May 25, 1948. J. L. BOYER ET AL 2,441,987

EXCITATION SYSTEM FOR VAPOR ELECTRIC VALVES

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Fig. 1.

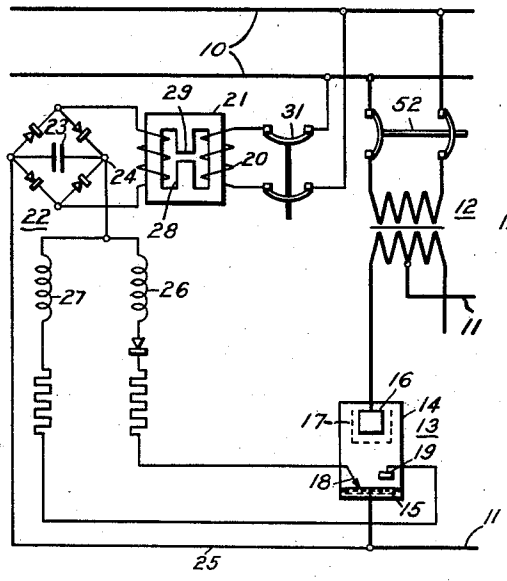


Fig. 2.

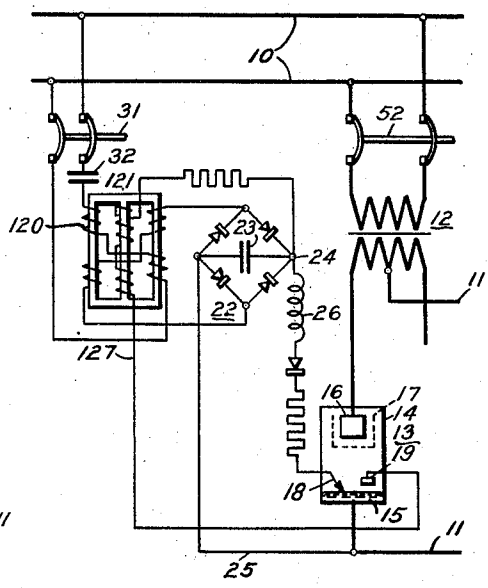


Fig. 3.

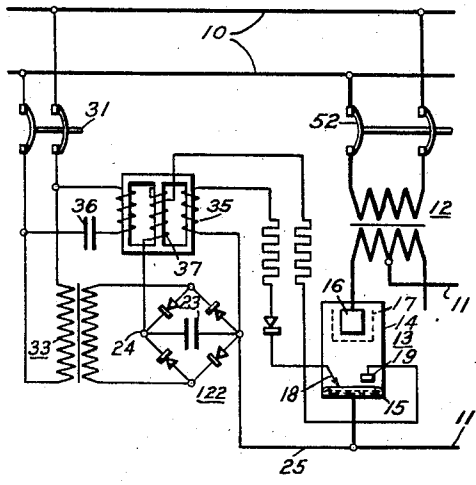


Fig. 4.

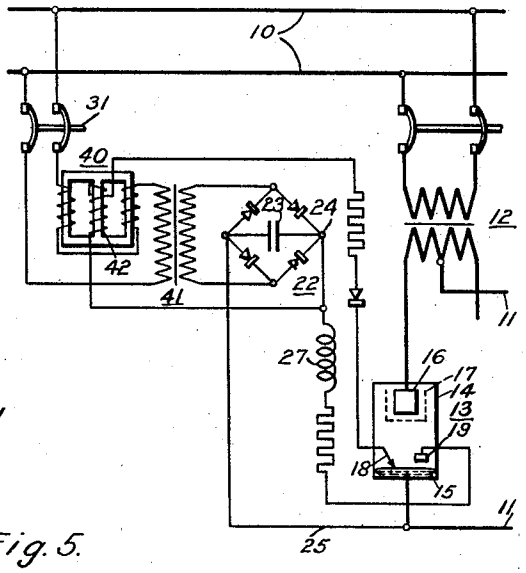
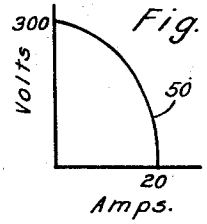


Fig. 5.



WITNESSES:
Helen Gumm
Wm. C. Groome

INVENTORS
John L. Boyer &
Herbert A. Rose.
BY
S. A. Stickle
ATTORNEY

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Fig. 6.

