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ELECTRIC VALVE CONVERTING SYSTEM

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Fig. 1.

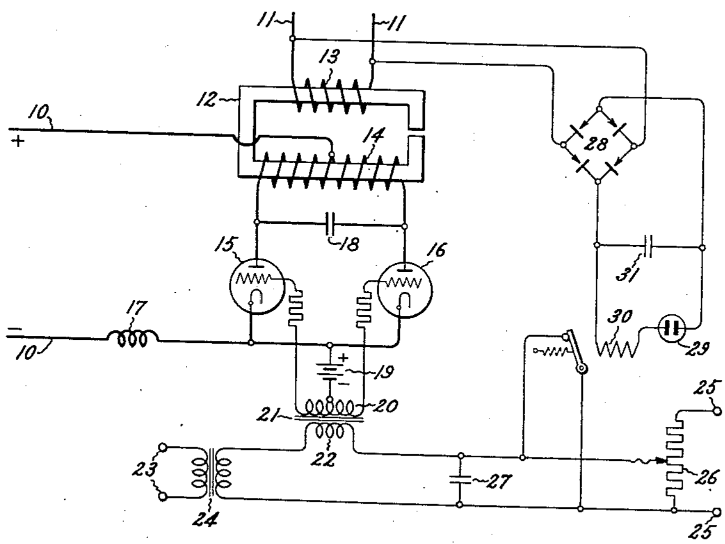
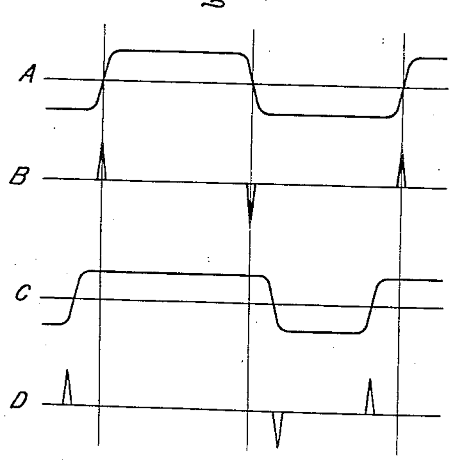


Fig. 2.



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ELECTRIC VALVE CONVERTING SYSTEM

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17 Claims. (Cl. 175—363)

My invention relates to electric valve converting systems and more particularly to such systems suitable for transmitting energy between constant current and constant potential circuits.

Heretofore numerous electric valve converting systems have been proposed for transmitting current between direct and alternating current circuits, one of which has a constant current characteristic. In general, such systems in the past have necessitated the use of a large number of electric discharge paths or valves and in some instances it may be highly desirable, where it is not necessary to transfer large amounts of power, to have an electric valve converting system wherein a minimum number of electric discharge paths or valves is utilized.

It is, therefore, an object of my invention to provide an improved electric valve converting system for transferring energy between direct and alternating current circuits, one of which has a constant current characteristic, which will overcome some of the disadvantages of the arrangements of the prior art, and which will be simple and reliable in operation.

It is a further object of my invention to provide an improved electric valve converting system of this type in which a minimum number of electric valves is utilized.

In accordance with my invention I utilize an electric valve converting system which has a marked resemblance to that form of electric valve converting system commonly known in the art as a simple parallel type electric valve converter. In accordance with my invention, however, I utilize a nonsaturable magnetic core structure for the transformer, and for the normal commutating capacitor I substitute a capacitor of much larger size which not only supplies the necessary commutating voltage to the tubes but also supplies a certain power component to the system in order to obtain the desired output characteristics. In addition thereto the electric valves are provided with a control circuit which operates to increase the period of conductivity of one of the valves while producing a corresponding decrease in the period of conductivity of the other of the valves thereby controlling the transfer of power between the two circuits and obtaining a constant potential characteristic in the output circuit throughout the range of operation for which the system is designed.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 represents the embodiment of my invention, and Fig. 2 shows curves illustrating certain operating characteristics.

