

May 9, 1939.

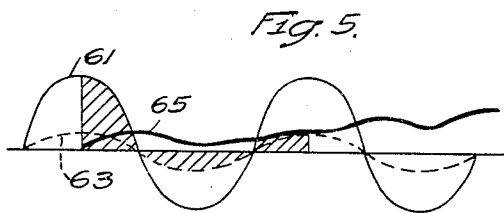
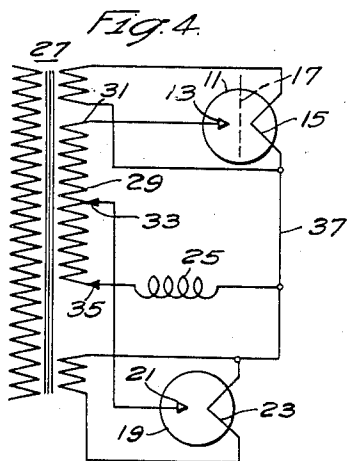
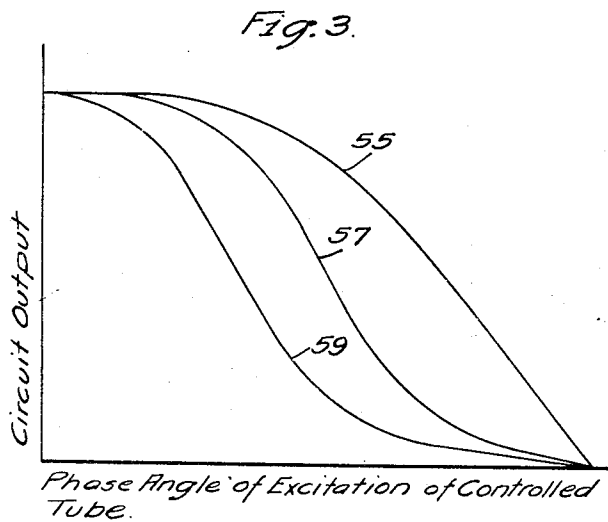
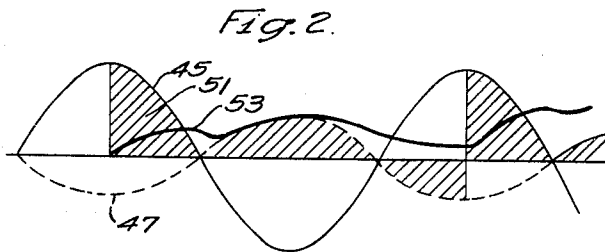
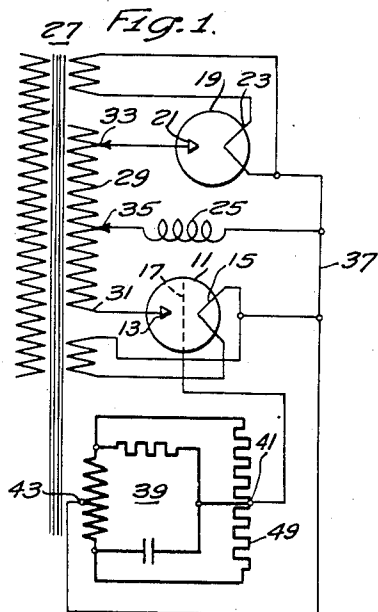
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2,157,888

