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CURRENT SUPPLY SYSTEM

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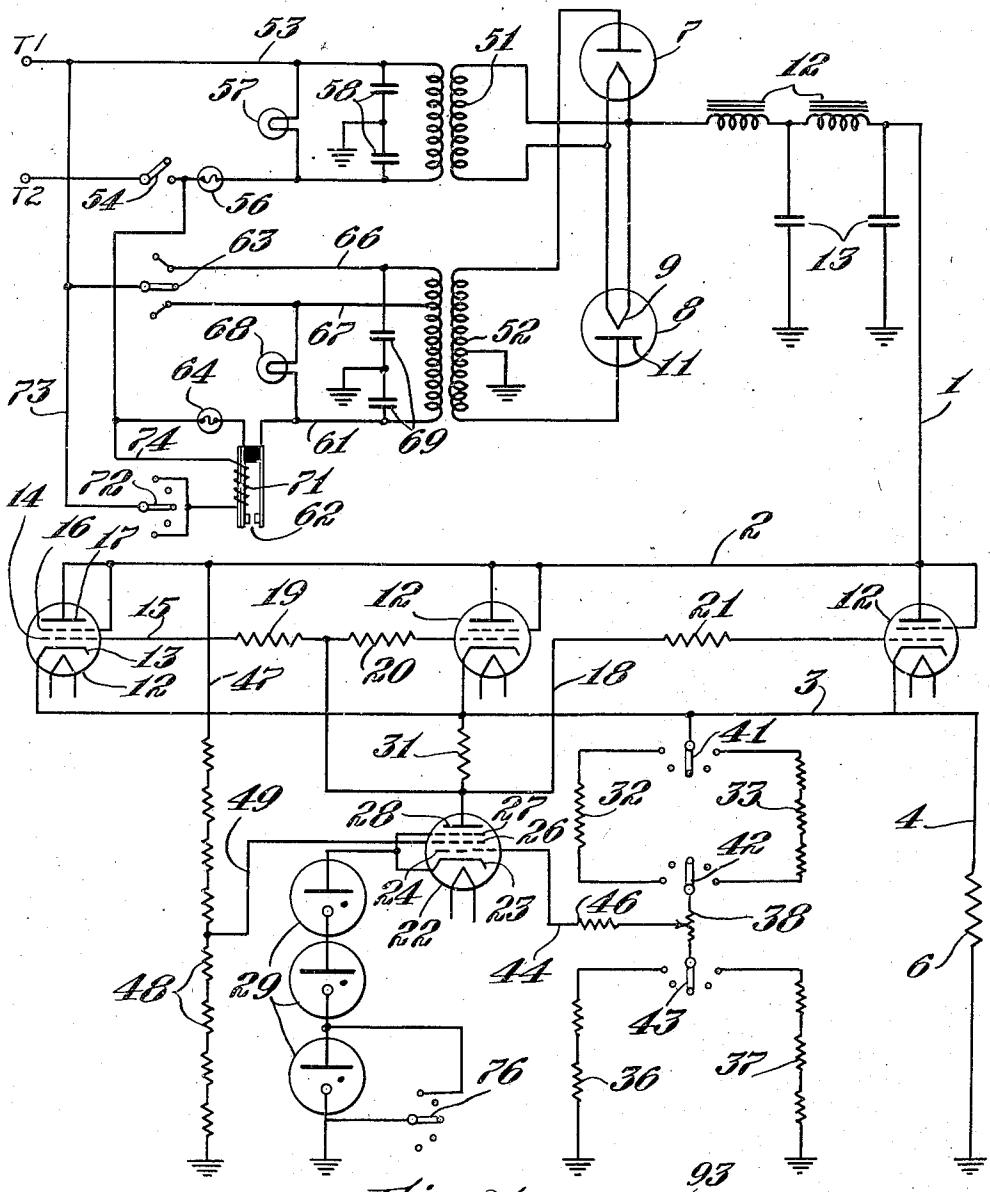