Referring to Fig. 1 of the drawing, I have illustrated therein an electric valve converting system for transferring energy between the constant current direct current circuit 10 and the constant potential alternating current circuit 11. The electric valve converting system includes a transformer having a nonsaturable magnetic core structure 12 upon which is mounted a pair of windings 13 and 14. The winding 13 is connected to the alternating current circuit 11 and the winding 14 is connected at an intermediate point thereon to one side of the direct current circuit 10. The remaining terminals of the winding 14 are each connected through one of a pair of electric valves 15 and 16 to the other side of the direct current circuit 10 through an inductor 17, which serves to prevent any undesired interaction between the direct current circuit and the electric valve converting system. While each of the electric valves 15 and 16 is shown as being of the type comprising an envelope containing an anode, a cathode, a control grid and an ionizable medium, it is to be understood that any other valve known in the art having an anode, a cathode, a control electrode and containing an ionizable medium may be utilized. A capacitor 18 is connected across the inductive winding 14 of the transformer structure 12 in order to supply the necessary commutating voltage to the electric valves 15 and 16 and also to supply sufficient power to the transformer winding 14 thereby to change the operating characteristics of the system. Each of the electric valves 15 and 16 is provided with a control circuit, which includes a protective resistor, a source of biasing potential 19 and a portion of the transformer winding 20 of the saturable transformer 21. In addition to the transformer winding 20, the saturable transformer 21 is provided with a primary winding 22 which is arranged to be energized from a circuit supplying thereto an alternating voltage and a variable direct current voltage. The alternating voltage is supplied from a suitable source of alternating current 23 by means of a transformer 24. The direct current circuit 25 supplies energy to the voltage divider 26 so that the amount of direct current voltage supplied to the transformer 22 may be controlled. In order to prevent the alternating current supplied by the transformer 24 from affecting the direct current circuit, the circuit connections to the voltage divider 26 may be bypassed by a suitable capacitor 27. A control circuit responsive to an electrical condition of the alternating current output circuit 11 is provided in order to control the direct current supplied to the transformer 22. This control circuit includes a rectifying circuit 28 which may comprise, as shown, a bridge rectifier consisting of a plurality of contact rectifiers. The output of the rectifying circuit 28 is connected to a circuit containing a glow tube 29 connected in series with the actuating winding 30 of a rapid acting relay. In order to improve the operation of the circuit including the glow tube 29 and the relay actuating winding 30 a capacitor 31 is connected in parallel to these elements. The glow tube 29 is arranged so as to be in a continuously ionized condition so that it will subtract a constant voltage from the voltage supplied by the bridge rectifier 28 and the difference in voltage will cause the actuating winding 30 of the rapid acting relay to draw up its armature whenever this difference in voltage exceeds a predetermined amount. The armature of the relay 30 is normally spring-biased so that the contact thereon short circuits that portion of the voltage divider 26 which supplies voltage to the transformer 21.

In operation, the moment at which the electric valves 15 and 16 are rendered conductive is determined by the peaked voltages supplied to the control circuits of these tubes by the transformer winding 20 of the saturable transformer 21. For the purposes of explanation it will be assumed that the maximum possible load is being drawn from the output terminals 11 so that the output voltage is either normal or below normal. The contacts of the relay 30 are closed thereby short-circuiting the voltage divider 26 so that no direct current component is being supplied to the saturable transformer 21. Thus, the alternating current supplied from the transformer 24 to the saturable transformer 21 will cause peaked voltages to appear in the transformer winding 20 which are 180 electrical degrees apart. Hence, each of the electric valves 15 and 16 is rendered conductive 180 electrical degrees apart and each valve is conductive for a like period. Under these conditions the converter system operates in a manner analogous to the well known parallel type of converter, and produces a maximum alternating current output.