ELECTRIC DISCHARGE APPARATUS

Filed Feb. 27, 1937

2 Sheets-Sheet 1



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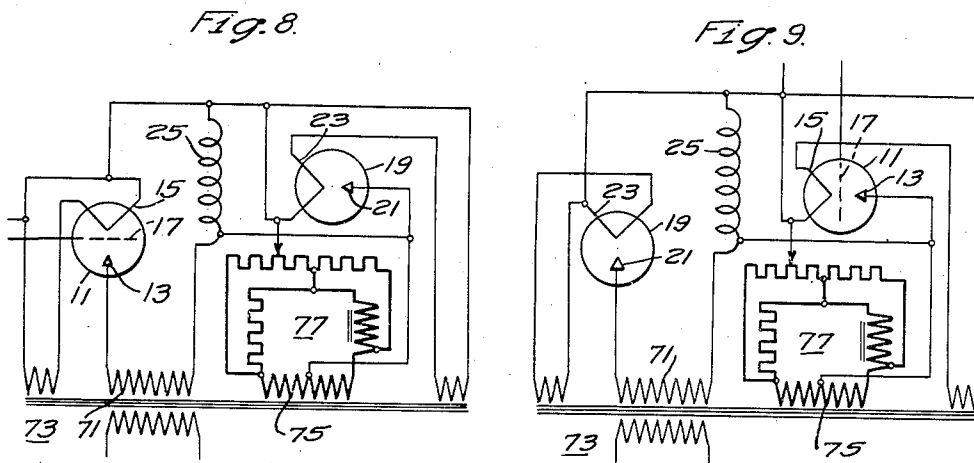
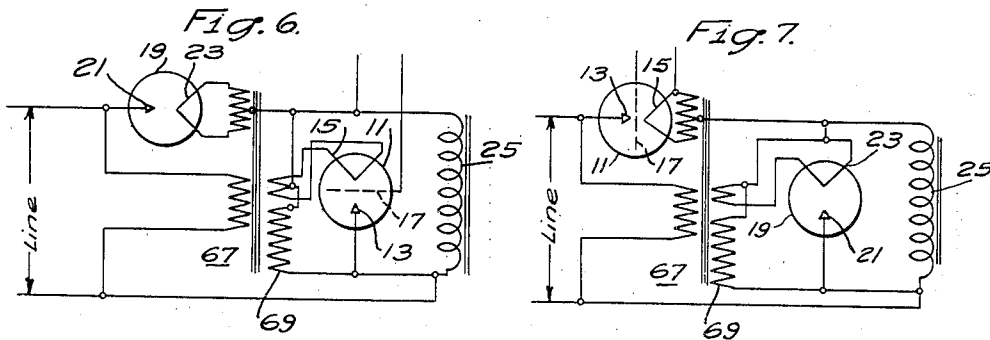
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ELECTRIC DISCHARGE APPARATUS

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2 Sheets-Sheet 2



WITNESSES:

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2,157,888

ELECTRIC DISCHARGE APPARATUS

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Application February 27, 1937, Serial No. 128,196

11 Claims. (Cl. 250—27)

My invention relates to electric discharge apparatus and it has particular relation to discharge apparatus through which a reactive load is energized.

5 It is an object of my invention to provide a simple and inexpensive system for supplying power of variable magnitude to a reactive load.

A more specific object of my invention is to provide a system incorporating a controlled electric
10 discharge device for supplying power of variable magnitude to a reactive load, in which the magnitude of the power supplied to the load varies in a predetermined manner with the variation in the control of the discharge device.

15 According to my invention, I provide a discharge device having a control electrode and a plurality of principal electrodes and a second discharge device which has only in effect a plurality of principal electrodes. While in certain modifications of my invention, either one or both of the
20 discharge devices may be of the high vacuum type, in general I prefer to use discharge devices of the gaseous type. I provide also a source of alternating potential having at least three taps. One of the principal electrodes of each of the discharge
25 devices is connected to one of the taps of the source. The reactive load to be supplied is connected at one terminal to another tap of the source and at the other terminal to the other principal electrodes of the discharge devices. The discharge device having a control electrode is supplied with control potential through a phase shift
30 circuit or in any other known manner, and the supply of power to the load is controlled by varying the control potential. To change the mode of variation of the power supplied to the load with the variation in the control potential, I provide means for varying the differences of potential between the pairs of taps of the source. I have
40 found that by varying the relative differences of potential, different functional relationships between the current supplied to the load and the potential supplied to the controlled discharge device, may be obtained.

45 The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional
50 objects and advantages thereof, will best be understood from the following description of specific embodiments, when read in connection with the accompanying drawings, in which

55 Figure 1 is a diagrammatic view showing an embodiment of my invention,

Fig. 2 is a graph illustrating the operation of the apparatus shown in Fig. 1,

Fig. 3 is a graph illustrating the different load variation characteristics which may be obtained with the apparatus shown in Fig. 1,

Fig. 4 is a diagrammatic view showing a modification of Fig. 1,

Fig. 5 is a graph illustrating the operation of the apparatus shown in Fig. 4,

Fig. 6 is a diagrammatic view showing a modification of my invention,

Fig. 7 is a diagrammatic view of another modification of my invention,

Fig. 8 is a diagrammatic view showing a further modification of my invention, and

Fig. 9 is a diagrammatic view showing still another modification of my invention.

