March 17, 1936. M. HÜRLIMANN 2,034,676

ELECTRIC VALVE CONTROL SYSTEM

Filed April 4, 1934 2 Sheets-Sheet 1

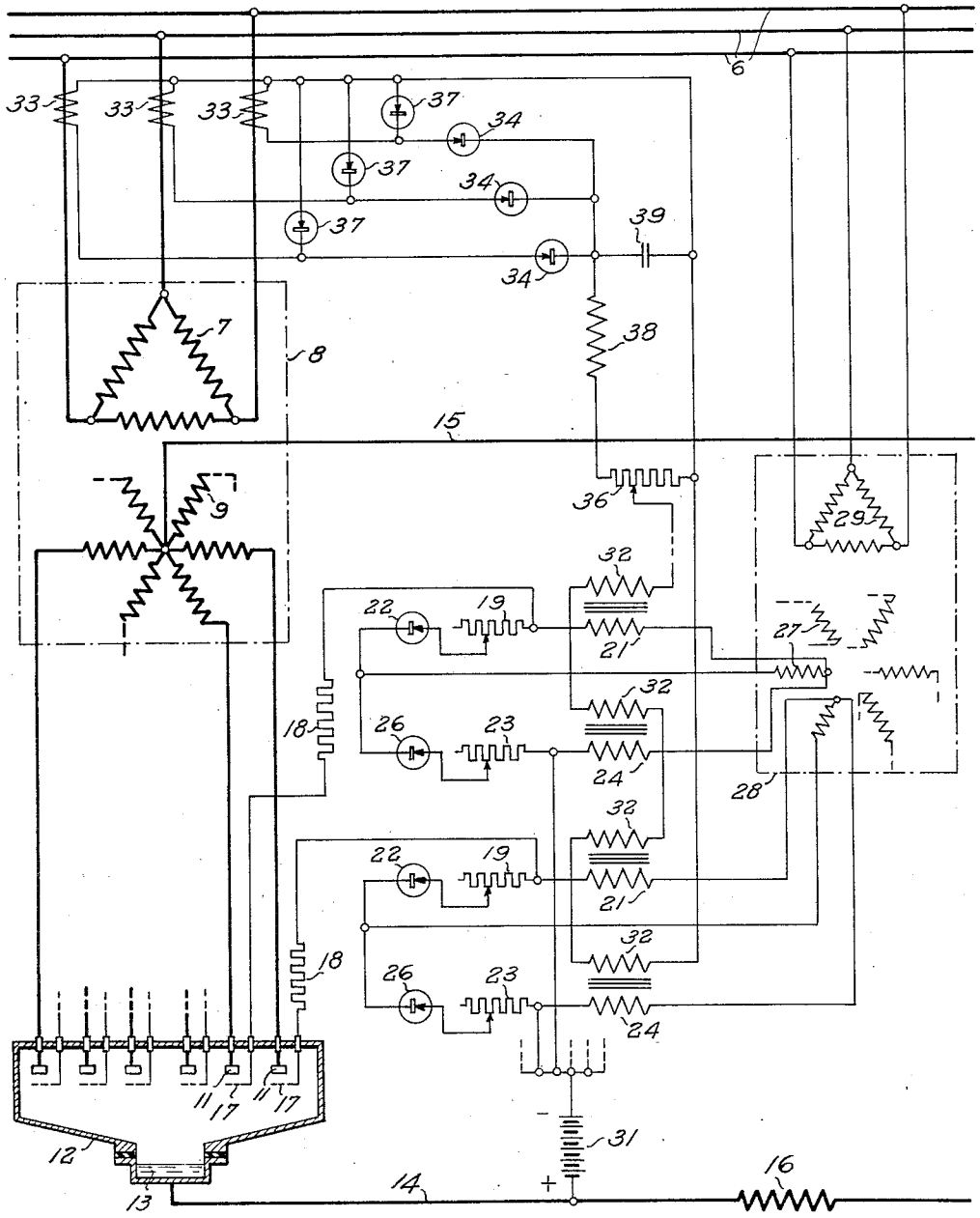


Fig. 1

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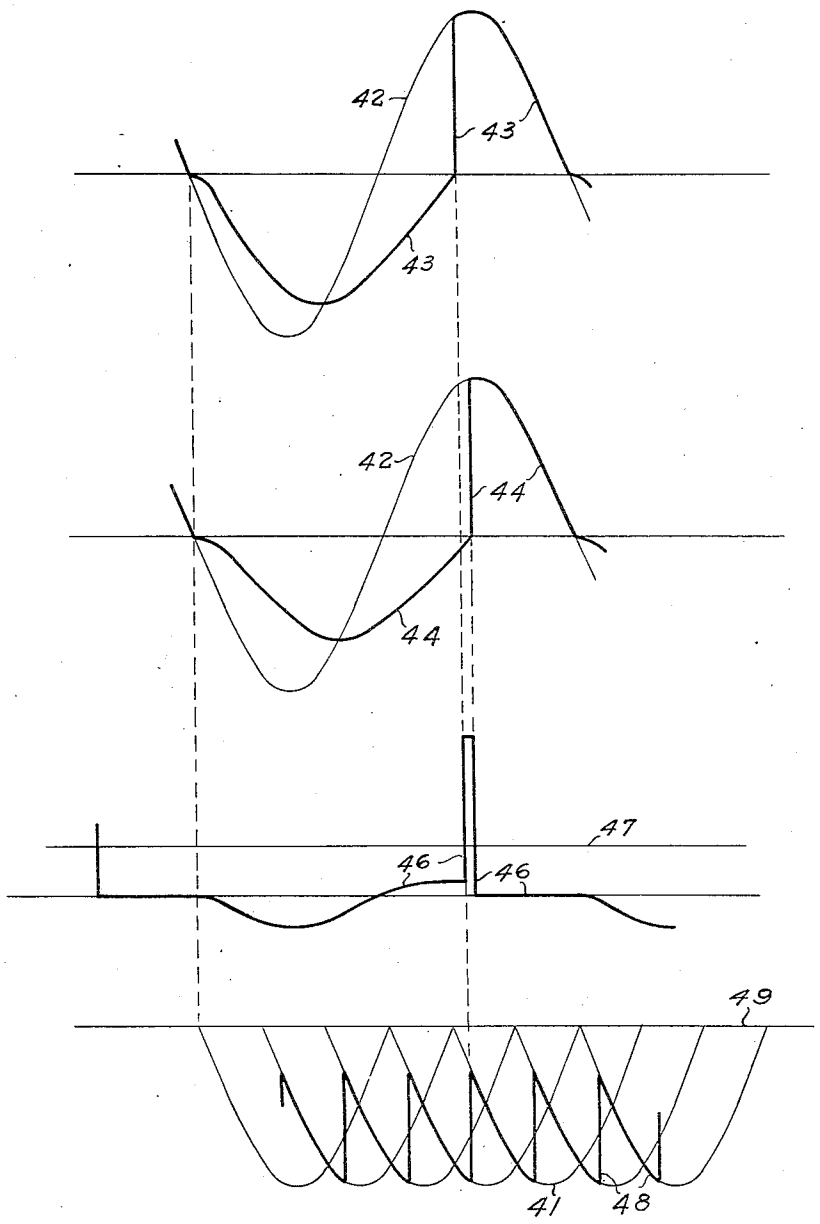


Fig. 2

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ELECTRIC VALVE CONTROL SYSTEM

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12 Claims. (Cl. 175—363)

This invention relates in general to improvements in electric valve control systems and more particularly to means for impressing substantially rectangular positive voltage impulses of short duration on the control electrodes of a valve.