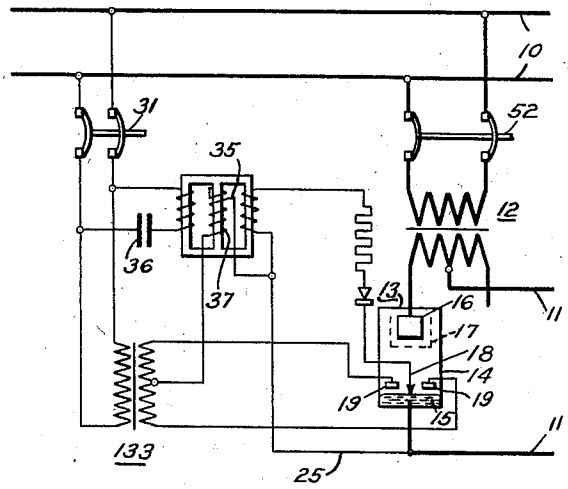
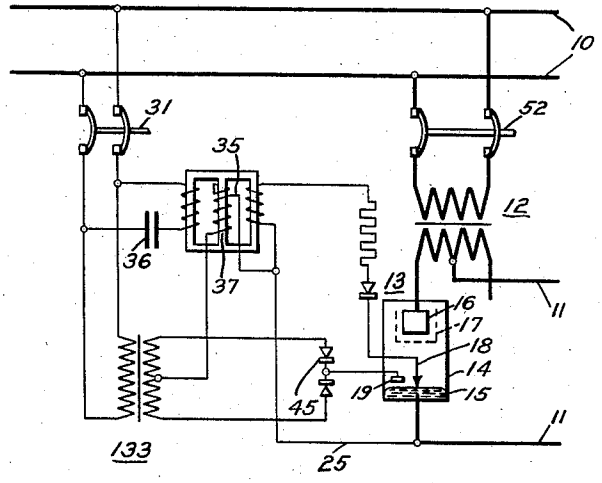


Fig. 7.



WITNESSES:

Helen Gumm

Wm. C. Grouse

INVENTORS

John L. Boyer &

Herbert A. Rose.

BY

S. A. Strickland

ATTORNEY

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EXCITATION SYSTEM FOR VAPOR ELECTRIC VALVES

John L. Boyer, Wilkinsburg, and Herbert A. Rose, Pittsburgh, Pa., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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Our invention relates to a vapor electric converter, and particularly to an excitation system for a vapor electric device, such as a vapor electric valve.

In the operation of vapor electric devices it has long been customary to provide a continuous source of excitation to maintain a cathode spot for the establishment of the main arc in the valve. Heretofore, considerable difficulty has been met in establishing and maintaining such excitation arcs.

It has heretofore been considered desirable to provide mechanical means for starting and restarting the cathode spot for the excitation arcs. According to our invention, the starting and maintaining of an excitation arc is accomplished by means of static equipment which is automatically operative without any mechanical wear or adjustment.

In the excitation system according to our invention, the vapor electric device is provided with two excitation electrodes, one in the form of a make-alive or high resistance type electrode associated and usually in permanent contact with the cathode and the other a main excitation or keep-alive electrode in spaced insulated relation to the cathode.

A source of alternating current excitation potential is provided and from this is derived an excitation potential having a high regulation characteristic. This excitation potential is applied to both the make-alive and keep-alive electrodes and means responsive to the flow of current to the electrodes is provided for controlling the regulation characteristic so that when no current is flowing to the excitation electrodes, the excitation potential will have sufficient value to initiate a cathode spot through the make-alive electrode and after current has started to flow, the excitation potential will be reduced to a value just sufficient to maintain the excitation arc and certainly below a potential which will operate the make-alive electrode.

It is, accordingly, an object of our invention to provide an excitation system having an excitation voltage with a high regulation characteristic.

It is a further object of our invention to provide a static excitation system having a high order of dependability.

It is a further object of our invention to provide a simple and efficient excitation system for a vapor electric valve.

It is a further object of our invention to provide an excitation system having a make-alive

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and a keep-alive electrode energized from the same potential source.

It is a further object of our invention to provide an excitation system having an automatic regulation characteristic.

It is a further object of our invention to provide an excitation system which has an automatic restart in the event of failure of the excitation arc.