Fig. 1

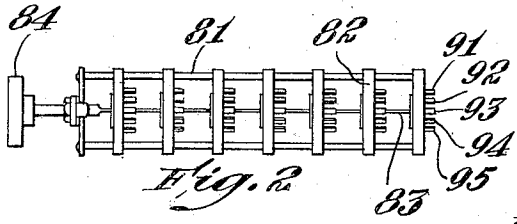

Fig. 2

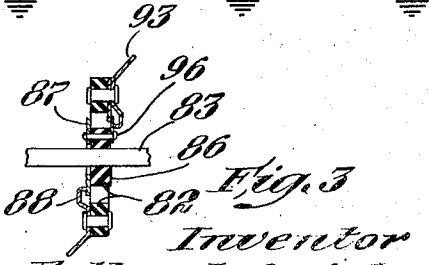

Fig. 3

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CURRENT SUPPLY SYSTEM

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5 Claims. (Cl. 315—102)

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This invention relates to current supply systems and more particularly to voltage regulator systems of the type using electronic rectifying and control tubes.

Objects of the invention are to provide a system which is simple and economical in construction, which is durable and reliable in use, which affords close regulation of the voltage, which minimizes filter ripple, which affords many different voltages from a single constant-voltage source, and which is generally superior to prior systems of the character referred to.

In one aspect the present invention involves a voltage regulating system comprising a regulator tube having a cathode, plate and control grid, a control tube having a cathode, plate, control grid and screen grid, a constant-voltage device having a substantially constant voltage drop throughout a range of loads, a supply circuit connected to the plate of the regulator tube, a load circuit having one end connected to the cathode of the regulator tube, a regulating circuit interconnecting the plate of the control tube and the cathode of the regulator tube, a load resistance in the regulating circuit, means for varying the bias of the control grid of the control tube in proportion to voltage variations in the load circuit, a circuit interconnecting one end of the constant-voltage device and the cathode of the control tube, the other end of the device being connected to the other end of the load circuit, a control circuit containing a control resistance, and a branch circuit interconnecting the control resistance and the screen grid of the control tube, characterized in that the control circuit is connected across the supply circuit so that variation in the voltage of the supply circuit directly varies the bias of the screen grid of the control tube to help regulate the voltage in the load circuit. Preferably the aforesaid means for varying the bias of the control grid of the control tube comprises a primary control circuit connected across the load circuit, a primary branch control resistance in the primary control circuit and a primary circuit interconnecting the primary resistance and the control grid of the control tube, and the aforesaid control resistance is located in a secondary control circuit connected across the supply circuit with a secondary branch circuit interconnecting the secondary resistance and the screen grid of the control tube.

In another aspect the invention involves a current supply system comprising an electrical circuit, a relay having contacts for controlling the circuit, a circuit switch in series with the contacts for conjointly controlling the circuit, a relay

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switch for controlling the relay, each of the switches having open, closed and intermediate positions, the circuit switch having its closed and intermediate contacts interconnected so that the circuit is closed when the switch is in either closed or intermediate position or moving from one to the other, and means interconnecting the switches for conjoint operation so that they are always in corresponding positions, whereby the circuit is first closed by the circuit switch when the switches are moved from open to intermediate position and then closed by the relay contacts after the switches have been moved to closed position.

In a more specific aspect the system comprises a tube having a cathode and anode, a main circuit for supplying plate current to the tube, an auxiliary circuit for supplying heating current to the cathodes, a relay having contacts for closing the main circuit, a main switch in series with the contacts for conjointly controlling the main circuit, an auxiliary switch for controlling both the auxiliary circuit and the relay, a relay switch in series with the auxiliary switch for conjointly controlling the relay, the main and relay switches each having open, closed and intermediate positions, the main switch having its closed and intermediate contacts interconnected so that the circuit is closed when the switch is in either closed or intermediate position or moving from one to the other, and means interconnecting the main and relay switches for conjoint operation so that they are always in corresponding positions, whereby the main circuit is first closed by the main switch when the main and relay switches are moved from open to intermediate positions and then closed by the relay contacts after all three switches have been moved to closed positions. Preferably the relay is slow-acting so that the main circuit is not closed until a predetermined time after heating current is supplied to the cathode. In the preferred embodiment the main and relay switches each has two closed positions, together with means for supplying different voltages when the main switch is in the closed positions respectively.