Electric valves are frequently associated with inductive windings and suitable circuits therebetween to constitute different current converting systems such as alternating current rectifying, direct current inverting, frequency converting and other types of current converting systems. In such instances, it is frequently desirable that the control electrodes receive voltages which are negative relative to the cathode during comparatively long intervals, and recurringly receive positive voltage impulses of comparatively short duration compared to the duration of the cycle of the corresponding anode voltage. More particularly, in direct current inverting systems, each anode is positive with respect to the associated cathode during substantially the entire idling period of the anode, so that the periods of positive energization of each control electrode must be comparatively short to avoid undesired release of the flow of current during the idling period of the associated anode. Such result is not easily obtainable when sinusoidal voltages are impressed on the control electrodes and it is, therefore, preferable to impress, on the control electrode, a voltage wave having vertical front and back portions. Such a voltage impulse may be obtained by use of static means comprising reactors and auxiliary valves supplied with alternating current in relation with the voltage cycle of the anodes.

It is, therefore, one of the objects of the present invention to provide a control system for an electric valve in which the control electrodes of the valve are positively energized during intervals of short duration relative to the cycle of the anode voltage.

Another object of the present invention is to provide a control system for an electric valve in which the control electrodes of the valve are positively energized during intervals of shorter duration than the periods of current flow through the associated anodes.

Another object of the present invention is to provide a control system for an electric valve in which the control electrodes of the valve receive voltages of substantially rectangular wave form.

Another object of the present invention is to provide a control system for an electric valve in which the control electrodes of the valve receive voltages of wave form having vertical front and back portions.

Another object of the present invention is to provide a control system for an electric valve in which the control electrodes of the valve receive voltages from control circuits associated in pairs and including auxiliary valves.

Objects and advantages other than those above described will be apparent from the following description when read in connection with the accompanying drawings, in which:

Fig. 1 diagrammatically illustrates one embodiment of the present invention applied to the control of an electric valve operable for rectifying alternating current or inverting direct current; and

Fig. 2 is a diagram of some of the voltages present in the circuits of the embodiment illustrated in Fig. 1.

Referring more particularly to the drawings by characters of reference, reference numeral 6 designates an alternating current line of any suitable number of phases herein represented as a three-phase line. Line 6 is assumed to be connected with current consuming devices effective to determine the wave shape and frequency of the voltage thereof to permit operation of inverting systems connected therewith as is well known in the art. Line 6 is connected with a first winding 7 of a transformer 8 having a second winding 9 comprising a plurality of phase displaced portions connected to form a neutral point or in any other suitable manner. The different portions of winding 9 are severally connected with the anodes 11 of an electric valve 12 of any suitable type herein represented as a valve of the vapor type having a cathode 13. The conductors 14 and 15 of a direct current line are connected with cathode 13 and with the neutral point of winding 9 respectively, conductor 15 being positively energized from suitable direct current sources (not shown) connected with the line when energy is to be transmitted from line 14, 15 to line 6, and conductor 14 being positive when energy is to be transmitted from line 6 to line 14, 15.

The flow of current through the different anodes 11 is controlled by a plurality of control electrodes 17 each connected with cathode 13 through a circuit including the usual current limiting resistor 18, each control electrode circuit being further connected across a portion of a different pair of a plurality of control circuits. One circuit of each pair of control circuits in-

cludes a resistor 19, a reactor 21 and a valve 22 and the second circuit of each pair similarly comprises a resistor 23, a reactor 24 and a valve 26. Each such circuit receives a voltage from a portion of the secondary winding 27 of a transformer 28 energized from line 6. In the present embodiment both circuits of each pair have been shown connected with a common portion of winding 27 but it will be understood that the two circuits of each pair may be severally connected with separate portions of winding 27 energizing such circuits at identical voltages or at voltages differing in magnitude or in phase or in both magnitude and phase. Each resistor 18 is preferably connected with the connection between the associated resistor 19 and reactor 21, the circuit being completed by connecting cathode 13 with the connection between each resistor 23 and the associated reactor 24. Each control electrode circuit is, therefore, connected across the associated resistors 19 and 23 and valves 22 and 26, but each circuit may also be connected across valves 22 and 26 only. If so desired, the control electrode circuits may include a common source of negative voltage such as a battery 31 which is, in general, necessary when control electrodes 17 are of such construction as to prevent the flow of current through anodes 11 only when the control electrodes are maintained at a substantially negative voltage.