Other objects and advantages of our invention will be apparent from the following detailed description taken in conjunction with the accompanying drawing, in which:

Figure 1 is a diagrammatic illustration of a simplified embodiment of our invention,

Fig. 2 is a modification according to our invention,

Fig. 3 is a further modification showing means for conserving space for a plurality of excitation circuits,

Fig. 4 is a further modification according to our invention,

Fig. 5 is a graphical illustration of the preferred regulating characteristic according to our invention,

Fig. 6 is a further modification utilizing alternating current keep-alive arcs, and

Fig. 7 is a further modification utilizing unidirectional keep-alive potential.

In the simplified embodiment of our invention, as shown in Fig. 1, an alternating-current circuit 10 is connected to a direct-current circuit 11 by means of a rectifier transformer 12 which is preferably connected to the alternating-current circuit by means of a circuit breaker 52 and having the phase terminals of the transformer connected to vapor electric valves 13 only one of which is shown for simplicity of illustration.

Each of the valves 13 comprises a container 14 in which is a vaporizable reconstructing cathode 15 of suitable material such as mercury, and spaced from and insulated from the cathode 15 is an anode 16 which may, or may not, be provided with a control shield or grid 17. A make-alive electrode 18 usually in the form of a high resistance material is placed in contact with the cathode 15 and spaced from the cathode and insulated therefrom is an excitation anode or keep-alive electrode 19.

Excitation potential derived from any suitable alternating current source herein shown as the alternating-current circuit 10 is connected to the excitation circuit by means of a circuit breaker 31. The alternating-current potential is applied to the primary winding 20 of an excitation trans-

former 21 and the output potential of the transformer 21 is rectified by means of a full-wave rectifier 22 usually of the dry plate type. A capacitor 23 is usually connected across the terminal of the rectifier 22 and serves the dual purpose of smoothing the rectified potential and furnishing a source of stored energy for initiating the cathode spot.

The make-alive electrode 18 and the keep-alive electrode 19 are connected in parallel to the positive terminal 24 of the direct current, both being connected across the rectified potential by means of a return connection 25 from the cathode 15 of the vapor electric device to the negative terminal of the rectifier. To facilitate the initiation of the cathode spot, a saturable reactor 26 is connected in series with the make-alive electrode 18 while it is desirable to place an impedance 27 usually in the form of a linear reactor in series with the keep-alive electrode 19.

In order to provide a high regulation characteristic for the excitation potential, the excitation transformer 21 is provided with a magnetic bridge herein illustrated as a third leg 28 of the transformer 21, said third leg 28 having an air gap 29 therein.

In the operation of this simplified form of our invention, the output potential of the transformer 21 will be rectified and charge up the capacitor 23 across the terminals of the rectifier 22. When this potential reaches sufficient value, the saturable reactor 26 will saturate permitting a sudden flow of current to the make-alive electrode 18. This flow of current will establish a cathode spot on cathode 15 after which an arc will establish to the keep-alive electrode 19.

The flow of current through the secondary winding of the excitation transformer 21 shifts the flux to the magnetic bridge 28, and thus materially reduces the secondary potential of the excitation transformer 21. The potential is then below the value which will produce saturation of the saturable reactor 26, so that current will flow substantially only to the keep-alive electrode 19. However, in the event of cessation of current flow to the excitation electrodes, the magnetic current will again flow through the secondary winding of the transformer 21 and reestablish the potential sufficient to reinitiate the cathode spot, thus automatically maintaining excitation in the event that the excitation arc should be extinguished for any reason.

In the modification according to Fig. 2, the excitation transformer 121 is of the three-legged variety with the primary and secondary windings being distributed over two of the legs while the third leg is interlinked with the connection 127 to the keep-alive electrode 19. An impedance preferably 32 in the form of a capacitor is connected in series between the source and the primary winding of the transformer 121.

In the operation of this form of our invention, the application of potential to the primary winding 120 will produce a high potential which is rectified and applied to the excitation electrodes 18 and 19 in the manner as hereinbefore described. However, the flow of current to the keep-alive electrode 18 will change the magnetization characteristic of the transformer 121 and producing high voltage drop across the series impedance 32 and thus materially reduce the terminal voltage of the excitation transformer 121. The magnetic interlinkage 127 between the transformer 121 and the connection to the keep-alive electrode 19 substantially replaces the stabilizing impedance 27, as shown in connection with Fig. 1.

The modification of our invention, according to Fig. 3, is particularly designed to save space requirements of the excitation system. A direct-current excitation potential of the right value for controlling the keep-alive electrode 19 is provided, and this source may be connected to a plurality of keep-alive electrodes 19. While this direct-current potential may be acquired from any source, we have shown it as being derived from the alternating-current source by means of a suitable transformer 33 and a full-wave rectifier 122. Separate transformers 35 are then provided for each of the make-alive electrodes 18. The primary winding of the make-alive transformer 35 has connected in series therewith a suitable impedance 36, preferably in the form of a capacitor, while the secondary potential is directly connected across the make-alive electrode 18 and the cathode 15 of the device.