Assume now that the load appearing across the alternating current circuit 11 is decreased so that the voltage across the output terminals 11 increases, it will now be necessary to change the moment of the ignition of the electric valves 15 and 16 to compensate for this. This increase in the alternating current voltage of the circuit 11 causes a higher direct current voltage to be supplied by the bridge circuit 28 with the result that the voltage appearing across the actuating winding of the relay 30 is now sufficient to cause the armature to be attracted thereby opening its contacts and allowing direct current to be supplied to the transformer 21. The rapid acting relay 30 is so arranged as to respond to this change in voltage within one cycle of alternating current of the circuit 11. The direct current supplied to the transformer 21 from the voltage divider 26 is now sufficient to change the moments at which the electric valves 15 and 16 are rendered conductive. An increase in the direct current voltage supplied to the transformer winding 22 of the transformer 21 will cause, for example, the electric valve 15 to become conductive for a period greater than 180 electrical degrees and to cause the electric valve 16 to be conductive for a period less than 180 electrical degrees. This variable direct current supplied to the transformer 21 serves variably to bias the magnetic flux of the transformer so that the saturation point is reached at different instants of time whenever a flux change occurs due to the alternating current supplied to the transformer.

This, perhaps, can best be understood by referring to Fig. 2 in which the curve shown at A represents the alternating magnetic flux component passing through the transformer winding 22. At the time that the change in this alternating magnetic flux is most rapid a sharp peak of voltage will appear across the transformer winding 20, which peak of voltage causes the electric valves 15 and 16 to become conductive. These alternating voltage peaks are shown at curve B, the positive peaks being the ones which rendered electric valve 15 conductive and the negative peaks being the ones which rendered the electric valve 16 conductive. If now, additional direct current is supplied to the transformer winding 22 to bias the magnetic flux of the transformer, the saturated magnetic flux will have the wave shape of curve C and the alternating potential generated in the transformer winding 22 will appear as shown at curve D with the result that the alternating voltage wave is not symmetrical. Thus it will be seen that while each of the positive and negative peaked voltage waves appearing across the transformer winding 20 are 360 electrical degrees apart, the initial positive voltage peak is followed considerably in excess of 180 electrical degrees by the negative peak, which peak in turn is followed by a positive peak in a period substantially less than 180 electrical degrees. Thus, for instance, the electric valve 15 is conductive from the time that the positive peak is supplied thereto until the negative peak is supplied to the electric valve 16, and the electric valve 15 is again rendered conductive when the next positive peak appears as shown in the curve D.

The electric valve converting system shown will operate over a considerable range of variations of the load appearing across the output circuit 11 as a converter supplying substantially constant potential alternating current to this circuit because the direct current or unidirectional current component supplied to the transformer 22 is being continually adjusted by the rapid make and break action of the rapid acting or vibratory relay 30. The rectifying network 28 always supplies sufficient potential to maintain the glow tube 29 in an ionized condition and small variations in the rectified voltage will produce large variations in the current flowing through the glow tube 29 because the drop across the glow tube is substantially constant. These variations in current operate to energize the relay coil 30 which actuates the armature, the contacts of which control the short circuit across that portion of the voltage divider 26 which supplies unidirectional current to the transformer winding 22. When the contacts of the vibratory relay 30 are in the closed position the alternating current voltage across the circuit 11 tends to become too high, and when the contacts are open the alternating current voltage tends to become too low; but due to the extremely fast and continuous making and breaking of these contacts the alternating current voltage of the circuit **11** is maintained at the average proper value. The contacts of the vibratory relay **30** therefore operate to supply unidirectional current to the winding **22** of the transformer **21** which has the proper average value to cause the rectifier to supply a substantially constant alternating current voltage. The unidirectional current component in the winding **22** of the transformer **21** is a direct current substantially continuous in nature because of the self-inductance of the winding **22** and the high frequency of the making and breaking of the contacts of the relay **30**. This control circuit is so arranged that if the load across the output circuit terminals **11** were entirely removed, the vibrations of the relay **30** would permit sufficient direct current to flow through the winding **22** so as to cause a shift in the conductive period of the electric valves as great as 280 electrical degrees for the valve **15** and as short as 80 electrical degrees for valve **16** thereby maintaining the output voltage within very narrow limits.