When the voltages received by the two circuits of each pair of control circuits are identical, the circuits are so adjusted that the flow of current occurs therethrough at different power factors, such adjustment being obtained by suitable adjustment of resistors 19 and 23 and of reactors 21 and 24 (as will be explained hereinafter or by other known means) which may have different values of inductance. Each reactor may be provided with a saturating winding 32 and the different windings may be serially connected to receive current from a source of direct current. In the present embodiment, windings 32 receive current from current transformers 33 inserted in the connection between line 6 and winding 7, such current being rectified by suitable rectifying devices 34 and being supplied to the coils 32 through a voltage divider 36 or other suitable adjusting device. Further rectifying devices 37 provide a path for the current half-waves not utilized, to thereby obviate the occurrence of excessive voltages in the windings of current transformers 33. Suitable wave smoothing means may be provided such as a reactor 38 and a capacitor 39 to maintain the flow of current through coils 32 substantially uniform.

The operation of the above described system will be understood from a consideration of Fig. 2 in which curve 41 represents the voltage impressed on one of the anodes 11 by the associated portion of winding 9 with respect to the potential of conductor 15 represented by line 49. The voltage of the corresponding portion of winding 27 is then represented by a curve 42 having a suitable phase relation with the voltage of the anode, such relation being obtained by suitable connection and construction of transformer 28. As a result of the connection of the outside terminal of such portion of winding 27 with the cathode of valve 22, the flow of current through the circuit of such valve occurs mainly during the negative period of curve 42. Such flow of current continues during part of the succeeding positive period of curve 42 as a result of the action of reactor 21. During such flow of current the voltage across resistor 19 and valve 22 is proportional to the magntiude of the current whereas during the remainder of the cycle the circuit is without current and such voltage is equal to the voltage represented by curve 42. The voltage across resistor 19 and valve 22 thus found is represented in Fig. 2 by curve 43. The voltage across resistor 23 and reactor 26 may be determined by a similar reasoning and is represented by curve 44 differing from curve 43 in the magnitude of the ordinates of the negative portion thereof and in the point of transition between such negative portion and the following positive portion. The voltage impressed by winding 27 on control electrode 11 through the associated pair of circuits is equal to the difference between the voltage across resistor 19 and valve 22 and the voltage across resistor 23 and valve 26. Such difference is determined by subtracting the ordinates of curve 44 from the ordinates of curve 43 to thereby obtain curve 46, such curve being read with respect to a line 47 representing the voltage of battery 31. Curve 46 accordingly presents a positive portion of substantially rectangular wave form having vertical front and back portions.

Upon positive energization of the control electrode, the flow of current through the associated anode is released to transmit energy from line 14, 15 to line 6 at a voltage momentarily represented by curve 41. Such sequence of operation is repeated successively for the several anodes of valve 12 to cause a continuous transfer of energy from line 14, 15 to line 6, the voltages of line 6 during such transfer being represented by curves similar to curve 41 and the voltage of line 14, 15 being represented by curve 48. During such operation, each anode is maintained by the associated portion of winding 9 at a voltage which is materially positive with respect to the voltage of cathode 13 during the entire inoperative period of the anode except a portion of the conductive period of the following anode. The flow of current must therefor be prevented by the action of the control electrode during substantially the entire inoperative period of the anode and the control electrode must therefore be positive during a period of time materially shorter than the conductive period of the associated anode to avoid faulty operation of the valve. By suitable adjustment of resistors 19 and 23 and suitable construction of reactors 21 and 24, the flow of current through valves 22 and 26 may be caused to cease at points of the voltage cycle in close succession to thereby obtain a positive energization of the control electrodes of arbitrarily short duration.