For the purpose of illustration a typical embodiment of the invention is shown in the accompanying drawings in which

Fig. 1 is a circuit diagram;

Fig. 2 is a side view of a switch; and

Fig. 3 is an axial section of one element of the switch.

The particular embodiment of the invention chosen for the purpose of illustration comprises a supply circuit including conductors 1 and 2

and a load circuit including conductors 3 and 4, the load being indicated at 6. Current is supplied from a suitable source through a full-wave rectifier comprising tubes 7 and 8, each comprising a cathode 9 and an anode 11, and thence through a choke input filter including inductances 12 and condensers 13.

Connected in parallel between the conductors 2 and 3 are three regulating tubes 12 each having a cathode 13, a control grid 14, a screen grid 16 and a plate 17, the plates and screen grids being connected to conductor 2, the cathodes being connected to conductor 3 and the control grids being interconnected through conductors 15 and 18 and resistances 19, 20 and 21.

The voltage regulating portion of the system also comprises a control tube 22 comprising a cathode 23, a control grid 24, a screen grid 26, a suppressor grid 27 and a plate 28. The cathode 23 and suppressor grid 27 are connected together and then to ground through three constant-voltage tubes 29. Plate 28 is connected to conductor 18 and a load resistance 31 is interposed between the conductors 3 and 18. Connected across the load circuit is a primary control circuit comprising branches 32 and 33 and branches 36 and 37, the two pairs of branches being interconnected through a common portion 38. The portions of the network are interconnected by switches 41, 42 and 43 which have right-hand positions in which they interconnect the branch circuits 33 and 37, left-hand positions in which they interconnect the branch circuits 32 and 36 and intermediate positions in which the circuits are open. The control grid 24 of the control tube 22 is connected to an adjustable tap on the resistance 38 through a primary branch circuit 44 containing a resistance 46.

Interconnected between the conductor 2 and ground is a secondary control circuit 47 containing resistances 48, and a secondary branch circuit 49 interconnects the secondary control circuit with the screen grid 26 of the control tube 22.

Current is supplied to the rectifier tubes 7 and 8 through transformers 51 and 52, transformer 51 supplying heating current to the cathodes 9 and transformer 52 supplying the anode potential. Transformer 51 is connected by the terminals $t1$ and $t2$ to a source of alternating current through an auxiliary circuit 53 including an auxiliary switch 54, a fuse 56, a pilot light 57 and condensers 58. The transformer 52 is connected to the terminals $t1$ and $t2$ of the source of alternating power through a main circuit 61 including relay contacts 62, a main switch 63, a fuse 64 and two branches 66 and 67, a pilot lamp 68 and condensers 69. The relay 62 is controlled by a winding 71 connected to the source of alternating current through a relay switch 72, conductors 73 and 74 and the switch 54. The relay 71 may be of any slow-acting type, as for example the thermostatic type diagrammatically illustrated in Fig. 1.

The switches 63 and 72 each has a mid-position in which it is open, two closed positions and an intermediate position between the mid-position and each of the closed positions. In the case of the main switch 63 the closed and intermediate positions are interconnected so that the circuit is closed when the switch is in either closed or intermediate position or moving from one to the other. When the switch is moved upwardly the entire primary of the transformer 52 is connected in circuits through conductor 66, and when the switch is moved downwardly only a portion of the primary of the transformer is connected in circuit through the conductor 67. The switches 63 and 72 are interconnected with each other and with the switches 41, 42 and 43 so that they all move together. The multiple switch also includes a switch 76 for shunting one of the constant voltage tubes 29.