The apparatus shown in Fig. 1 comprises a gaseous electric discharge device 11 having an anode 13, a cathode 15 and a control electrode 17 and a second gaseous discharge device 19 having an anode 21 and a cathode 23. In the embodiment of my invention actually illustrated, both discharge devices 11 and 19 are of the hot cathode type. It is apparent that discharge devices of the mercury pool type with make-alive or keep-alive electrodes and discharge devices of the Ignitron tube type may also be utilized. It is further to be noted that if discharge devices of the Ignitron tube type are utilized, the control electrode of the controlled discharge device may be the starting electrode of the Ignitron tube. Finally, attention is called to the fact that in actual practice, the two-electrode discharge device 19 may incorporate more than two electrodes. The additional electrodes, however, are not utilized for control purposes. Thus the discharge device 19 may be identical in structure to the controlled discharge device 11 but with its control electrode connected to its cathode.

A reactive load 25 is supplied through the discharge devices 11 and 19 from a suitable supply transformer 27. The principal secondary 29 of the transformer 27 is provided with a plurality of taps 31, 33 and 35. One tap 31 is connected to the anode 13 of the controlled discharge device 11 and another tap is connected to the anode 21 of the other discharge device 19. One terminal of the load 25 is connected to the remaining tap 35 while the other terminal of the load is connected to the common connection conductor 37 of the cathodes 15 and 23 of the discharge devices.

Control potential is supplied to the controlled discharge device 11 from the supply transformer 27 through a phase shift network 39 of the usual

type. The output terminals 41 and 43 of the network are connected respectively to the control electrode 17 and the cathode 15 of the controlled discharge device.

5 The taps 33 and 35 to which the anode 21 of the uncontrolled discharge device 19 and the load 25 are connected are adjustable along the main secondary 29 so that the potential difference between the pairs of taps 33—35, 31—33 and 31—35 may be varied at will. By thus varying the potential differences, the desired functional characteristic of the load variation with variation in the control potential is attained.

15 The operation of the system is illustrated in Fig. 2. In this view the magnitude of the anode-cathode potentials impressed in the discharge devices 11 and 19 and the current supplied to the load 25 are plotted as ordinate and time is plotted as abscissa. The full line sine curve 45 represents the anode-cathode potential supplied to the controlled discharge device 11 and the broken line sine curve 47 represents the anode-cathode potential supplied to the uncontrolled discharge device 19. It is to be noted that the anode cathode potential impressed on the former is, in the system illustrated by the curves, considerably greater than the anode-cathode potential impressed on the latter. The controlled discharge device 11 may be energized at any point in its positive half cycle of anode-cathode potential by properly adjusting the position of the movable tap 41 of the potentiometer 49 of the phase shift network 39. In the illustrated system, the controlled discharge device is assumed to be energized a quarter cycle after the commencement of the positive half cycle and the portion of the half cycle during which the discharge device is energized is represented by the shaded area 51 in Fig. 2. The corresponding load current is illustrated by the heavy curve 53. When the controlled discharge device 11 is thus energized, the load is supplied with the current.

At the end of the positive half cycle of the anode-cathode potential supplied to the controlled discharge device 11, the flux in the load 25 begins to decay and a positive potential is impressed between the anode 21 and the cathode 23 of the uncontrolled discharge device 19 which is superimposed on the potential (represented by curve 47) impressed by the transformer 27. Current, therefore, flows through the load and the uncontrolled discharge device 19 during the positive half cycle of anode-cathode potential supplied thereto. During the succeeding positive half cycle of anode-cathode potential supplied to the controlled discharge device 11, the current through the load begins to decrease, but the excitation of the discharge device 11 at the quarter-phase point reverses this tendency. After current has thus been supplied to the load 25 through the discharge devices 11 and 19 for several cycles it attains a substantially steady value and the load is supplied until the discharge device 11 is no longer energized at the quarter-cycle point. To vary the current supplied to the load 25, the phase of the control potential supplied to the controlled discharge device 11 is varied. This object is of course accomplished by adjusting the position of tap 41 along potentiometer 49.