In the operation of this form of the device, the direct-current potential will be applied to the keep-alive electrode 19 and if no current is flowing thereto, the secondary or output potential of the make-alive transformer 35 will apply a high potential to the make-alive electrode 18. However, as soon as current flows to the keep-alive electrode, the winding 37 connected in series between the direct-current source 122 and the keep-alive electrode 18 will modify the impedance of the transformer 35 so that the major portion of the primary voltage will appear across the series connected impedance 36, thus reducing the make-alive potential to a value insufficient to supply current through the make-alive electrode 18.

In the modification, according to Fig. 4, the regulation characteristic of the excitation potential is controlled by means of a variable reactor 40 connected in series with the excitation transformer 41. When no current is flowing to the excitation electrodes, the potential will operate to produce a current to the make-alive electrode 18 which current is interlinked by means of winding 42 with the variable reactor 40 to produce saturation of the reactor 40 and a consequent high potential applied to the transformer 41. However, once the cathode spot has been established, the current will flow through the keep-alive electrode 19, thus reducing the flow of current through the make-alive electrode 18 and desaturating the reactor 40 which then absorbs the major portion of the available potential and thus reduces the output potential of the excitation transformer 41 to a value insufficient to produce current flow through the make-alive electrode 18.

While the regulation characteristic obviously will be variable with various types of make-alive electrodes 18, we have found that it is desirable to have a regulation characteristic 50 substantially as graphically illustrated in Fig. 5, in which the no-load terminal potential of the excitation transformer is of the order of 300 volts and having a rapidly drooping characteristic to zero potential at a current of the order of 20 amperes.

Instead of utilizing a direct-current keep-alive arc as shown in Fig. 3 it is sometimes desirable to utilize an alternating current keep-alive arc in which case two keep-alive electrodes 19 are provided as shown in Fig. 6 and supplied with current of the desired potential by a transformer 133 the winding 37 in the return circuit 25 then serves the dual purpose of controlling the potential of transformer 35 and as a stabilizing

reactor to maintain the keep-alive arc through current zero.

Where it is desired to avoid the necessity for two entrance bushings one of the exciting electrodes 19 may be eliminated, as shown in Fig. 7, by utilizing two half wave rectifiers 45 connected between the secondary terminals of transformer 133 and the exciting electrode 19. Care must be exercised to provide the winding 37 with sufficient energy storage capacity to maintain the arc through potential zero.

For purposes of illustration, we have shown and described specific modifications of our invention. It will be apparent that changes and modifications can be made therein without departing from the spirit of our invention.

We claim as our invention:

1. An excitation system for an arc discharge device having at least a main anode and cathode, comprising a make-alive electrode and a keep-alive electrode cooperating with said cathode, a source of alternating control potential, a transformer energized from said source, an impedance connected in series with the input of said transformer, means for rectifying the output of said transformer, connections for impressing said rectified output on said make-alive and keep-alive electrodes in parallel, and means responsive to flow of current to said keep-alive electrode for modifying the potential appearing across said impedance.

2. An excitation system for an arc discharge device having at least a main anode and cathode, comprising a make-alive electrode and a keep-alive electrode cooperating with said cathode, a source of alternating control potential, a transformer energized from said source, a capacitor connected in series with the input of said transformer, means for rectifying the output of said transformer, connections for impressing said rectified output on said make-alive and keep-alive electrodes in parallel, and means responsive to flow of current to said keep-alive electrode for modifying the potential appearing across said capacitor.

3. An excitation system for a vapor electric device having a main anode and a vaporizable cathode comprising a make-alive electrode and a keep-alive electrode in said device, a source of alternating control potential, a transformer energized from said source, a variable reactor connected between said source and the input of said transformer, a full-wave rectifier for rectifying the output of said transformer, connections for impressing the output of said rectifier on said make-alive electrode and said keep-alive electrode in parallel, and winding means in series with said keep-alive electrode for varying the reactance of said variable reactor.

4. An excitation system for a vapor electric valve having a vaporizable cathode comprising a make-alive electrode in contact with the cathode, a keep-alive electrode in spaced insulated relation to the cathode, a source of alternating excitation potential, transformer means energized from said source, means for rectifying the output potential of said transformer means, connections for impressing the rectified output of said transformer on both said make-alive electrode and said keep-alive electrode, and means responsive to current flow to said keep-alive electrode for reducing the output potential of said transformer.