As illustrated in Figs. 2 and 3, a suitable multiple switch comprises a frame 81 carrying a plurality of rings 82 of insulation, a shaft 83 journaled in the frame, a handle 84 for rotating the shaft, a plurality of disks 86 of insulation mounted on the shaft 83 inside the rings 82 respectively, a conducting ring 87 mounted on one side of each disk 86, a conducting wiper 88 mounted on each ring 82 and engaging the adjacent conducting ring 87 in all positions of the rotor, a series of conducting terminals 91, 92, 93, 94 and 95 mounted on the other side of each ring 82, these contacts corresponding to the five contacts of each of the switches 41, 42, 43, 63, 72 and 76 shown in Fig. 1, and a conducting finger 96 mounted on each disk 86, the finger 96 being interconnected with the adjacent conducting ring 87 and engaging one of the contacts 91 to 95 in each of the five positions of the switch. The multiple switch is so connected that when the switches 63, 72 and 76 are in their upper positions the switches 41, 42 and 43 are in their left-hand positions, and when the switches 63, 72 and 76 are in their lower positions the switches 41, 42 and 43 are in their right-hand positions.

To start the operation of the system the switch 54 is first closed to supply heating current through the auxiliary circuit 53 to the cathodes 9 of the rectifier tubes 8. Then the multiple switch is moved from the mid-position to the right or left depending upon the voltage desired. If moved to the high voltage side where part of the primary of transformer 52 is included, the switches 41, 42 and 43 occupy their right-hand positions where more resistance is included and the switch 76 occupies its lower position where the lower tube 29 is not shunted. When the switch is turned in the opposite direction contact 63 connects with conductor 66 to include all of the primary of the transformer 52, the switches 41, 42 and 43 occupy their left-hand positions to include a lesser amount of resistance in the circuit and the switch 76 occupies its upper position in which the lower tube 29 is shunted.

When the switch 63 is first closed current is not supplied to the transformer 52 because the slow acting relay 71 is still open. However switch 72 closes when the multiple switch reaches closed position, thereby supplying current to the relay 71. After a predetermined time the relay closes its contacts 62 thereby completing the circuit to the transformer 52. Thus, even if the multiple switch is closed at the same time as the auxiliary switch 54, voltage is not impressed upon the supply circuit until the cathodes 9 are heated. Likewise if the multiple switch is closed before the auxiliary switch 54 is closed, voltage is not impressed upon the plate circuit of the rectifier tubes until the relay 71 has had time to operate because the relay switch 72 is in series with the auxiliary switch 54. Thus the rectifier tubes can not be damaged by impressing voltage on the plate circuit before the cathodes have been heated.

From the foregoing it will be evident that a characteristic feature of the invention consists in that the secondary control circuit 47 is connected to supply conductor 2, the voltage of which is not regulated, instead of the conductor 3, the

voltage of which is regulated. Thus sudden changes in the unregulated voltage input will have a greater effect on the control tube than would the variations of the regulated output if the secondary control circuit 47 were connected to the conductor 3 instead of to the conductor 2. In other words the change in screen voltage is a larger fraction of the normal screen voltage than would be the case if the screen were subjected to the lower voltages existing on the regulated side. Also if there is a sudden drop in voltage because of heavy load, before the regulator action begins the control grid 24 of the control tube 22 becomes more negative as the plate current decreases. At the same time the screen voltage decreases, more than it would if fed from the regulated side, causing a further decrease in the plate current of tube 22. Hence the voltage drop in the load resistor 31 decreases, the bias on tubes 12 becomes less negative, and a larger current passes through tubes 12 to compensate for the tendency for the voltage to drop. Likewise small voltage variations, such as ripples, are smoothed out more effectively because the screen voltage varies a larger percentage of its normal value when fed from the unregulated side 2.

Another characteristic feature of the present invention is the exceptionally wide voltage range achieved by the aforesaid switching arrangement. For example, when fed from a 110 volt source the system may supply 700 to 1,000 volts when a part of the transformer 52 is cut out and 500 to 700 volts when the entire transformer is used. The relay 71 not only protects the rectifier tubes 8 as above described but also eliminates arcing at the switch 63. When the multiple switch is moved from closed to open position the relay switch 72 opens at the beginning of the switch movement, thereby causing the relay 71 to open the circuit at contacts 62, whereas the switch 63 does not open until the multiple switch has passed the intermediate position between open and closed positions.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. Apparatus of the character referred to comprising a tube having a cathode and anode, a main circuit having two terminals for connection to an alternating power source to supply an anode potential to the tube, an auxiliary circuit for supplying heating current to the cathode, a main switch connecting one of said terminals to said tube, a relay having contacts connecting the other of said terminals to said tube thereby energizing the main circuit to impress a potential upon said anode, an auxiliary switch for controlling both the auxiliary circuit and the relay, a relay switch in series with said auxiliary switch for conjointly controlling the relay, said main and relay switches each having two closed positions, an open position between the two closed positions, and an intermediate position between the open position and each closed position, means for supplying different voltages when the main switch is in its closed positions respectively, the main switch connecting the first terminal to said tube in both the closed and intermediate positions, and means interconnecting the main and relay switches for conjoint operation so that they are always in corresponding positions, whereby the main switch first connects the first terminal to the tube when the main and relay switches are moved from the open to one of the intermediate positions, the main circuit then being completed by the relay contacts after all three switches are in the closed position.

