting condition when the anode is subsequently rendered positive with respect to the cathode.

When it is desired to perform a weld, the work W is placed between the welding electrodes furnished with energy by the welding transformer at which time the electrodes may be pressed against the work by any of the usual means.

To perform a welding operation and as indicated above the switch SW is closed to reduce the direct current blocking bias on the valve V1 sufficiently to permit the transformer T3 to render the valve V1 conductive at the desired point on the positive half cycle. The valve V1 will commence when the line L1 becomes positive with respect to the line L2 and at a point in this voltage wave as determined by the network PS2 and preferably corresponds to the angle of lag of the current with respect to the voltage which flows through the welding circuit including the welding transformer WT. Subsequently except as noted below the valve will conduct in this manner each positive half cycle.

Immediately upon conduction of the valve V1 a potential appears across the resistor R1 which is transmitted by the busses 2 and 30 to the valve V5 and renders the valve V5 nonconductive thus starting the timing out of the network TN1. Conduction of the valve V1 also provides a potential across the anode and cathode of the valve V3 so that when the proper period in the voltage wave occurs as determined by the phase-shifting network PS and which is proportioned to cause the proper value of energy to flow through the welding transformer WT, the grid g1 unblocks the valve V3 causing current to flow through the valve V3 and the resistor R3.

Flow of current through the resistor R3 sets

up a potential thereacross which immediately appears across the transformer T9 which transformer T9 is then operable to render the grid of the valve V1 positive with respect to the cathode thereof and places the valve V1 in a conducting condition. This potential across the resistor R3 also appears across the primary winding of the transformer T5 whereby a transient voltage will appear to oppose that induced in the secondary winding 22 of the transformer T4 whereby the valve V2 will conduct during the negative half cycle following the positive half cycle in which the valve V1 was conductive.

Conduction of the valve V2 causes current to flow therethrough and through the resistor R2. At the proper period on the voltage wave as determined by the phase-shifting network PS, the valve V4 will be rendered conductive whereby current will flow therethrough and set up a potential across the resistor R4 which will appear across the primary winding of the transformer T10 whereby the valve V8 is rendered conductive to supply current to the welding transformer during this subsequent negative half cycle of the voltage wave similarly as valve V1 was rendered conductive. It will now be apparent that alternating current of controlled magnitude will flow through the welding transformer WT. The valves V1, V2, V3, V4, V7, and V8 will continue to be rendered conductive as disclosed until such time as the timing network TN1 times out and renders the valve V6 conductive.

At the end of the weld time interval, the potential across the timing network TN1 will have decreased sufficiently so that the blocking bias will be removed on the grid of the valve V6 and the valve V6 will begin to conduct. Immediately upon conduction of the valve V6 a potential will appear across the resistor R6 whereby the potential of the grid g2 of the valve V3 will be rendered negative with respect to the common bus 2 and the valve V3 will be blocked independently of the grid g1. The valve V3 will continue to be held in blocked condition even though the switch SW may be maintained closed and the valve V1 maintained conductive.

Blocking of the valve V3 will prevent current flow through the resistor R3 so that the valve V7 will not be rendered conductive. Since the trigger or the trailing action of the valve V2 is dependent upon current flow through the resistor R3 no pulse or transient voltage will be applied by the transformer T5 and the valve V2 will not be rendered conductive to place a potential across the valve V4. Therefore, even though the grid of the valve V4 may continue to be placed by the network PS in a condition for rendering the valve V4 conductive, it will not conduct since its anode potential has been discontinued.

As long as the switch SW is maintained closed, the valve V1 will continue to conduct each half cycle setting up a potential across the resistor R1 which potential will be applied between the grid and cathode of the valve V5 maintaining this valve V5 nonconductive. As long as the valve V5 is maintained nonconductive no bias potential will be applied across the cathode and grid of the valve V6 for rendering the valve V6 nonconductive and it will continue to conduct and continue to apply a blocking bias voltage between the grid g2 and the cathode of the valve V3 holding the valve V3 blocked. Unless the valve V3 conducts, none of the valves V2, V4, V7, and V8 will be placed in a conducting condition and

no welding current will flow through the welding transformer.

Upon opening of the switch SW, the valve V1 is blocked due to the direct current bias supplied between the grid and cathode thereof by the supply DC3. The valve V5 will conduct to block the valve V6 and the networks will be in their original condition ready for a subsequent closing of the switch SW to initiate another welding cycle as was just described.