5. An excitation system for a vapor electric valve having a vaporizable cathode comprising

a make-alive electrode in contact with the cathode, a keep-alive electrode in spaced insulated relation to the cathode, a source of alternating excitation potential, transformer means energized from said source, means for rectifying the output potential of said transformer means, a capacitor connected across the rectified potential of said transformer, connections for connecting said make-alive electrode and said keep-alive electrode in parallel across said rectified potential, a saturable impedance in series with said make-alive electrode, and means responsive to current flow to said keep-alive electrode to reduce the rectified potential to a value insufficient to produce saturation of said saturable impedance.

6. A exciting system for a vapor electric device having at least a main anode and a vaporizable cathode comprising a resistance type electrode associated with the cathode, a keep-alive electrode spaced from said cathode, a source of alternating exciting potential, a source of direct-current exciting potential, connections for impressing the potential of said direct-current source on said keep-alive electrode, a transformer energized from said source of alternating potential, connections for impressing the output of said transformer on said make-alive electrode and winding means associated with said transformer and connected in series with said keep-alive electrode for controlling the output potential of said transformer.

7. An excitation system for a vapor electric device comprising a make-alive electrode for initiating a cathode spot in the device, a keep-alive electrode for maintaining the cathode spot, a source of alternating excitation potential, transformer means connected between said source and said electrodes, said transformer means having a high no-load output potential and a relatively low output potential under load conditions.

8. An exciting system for a vapor-electric valve comprising a make-alive electrode in said valve, a keep-alive electrode, a source of alternating control potential, means for energizing both said electrodes from said source, and means controlled by current flow to said electrodes for producing a high regulation characteristic to said control potential.

9. An exciting system for a vapor-electric valve having a vaporizable cathode comprising a make-alive electrode in contact with said cathode, a keep-alive electrode in spaced relation to said cathode, a source of alternating control potential, a transformer energized from said source, rectifying means for rectifying the output of said transformer, connections for connecting said electrodes in parallel across the rectified output of said transformer and a shunt flux path in said transformer for producing a rapidly drooping current voltage characteristic in the output potential of said transformer.

10. An excitation system for a vapor-electric device having a main anode and a vaporizable cathode, comprising a resistance type starting electrode in permanent contact with said cathode, a keep-alive electrode in spaced insulated relation to said cathode, a source of alternating excitation potential, transformer means energized from said source, means for rectifying the output potential of said transformer means, circuit means for connecting said starting electrode and said keep-alive electrode in parallel across the rectified potential of said transformer, and means responsive to current flow to said keep-alive elec-

trode to materially reduce the terminal voltage of said transformer means.

11. An excitation system for a vapor-electric device having a main anode and a vaporizable cathode, comprising a resistance type starting electrode in permanent contact with said cathode, a keep-alive electrode in spaced insulated relation to said cathode, a source of alternating excitation potential, transformer means energized from said source, means for impressing a unidirectional output of said transformer on said starting electrode, an auxiliary winding on said transformer, means including said auxiliary winding for impressing keep-alive potential on said keep-alive electrode, said auxiliary winding being energized by current flow to said keep-alive electrode to change the regulation characteristic of said transformer.

12. An exciting system for a vapor-electric valve having a main anode and a vaporizable cathode comprising a resistance type starting electrode in permanent contact with the cathode, an auxiliary exciting electrode in spaced insulated relation to the cathode, a source of alternating potential, means for deriving a unidirectional potential from said source, circuit means for impressing said unidirectional potential on said auxiliary exciting electrode, transformer means for deriving a high potential from said source, circuit means for impressing said high potential on said starting electrode and regulating means responsive to current flow to said auxiliary exciting electrode for reducing the output potential of said transformer means.

13. An exciting system for a vapor-electric valve having a main anode and a vaporizable cathode comprising a resistance type starting electrode in permanent contact with the cathode, an auxiliary exciting electrode in spaced insulated relation to the cathode, a source of alternating potential, circuit means for impressing a potential derived from said source on said auxiliary exciting electrode, transformer means for deriving a high potential from said source, circuit means for impressing said high potential on said starting electrode and regulating means energized by current flow to said auxiliary exciting electrode for controlling the output potential of said transformer means.

JOHN L. BOYER.
HERBERT A. ROSE.

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