70 The variation of the current supplied to the load with the phase angle of excitation of the controlled discharge device 11 is illustrated in Fig. 3. To obtain the different curves 55, 57 and 59 shown in this view, the position of the movable taps 33 and 35 of the main secondary 29 of the

transformer 27 is varied to vary the differences of potential between the pairs of taps. For different relationships between the differences of potential, the different curves shown in Fig. 3 may be attained.

It is to be noted that in the actual embodiment illustrated in Fig. 1, the anode-cathode potential supplied to the controlled discharge device 11 is in opposite phase to the anode-cathode potential supplied to the uncontrolled discharge device 19. This need not necessarily be the case. The movable-taps 33 and 35 of the main secondary 29 may be so adjusted that the one connected to the anode 21 of the uncontrolled tube 19 is below the one connected to the load 25. The system which is attained by this adjustment is illustrated in Fig. 4.

The operation of the latter system is illustrated in Fig. 5, in which the full line curve 61 and the broken line curve 63 represent respectively the anode-cathode potentials of the controlled and the uncontrolled discharge devices 11 and 19, respectively, and the heavy curve 65 again represents the current supplied to the load.

In the system in Fig. 6, the uncontrolled discharge device 19 is connected in series with the main source (not shown) and the load 25. The controlled discharge device 11 is supplied with alternating potential from the main source through a transformer 67, the secondary 69 of which is connected between its cathode 15 and its anode 13.

In the apparatus shown in Fig. 7, it is the controlled discharge device 11 which is connected in series with the source and the load 25 and the uncontrolled discharge device 19 which is supplied through the secondary 69 of the transformer 67.

In the apparatus shown in Fig. 8, the anode-cathode potential supplied to the controlled discharge device 11 is out of phase with the anode-cathode potential supplied to the uncontrolled discharge device 19. The former is supplied from one secondary section 71 of transformer 73 while the latter is supplied from another section 75 through a phase shift network 77 of any convenient type.

In the apparatus shown in Fig. 9, it is the controlled discharge device 11 which is supplied through the phase shift network 77 and the uncontrolled discharge device 19 which is supplied directly.

In the system shown in Figs. 4, 6, 7, 8 and 9, the control potential may be supplied by a system of the type shown in Fig. 1 or in any other well known manner.

Although I have shown and described certain specific embodiments of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. For use in supplying a reactive load the combination comprising a first electric discharge device having a control electrode and a plurality of principal electrodes, means for impressing a control potential between said control electrode and one of said principal electrodes, a second electric discharge device having in effect only a plurality of principal electrodes, a source of periodic potential having a plurality of terminal taps and an intermediate tap, means including said load for connecting the principal electrodes of said first discharge device between said intermediate

tap and one of said terminal taps, means including said load for connecting the principal electrodes of said second discharge device between said intermediate tap and another terminal tap, the electrode of said second discharge device that is connected to said last-mentioned terminal tap being connected to said first-mentioned terminal tap only through said source of periodic potential, and means for varying the potential impressed between one of said terminal taps and said intermediate tap.

2. For use in supplying a reactive load the combination comprising a first electric discharge device having a control electrode and a plurality of principal electrodes and a gaseous medium, means for impressing a control potential between said control electrode and one of said principal electrodes, a second electric discharge device having in effect only a plurality of principal electrodes, a source of periodic potential having a plurality of terminal taps and an intermediate tap, means including said load for connecting the principal electrodes of said first discharge device between said intermediate tap and one of said terminal taps, means including said load for connecting the principal electrodes of said second discharge device between said intermediate tap and another terminal tap, the electrode of said second discharge device that is connected to said last-mentioned terminal tap only through said source of periodic potential and means for varying the potential impressed between one of said terminal taps and said intermediate tap.

3. For use in supplying a reactive load the combination comprising a first electric discharge device having a control electrode and a plurality of principal electrodes, means for impressing a control potential between said control electrode and one of said principal electrodes, a second electric discharge device having in effect only a plurality of principal electrodes, a source of periodic potential having a plurality of terminal taps and an intermediate tap, means including said load for connecting the principal electrodes of said first discharge device between said intermediate tap and one of said terminal taps, means including said load for connecting the principal electrodes of said second discharge device between said intermediate tap and another terminal tap, the potential difference between said one terminal tap and said intermediate tap being different than the potential difference between said other terminal tap and said intermediate tap.