The flow of current from winding 7 to line 6 causes the flow of corresponding currents through the secondary windings of current transformer 33, such currents being rectified and supplied to windings 32 through devices 34. When the flow of current through valve 12 increases, the output voltage of the system decreases as a result of the occurrence through the system of resistive and inductive voltage drops. Such current increase also results in an increase in the flow of current through windings 32, thereby increasing the degree of saturation of the cores of reactors 21 and 24. The inductances of such reactors therefore decrease and the flow of current through valves 22 and 26 ceases at an earlier instant of the voltage cycle. The control electrode voltage wave represented by the positive portion of curve 46 is thereby advanced in the cycle, thereby advancing the release of the flow

of current through the corresponding anode and causing the output voltage of the system to increase. Voltage divider 36 may be adjusted in such a manner that the increase of voltage resulting from the variation of the flow of current through coils 32 exactly compensates the decrease in the output voltage of the system to thereby maintain such output voltage at a constant value. Voltage divider 36 may also be adjusted to cause the output voltage of the system to follow any other desired characteristic.

If the control electrode circuits are connected across valves 22 and 26 to the exclusion of resistors 19 and 23, the curves of the voltages across each valve differ from curves 43 and 44 by the absence of negative portions, presenting portions of zero ordinate over the negative intervals of such curves. Curve 46 then presents only the rectangular wave portion which may be utilized to control the operation of valve 12 in the manner described above. The operation of the control circuits remains substantially as above described when the system is utilized for rectifying alternating current received from line 6 and supplying the rectified current to line 14, 15, the voltage impulses being impressed on the control electrodes at suitable moments in the voltage cycle of line 6, by suitably rearranging the connections of transformer 28. The application of the control circuits to the control of other systems operable to perform other converting operations will readily be deduced from the above description by one skilled in the art.

In a system such as above described, winding 9 and valve 12 constitute part of an electric translation means connected with line 14, 15 operable, in the embodiment illustrated, as a supply line and with line 6 operable as an output line. The connection of each control electrode 17 with cathode 13 constitutes a load circuit receiving, from battery 31, a voltage of sign and magnitude effective to prevent the flow of current between the corresponding anode 11 and cathode 13. Resistors 19 and 23 and valves 22 and 26 constitute static means connecting such load circuit with transformer 28 from which such circuit recurringly receives voltage impulses of substantially rectangular wave form having vertical front and back portions and of shorter duration than the period of current flow through the associated anode to overcome the action of the voltage of battery 31. Such means are included in pairs of circuits each comprising a circuit including a resistor 19, a reactor 21 and a valve 22 and another circuit including a resistor 23, a reactor 24 and a valve 26, each circuit receiving, from transformer 28, a voltage similar to a voltage of winding 9. The inductances of reactors 21 and 24 are simultaneously varied to vary the impedances of the circuits thereof to thereby vary the times of occurrence of the control electrode voltage impulses relative to the voltage cycle of transformer 28. Such result is obtained by means of current transformers 33, rectifying devices 34 and saturating windings 32 operating in response to an operating condition of the system which is the magnitude of the current flow through valve 12 to cause the flow of current supplied to line 6 to occur at predetermined voltages.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

1. In a system for generating a variable voltage, a source of alternating current, means including an electric valve and resistance and inductance means connected with said source; means including a second electric valve and resistance and inductance means connected with said source, and a load circuit connected across a portion of the first said means and a portion of the second said means whereby said load circuit receives a periodic positive voltage impulse of substantially rectangular wave form from said source.

2. In a system for generating a variable voltage, a source of alternating current, a pair of circuits connected with said source and each including a reactor and a resistor and an electric valve, and a load circuit connected across portions of said circuits including said valves to thereby receive a periodic positive voltage impulse of substantially rectangular wave form from said source.