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

1. In an electrical network of the character described for energization from a source of electrical energy, a pair of reversely connected valves electrically connected for controlling the flow of current to a load, a first set of series connected control valves, means adapted to be energized from such source and connected to supply energy to said series connected valves, means normally holding the first of said series connected valves in a nonconducting condition, means for rendering said last-named means ineffective, a second of said control valves connected in series with said first valve, means responsive to a conducting condition of said second control valve for rendering one of said pair of reversely connected valves in a conducting condition, a timing network, means responsive to flow of current through said first control valve and independent of the flow of current through said second valve for initiating operation of said timing network, and means responsive to the timing out of said timing network for rendering said second-named control valve ineffective to conduct current.

2. The combination of claim 1 in which a second set of series arranged valves are provided, means normally maintaining nonconductive the first valve of said second set and operable to be rendered ineffective upon conduction of said first set second valve, means responsive to an operating condition of the second valve of said second set for rendering another of said reversely connected valves conductive.

3. The combination of claim 2 in which means is provided to render said second set second valve conductive at a predetermined selected part of said voltage wave during alternate half cycles thereof.

4. The combination of claim 3 in which a common means is provided for alternately biasing a control grid of each said second valve to a non-blocking condition during successive half cycles of said voltage wave.

5. The combination of claim 4 in which said common means is adjustable to determine the predetermined point in said successive half cycles and in which said predetermined point is located at the same point in alternate half cycles of said voltage wave.

6. In an electrical network of the character described, a controlling network comprising a pair of series-connected valves, a timing network, means for supplying an alternating current energy to one of said pair of valves including a first circuit for said one valve, means responsive to current flow through said first circuit operable to actuate said timing network to establish the initiation of a time interval, conduction of said one valve being operable to provide a source of potential to the second of said series-connected valves, means normally effective to permit conduction of said second valve, and means actuated by said timing network at the expiration of said

time interval for rendering said second valve ineffective to conduct under the influence of said normally effective means.

7. The combination of claim 6 in which said timing network comprises a pair of valves, one of said last-named pair being normally conductive and rendered non-conductive by said first valve of said first-named pair of valves, the other of said last-named pair of valves being normally non-conductive and rendered conductive subsequent to a predetermined time interval subsequent to said second-named pair one valve being rendered conductive, said other valve acting upon conduction to establish a blocking bias potential between a grid and cathode of said second valve.

8. In an electrical network of the character described, a controlling network comprising a pair of valves, a timing network, means for supplying an alternating current energy to one of said pair of valves including a first circuit for said one valve, an impedance element in said first circuit, means responsive to the potential across said element and operable to actuate said timing network to establish the initiation of a time interval, the potential across said element also providing a source of potential to the second of said pair of valves, means normally effective to permit conduction of said second valve, and means actuated by said timing network at the expiration of said time interval for rendering said second valve ineffective to conduct under the influence of said normally effective means.

9. In an electrical network of the character described, a controlling network comprising a pair of series-connected valves, a timing network, means for supplying an alternating current energy to one of said pair of valves including a first circuit for said one valve, an impedance element in said first circuit, means responsive to the potential across said element and operable to actuate said timing network to establish the initiation of a time interval, the potential across said element also providing a source of potential to the second of said pair of valves, means normally effective to permit conduction of said second valve, an impedance element in series circuit with said second valve, a control circuit connected across said second-named element and deriving its potential therefrom, and means actuated by said timing network at the expiration of said time interval for rendering said second valve ineffective to conduct under the influence of said normally effective means.

10. In an electrical network of the character described, a first valve, a first circuit for said valve including a source of alternating potential and an impedance element, said circuit being operable to establish a potential across said element variable in magnitude as a function of the conductivity of said valve, a control circuit energized as a function of the potential established across said element, a second valve, a second circuit for said second valve including a portion of said first circuit and including a second impedance element, said second circuit being operable to establish a potential across said second element variable in magnitude as a function of the conductivity of said second valve, a second control circuit energized as a function of the potential established across said second element, and means actuated by one of said control circuits for rendering one of said valves in a non-conducting condition.

11. The combination of claim 10 in which said

second valve is provided with a control element and said one circuit is said first-named control circuit and is effective to initiate a control sequence operable to place a blocking potential on said second valve control element.

12. The combination of claim 11 in which said control sequence comprises a timing network operable at the expiration of a time interval to initiate said blocking potential.

13. The combination of claim 10 in which said valves are each provided with main electrodes connected in series with each other and with said source, said first-named element being connected in series with said source and solely with the electrodes of one of said valves, said second element being connected in series with the electrodes of the other of said valves, said other valve and said second element being in parallel circuit with said first-named element.

14. In an electrical network of the character described, a first valve, a first circuit for said valve including a source of alternating potential and an impedance element, means normally maintaining said valve in a non-conductive condition and selectively rendered ineffective whereby said valve is rendered conductive, said circuit being operable to establish a potential across said element variable in magnitude as a function of the conductivity of said valve, a control circuit energized as a function of the potential established across said element, a second valve, a second circuit for said second valve including a second impedance element, means operable to initiate conduction of said second valve at a selected portion of the voltage wave, said second circuit being operable to establish a potential across said second element variable in magnitude as a function of the conductivity of said second valve, and a second control circuit energized as a function of the potential established across said second element.