4. For use in supplying a reactive load the combination comprising a first electric discharge device having a control electrode and a plurality of principal electrodes and a gaseous medium, means for impressing a control potential between said control electrode and one of said principal electrodes, a second electric discharge device having in effect only a plurality of principal electrodes and a gaseous medium, a source of periodic potential having a plurality of terminal taps and an intermediate tap, means including said load for connecting the principal electrodes of said first discharge device between said intermediate tap and one of said terminal taps, and means including said load for connecting the principal electrodes of said second discharge device between said intermediate tap and another terminal tap, the potential difference between said one terminal tap and said intermediate tap being different than the potential difference between said other terminal tap and said intermediate tap.

5. Apparatus for supplying a reactive load comprising a first discharge device having a control electrode and a plurality of principal electrodes and a gaseous medium, control means for said discharge device for impressing a potential between said control electrode and one of said principal electrodes, a second discharge device having in effect only a plurality of principal electrodes and a gaseous medium, a source of alternating potential having at least three taps, between any two of which potential differences exist, means for connecting a principal electrode of each of said discharge devices to one of said taps and another principal electrode of each of said discharge devices to said load, means for connecting the said load to another tap and means for varying the potential difference between said last mentioned tap and one of said former taps.

6. Apparatus for supplying a reactive load comprising a first discharge device having a control electrode and a plurality of principal electrodes and a gaseous medium, control means for said discharge device for impressing an alternating potential between said control electrode and one of said principal electrodes, a second discharge device having in effect only a plurality of principal electrodes and a gaseous medium, a source of alternating potential having at least three taps between any two of which potential differences exist, said control means including means for establishing a phase difference between the potential between said control electrode and said one principal electrode and said potential differences between said taps, means for connecting a principal electrode of each of said discharge devices to one of said taps and another principal electrode of each of said discharge devices to said load, means for connecting said load to another tap and means for varying the potential difference between said last mentioned tap and one of said former taps.

7. Apparatus for supplying a reactive load comprising a first discharge device having a control electrode, an anode and a cathode, control means for said discharge device for impressing a potential between said control electrode and said cathode, a second discharge device having in effect only an anode and a cathode, and a gaseous medium, a source of alternating potential having at least three taps, between any two of which potential differences exist, means for connecting the anodes of each of said discharge devices to one of said taps and the cathodes of each of said discharge devices to said load, means for connecting said load to another tap and means for varying the potential difference between said last mentioned tap and one of said former taps.

8. Apparatus according to claim 5, characterized by means for establishing a difference in phase of a magnitude between 0 and 180° between the differences of potentials impressed between the pairs of taps.

9. Apparatus according to claim 5 characterized by the fact that the differences of potential impressed between the taps are in phase with each other but of different magnitude.

10. For use in supplying a reactive load the combination comprising a first electric discharge device having a control electrode and a plurality of principal electrodes, means for impressing a control potential between said control electrode and one of said principal electrodes, a second electric discharge device having a plurality of principal electrodes, a source of periodic poten-

5 tial having a plurality of terminal taps and an
intermediate tap, means including said load for
connecting the principal electrodes of said first
discharge device between said intermediate tap
and one of said terminal taps, means including
said load for connecting the principal electrodes
of said second discharge device between said
intermediate tap and another terminal tap, the
10 potential difference between said one terminal
tap and said intermediate tap being different than
the potential difference between said other ter-
minal tap and said intermediate tap.

11. For use in supplying a reactive load the
combination comprising a first electric discharge
15 device having a control electrode and a plurality
of principal electrodes and a gaseous medium,
means for impressing a control potential be-

tween said control electrode and one of said prin-
cipal electrodes, a second electric discharge device
having a plurality of principal electrodes and a
gaseous medium, a source of periodic potential
having a plurality of terminal taps and an in- 5
termediate tap, means including said load for
connecting the principal electrodes of said first
discharge device between said intermediate tap
and one of said terminal taps, and means in-
cluding said load for connecting the principal 10
electrodes of said second discharge device between
said intermediate tap and another terminal tap,
the potential difference between said one terminal
tap and said intermediate tap being different
than the potential difference between said other 15
terminal tap and said intermediate tap.

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