3. In a system for generating a variable voltage, a source of alternating current, a pair of circuits of different impedance values connected with said source and each including a reactor and a resistor and an electric valve, and a load circuit connected across portions of said circuits including said valves to thereby receive a periodic positive voltage impulse of substantially rectangular wave form from said source.

4. In a system for generating a variable voltage, a source of alternating current, a pair of circuits of different impedance values connected with said source and each including a reactor and a resistor and an electric valve, a load circuit connected across portions of said circuits including said valves to thereby receive a periodic positive voltage impulse of substantially rectangular wave form from said source, and means for varying the times of occurrence of said voltage impulses with respect to the voltage cycle of said source.

5. In a system for generating a variable voltage, a source of alternating current, a pair of circuits of different impedance values connected with said source and each including a reactor and a resistor and an electric valve, a load circuit connected across portions of said circuits including said valves to thereby receive a periodic positive voltage impulse of substantially rectangular wave form from said source, and means for varying the values of the impedances of said circuits.

6. In a system for generating a variable voltage, a source of alternating current, a pair of circuits of different impedance values connected with said source and each including a reactor and a resistor and an electric valve, a load circuit connected across portions of said circuits including said valves to thereby receive a periodic positive voltage impulse of substantially rectangular wave form from said source, and means for simultaneously varying the values of the impedances of said circuits.

7. In a system for generating a variable voltage, a source of alternating current, a pair of circuits of different impedance values connected with said source and each including a reactor and a resistor and an electric valve, a load circuit connected across portions of said circuits including said valves to thereby receive a periodic positive voltage impulse of substantially rectangu-

lar form from said source, and means for simultaneously varying the effects of said reactors.

8. In a system for controlling the flow of electric current, an electric current supply line, electric translation means connected with said line and including an alternating current winding and an electric valve having an anode with an associated control electrode and a cathode, an electric current output line connected with said translation means, a pair of circuits each connected to receive a voltage similar to a voltage of said winding and each including a reactor and a resistor and an electric valve, and means for connecting said control electrode with said cathode through portions of said circuits including the valves thereof.

9. In a system for controlling the flow of electric current, an electric current supply line, electric translation means connected with said line and including an alternating current winding and an electric valve having an anode with an associated control electrode and a cathode, an electric current output line connected with said translation means, static means for impressing periodic positive voltage impulses of substantially rectangular wave form between said cathode and said control electrode and of shorter duration than the periods of current flow through said anode, and means responsive to an operating condition of said system for varying the times of occurrence of said voltage impulses with respect to the voltage cycle of said winding.

10. In a system for controlling the flow of electric current, an electric current supply line, electric translation means connected with said line and including an alternating current winding and an electric valve having an anode with an associated control electrode and a cathode, an electric current output line connected with said translation means, a pair of circuits each connected to receive a voltage similar to a voltage of said winding and each including a reactor and a resistor and an electric valve, means for connecting said control electrode with said cathode through portions of said circuits including said valve, and means responsive to the magnitude of the flow of current through said valve for varying the values of the impedances of said circuits.

11. In a system for controlling the flow of electric current, an electric current supply line, electric translation means connected with said line and including an alternating current winding and an electric valve having an anode with an associated control electrode and a cathode, an electric current output line connected with said translation means, a pair of circuits each connected to receive a voltage similar to a voltage of said winding and each including a reactor and a resistor and an electric valve, means for connecting said control electrode with said cathode through portions of said circuits including said valve, and means for varying the inductances of said reactors and effective to cause the flow of current through said output line to occur at predetermined voltages.

12. In a system for controlling the flow of electric current, an electric current supply line, electric translation means connected with said line and including an alternating current winding and an electric valve having a plurality of anodes with associated control electrodes and a cathode, an electric current output line connected with said translation means, a plurality of pairs of circuits each connected to receive a voltage similar to a voltage of said winding and each including a reactor and a resistor and a valve, a source of negative voltage connected with said cathode, and means for connecting each said control electrode with said source through portions of one of said pairs of circuits including the valves thereof.

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