It is to be understood that while I have shown one form of varying the magnetic flux bias of the saturable transformer **21**, any other form would be suitable, such as a system which is continuously responsive to all variations appearing across the alternating current circuit **11** thereby to supply a continuously variable direct current to the transformer **21**. It is also to be understood that any other form of circuit could be utilized in place of the control circuit utilizing the saturable transformer **21** which would increase the period of conductivity of one tube and correspondingly decrease the period of conductivity of the other tube. Such a control circuit might comprise a source of alternating current and a variable direct current bias which would vary in accordance with the change of electrical conditions of the alternating current circuit **11**.

While this invention has been shown and described in connection with certain specific embodiments it will, of course, be understood that it is not to be limited thereto, since it is apparent that the principles herein disclosed are susceptible of numerous other applications, and modifications may be made in the circuit arrangement and in the instrumentalities employed without departing from the spirit and scope of this invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is—

1. An electric valve converting system for transferring energy between a source of constant current direct current and a constant potential alternating current circuit, comprising a nonsaturable magnetic core structure having a winding mounted thereon, said winding being provided with an intermediate connection arranged to be connected to said direct current source, a pair of electric valves each connected between one extremity of said winding and said direct current source, a capacitor connected across said winding and arranged to supply energy thereto and to supply a commutating potential to said valves, means for energizing said constant potential circuit from said winding and means for controlling the conductivities of said valves.

2. An electric valve converting system for transferring energy between a constant current direct current circuit and a constant potential alternating current circuit comprising a nonsaturable magnetic core structure provided with a winding, said winding being connected at an intermediate point thereon to said direct current source, a pair of electric valves each interconnecting the remaining extremities of said winding with said direct current source, a capacitor connected across said winding, means for energizing said constant potential circuit from said winding and a control circuit for said electric valves, said control circuit operating to increase the conductive period of one of said valves and correspondingly decrease the conductive period of the other of said valves thereby to reduce the amount of energy transferred between said circuits.

3. The combination comprising a constant current input circuit and a constant voltage output circuit interconnected by an electric valve converting system, said electric valve converting system including a pair of controlled electric valves, a control circuit for said electric valves including a saturable transformer, means for supplying to said saturable transformer an alternating potential and a variable direct current potential, and means responsive to an electrical condition of said output circuit for controlling said direct current voltage.

4. The combination comprising constant potential and constant current circuits interconnected by an electric valve converting system, said electric valve converting system comprising a nonsaturable core structure provided with a pair of windings thereon for connecting two such circuits, a pair of electric valves interconnecting one of said windings with one of said circuits, a control circuit for said electric valves including a saturable transformer, means for supplying to said saturable transformer an alternating voltage and a direct current voltage, and means responsive to an electrical condition of one of said circuits for controlling said direct current voltage.

5. In an electric valve converting system, the combination comprising a constant current input circuit and a constant current output circuit, a nonsaturable magnetic core structure provided with a pair of windings mounted thereon, means including a pair of electric valves interconnecting one of said windings with said constant current circuit, means connecting the other of said windings to said constant potential circuit, a capacitor connected between the anodes of said valves, a control circuit for said valves including a saturable transformer, means for supplying thereto an alternating current voltage and a variable direct current voltage, and means responsive to an electrical condition of said output circuit for controlling said direct current voltage.

6. In an electric valve converting system, the combination comprising a constant current input circuit and a constant current output circuit, a nonsaturable magnetic core structure provided with a pair of windings mounted thereon, means including a pair of electric valves interconnecting one of said windings with said constant current circuit, means connecting the other of said windings to said constant potential circuit, a capacitor connected between the anodes of said valves, a control circuit for said valves including a saturable transformer, means for supplying thereto an alternating current voltage and a direct current voltage, and means including a vibratory relay

responsive to an electrical condition of said output circuit for controlling said direct current voltage.

7. In an electric valve translating system, the combination comprising a pair of controlled electric valves each having a control member for controlling the conductivity thereof, a control circuit for said valves including means for producing periodic voltages of variable phase displacement relative to each other for increasing the normal period of conductivity of one of said valves by a certain amount, and correspondingly decreasing the period of conductivity of the other of said valves by a like amount.