2. Apparatus of the character referred to comprising a tube having a cathode and anode, a main circuit having two terminals for connection to an alternating power source to supply an anode potential to the tube, an auxiliary circuit for supplying heating current to the cathode, a main switch connecting one of said terminals to said tube, a relay having contacts connecting the other of said terminals to said tube thereby energizing the main circuit to impress a potential upon said anode, an auxiliary switch for controlling both the auxiliary circuit and the relay, a relay switch in series with said auxiliary switch for conjointly controlling the relay, said main and relay switches each having open, closed and intermediate positions, the main switch connecting the first terminal to said tube in both the closed and intermediate positions, and means interconnecting the main and relay switches for conjoint operation so that the main switch first connects the first terminal to the tube when the main and relay switches are moved from the open to one of the intermediate positions, the main circuit then being completed by the relay contacts after all three switches are in the closed position, said relay being slow-acting so that the main circuit is not closed until a predetermined time after heating current is supplied to the cathode.

3. Apparatus of the character referred to comprising a tube having a cathode and anode, a main circuit having two terminals for connection to an alternating power source to supply an anode potential to the tube, an auxiliary circuit for supplying heating current to the cathode, a main switch connecting one of said terminals to said tube, a relay having contacts connecting the other of said terminals to said tube thereby energizing the main circuit to impress a potential upon said anode, an auxiliary switch for controlling both the auxiliary circuit and the relay, a relay switch in series with said auxiliary switch for conjointly controlling the relay, said main and relay switches each having open, closed and intermediate positions, the main switch connecting the first terminal to said tube in both the closed and intermediate positions, and means interconnecting the main and relay switches for conjoint operation so that the main switch first connects the first terminal to the tube when the main and relay switches are moved from the open to one of the intermediate positions, the main circuit then being completed by the relay contacts after all three switches are in the closed position.

4. Apparatus of the character referred to comprising a tube having a cathode and anode, a main circuit having two terminals for connection to an alternating power source to supply an anode potential to the tube, an auxiliary circuit for supplying heating current to the cathode, a main switch connecting one of said terminals to said tube, a relay having contacts connecting the other of said terminals to said tube thereby energizing the main circuit to impress a potential upon said anode, an auxiliary switch for controlling both the auxiliary circuit and the relay, a relay switch in series with said auxiliary switch for conjointly controlling the relay, said main and relay switches each having open, closed and intermediate positions, the main switch connecting the first terminal to said tube in both the closed and intermediate positions, and means interconnecting the

main and relay switches for conjoint operation so that they are always in corresponding positions, whereby the main switch first connects the first terminal to the tube when the main and relay switches are moved from the open to one of the intermediate positions, the main circuit then being completed by the relay contacts after all three switches are in the closed position.

5. Apparatus of the character referred to comprising an electrical circuit having two terminals for connection to an alternating power source, a main switch for connecting one of said terminals to said circuit, a relay having contacts connecting the other of said terminals to said circuit, a relay switch for controlling the relay, each of said switches having open, closed and intermediate positions, the main switch connecting the first terminal to said tube in both the closed and intermediate positions, and means interconnecting the switches for conjoint operation so that they are always in corresponding positions, whereby the main switch first connects the first terminal to the tube when the main and relay switches are moved from the open to one of the intermediate positions, the main circuit then being completed by the relay contacts after all three switches are in the closed position.

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