15. In an alternating current control system for a pair of back-to-back connected electric valves, each having a main electrode and a control electrode, and means normally providing a blocking bias potential between the control electrode and the main electrode, a firing network comprising a pair of sources of potential phased oppositely to each other and of the same frequency and phase as that supplied to said valves, a first and second set of two electric valves each having an anode and a cathode and at least one controlling element, said first and second set of valves being respectively connected in series with a respective one of said sources in which the anode of the first valve of each said sets is connected to corresponding first terminals of respective ones of said sources and in which the cathode of the second valves of each said sets is connected to corresponding second terminals of respective ones of said sources, the cathodes of each said first valves of said sets being connected through impedance elements to said corresponding second terminals, the cathodes of each said first valves of said sets being connected through other impedance elements to the anodes of the respective said second valves of said sets, a first means normally providing a blocking bias on a control grid of said first set first valve to render said first set first valve non-conductive, a second means normally providing a blocking bias on a control grid of said second set first valve to render said second set first valve non-conductive, a third means normally providing a conducting bias on one of the control elements of

11

each said second valve, a selectively operable means for rendering said first means ineffective whereby said first set first valve is rendered conductive, a timing network, circuit means controlled by the change in potential across said first set first element for initiating a timing function of said timing network, circuit means controlled by the change in potential across said first set second element for overcoming the effect of the blocking bias potential impressed on the control electrode of one of said back-to-back valves, and further operable to render said second means ineffective to hold said second set first valve non-conductive, circuit means controlled by the change in potential across said second set second element for overcoming the effect of the blocking bias potential impressed on the control electrode of the other of said back-to-back valves, and circuit means energized by said timing network for impressing a blocking bias potential on a second of said first set second valve control elements.

16. In an electrical network of the character described for energization from a source of electrical energy; an electric valve connected for controlling flow of current to a load, a pair of series connected control valves, means adapted to be energized from such source and connected to supply energy to said series connected valves, means controlling the flow of energy through the first of said series connected valves, means controlling flow of energy through the second of said series connected valves, a timing network, means responsive to a change in the flow of energy through one of said valves and independent of the condition of the other of said series connected valves for initiating a timing out operation of said network, and means responsive to said timing out operation for controlling said other valve.

17. The combination of claim 16 in which said timing out operation acts to render said other valve nonconductive.

18. In an electrical network of the character described for energization from a source of alternating potential electrical energy, a pair of series connected control valves, means adapted to be energized from said source and connected to energize said series connected valves, a first means normally rendering a first of said valves in a first condition, a second means for rendering said first means ineffective and for rendering said first valve in a second condition, means effective at a predetermined time in the cycle of such potential for rendering the second of said valves in a first condition and timing means actuated as a consequence of said first valve being rendered in said second condition for rendering said second valve in a second condition subsequent to a predetermined time interval after said first valve was rendered in said second condition.

19. In an electrical network of the character described for energization from a source of alter-

12

nating electrical energy, two pairs of series connected valves, means connecting a first of said pairs for conducting during a first half cycle of such energy, means connecting a second of said pairs for conducting during an opposite half cycle of such energy, means normally rendering each of a first of said pairs of valves in a non-conductive condition, means effective at a desired instant in said first half cycle for rendering the second valve of said first set conductive and effective at a desired instant in said opposite half cycle for rendering the second valve of said second set conductive, means operable to render said first set first valve in a conductive condition to provide potential for said first set second valve, means operable as a consequence of the conduction of said first set second valve for rendering said second set first valve conductive, timing means, means responsive to the conduction of said first set first valve for initiating a timing out function of said timing means, and means actuating a consequence of said timing means timing out for rendering said first set second valve nonconductive.

20. The combination of claim 19 in which means is provided for controlling the flow of electrical energy to a load, and in which said load controlling means is actuated as a consequence of conduction of said second valves.

21. In an electrical network of the character described for energization from a source of electrical energy, a current controlling device electrically connected for controlling the flow of current to a load, a first set of series connected control valves, means adapted to be energized from such source and connected to supply energy to said series connected valves, means normally holding the first of said series connected valves in a nonconductive condition, means for rendering said last-named means ineffective, means responsive to a conducting condition of a second of said series connected controlled valves for rendering said device in a condition to supply current to such load, a timing network, means responsive to a current conducting condition of said first valve and independent of the flow of current through said second valve for initiating operation of said timing network, and means responsive to the timing out of said timing network for rendering said second valve ineffective to maintain said device in a current conducting condition.

GUSTAV E. UNDY.

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