8. The combination comprising a pair of controlled electric valves, a control circuit for said valves including a saturable transformer, and means for variably biasing the magnetic flux of said transformer thereby to increase the period of conductivity of one of said valves and simultaneously to decrease correspondingly the period of conductivity of the other of said valves.

9. The combination comprising a pair of controlled electric valves, a control circuit for each of said valves, said control circuit being energized from a single saturable transformer, and means for variably biasing the magnetic flux of said transformer thereby to increase the period of conductivity of one of said valves while correspondingly operating to decrease the period of conductivity of the other of said valves.

10. The combination comprising a pair of controlled electric valves, a control circuit for said valves including a saturable transformer, means for supplying alternating current to said saturable transformer and means for supplying a direct current to said saturable transformer, and means for varying said direct current thereby to increase the period of conductivity of one of said valves and to decrease correspondingly the period of conductivity of the other of said valves.

11. The combination comprising a pair of controlled electric valves, a control circuit for said valves including means for supplying thereto two series of periodic voltage impulses of peaked wave form, one of said electric valves being controlled by one of said series of periodic voltage impulses and the other of said valves being controlled by the other of said series of periodic voltage impulses, and means for varying the phase relation between said one series and said other series of periodic voltage impulses.

12. The combination comprising a pair of controlled electric valves, a control circuit for said valves including a saturable transformer operating to supply one series of voltage impulses for controlling one of said valves and another series of voltage impulses for controlling the other of said valves, and means for varying the phase relation between said series of voltage impulses thereby to increase the period of conductivity of one of said valves and to decrease the period of conductivity of the other of said valves.

13. In combination, a source of current, a load circuit, apparatus for controlling the energization of said load circuit comprising a pair of electric valve means each having a control member for controlling the conductivity thereof, and means for producing periodic voltages of variable phase displacement relative to each other for energizing the control members to cause said pair of electric valve means to conduct different amounts of current.

14. In combination, a source of current, a load circuit, apparatus for controlling the energization of said load circuit and comprising electric valve means, the energization of said load circuit being a function of the ratio of the period of conduction to the period of nonconduction of said electric valve means, apparatus for rendering said electric valve means nonconducting comprising a second electric valve means, each of said electric valve means being provided with a control member of controlling the conductivity thereof, and means for impressing on the control members periodic voltages which are variable in phase with respect to each other.

15. In combination, a source of current, a load circuit, apparatus for controlling the energization of said load circuit and comprising electric valve means, the energization of said load circuit being a function of the ratio of the period of conduction to the period of nonconduction of said electric valve means, apparatus for rendering said electric valve means nonconductive comprising a second electric valve means, each of said electric valve means being provided with a control member for controlling the conductivity thereof, and means for impressing on the control members periodic voltages variable in phase displacement with respect to each other in accordance with a predetermined controlling influence.

16. In combination, a source of current, a load circuit, apparatus for controlling the energization of said load circuit and comprising electric valve means, the energization of said load circuit being a function of the ratio of the period of conduction to the period of nonconduction of said electric valve means, said electric valve means being provided with a control member for controlling the conductivity thereof, means for rendering said electric valve means nonconducting and comprising a second electric valve means having a control member, and means for controlling the ratio of the period of conduction to the period of nonconduction of said first mentioned electric valve means and comprising a saturable inductive device for impressing on the control members periodic voltages of peaked wave form variable in phase with respect to each other.

17. In combination, a source of current, a load circuit, apparatus for controlling the energization of said load circuit and comprising electric valve means, the energization of said load circuit being a function of the ratio of the period of conduction to the period of nonconduction of said electric valve means, said electric valve means being provided with a control member for controlling the conductivity thereof, means for rendering said electric valve means nonconducting and comprising a second electric valve means having a control member, a control circuit, a saturable inductive device for impressing on the control members periodic voltages of peaked wave form which are variable in phase with respect to each other, and means for controlling said saturable inductive device in accordance with a predetermined electrical quantity of said control circuit.

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