

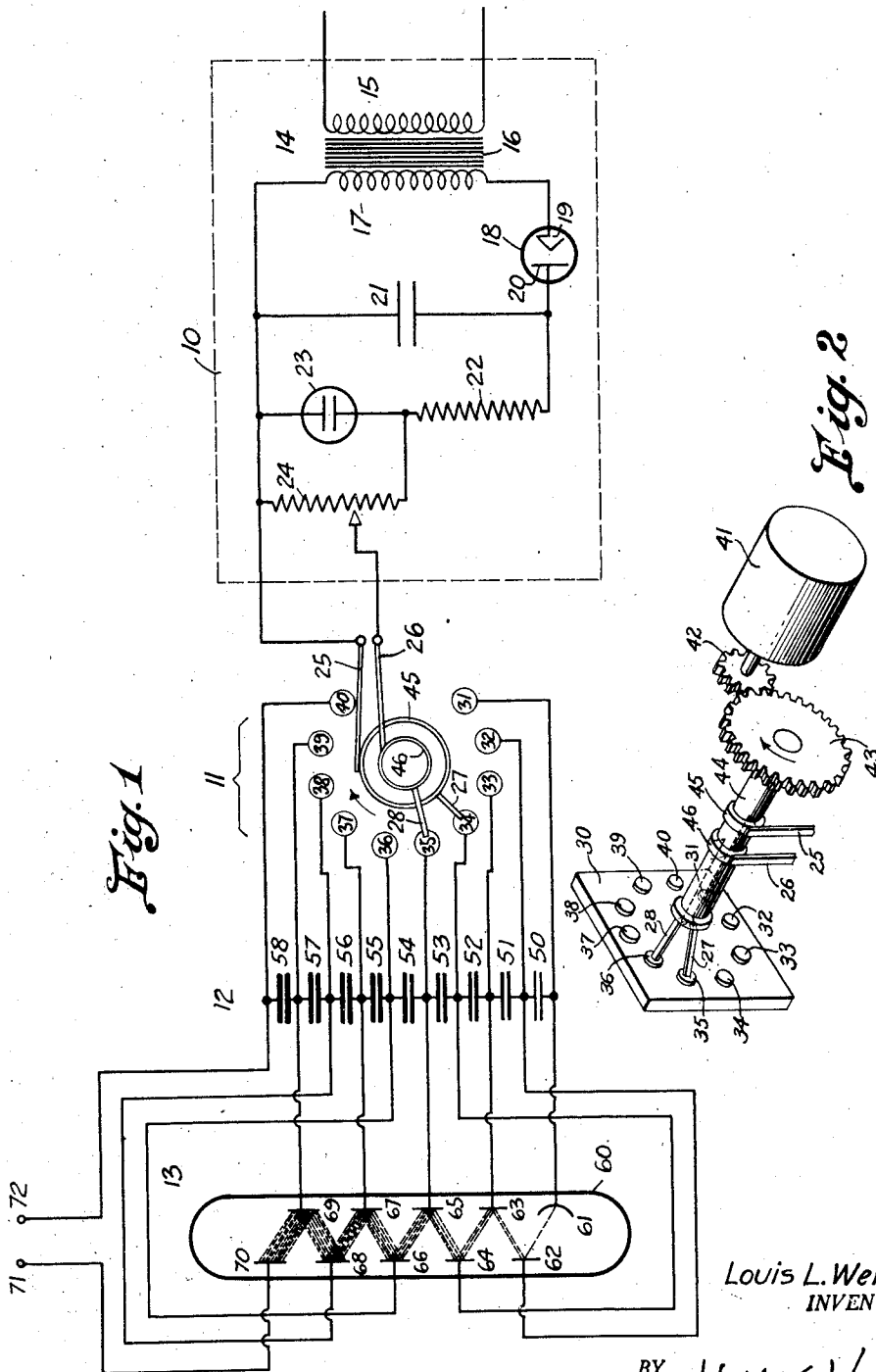
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VOLTAGE SUPPLY SYSTEM FOR AMPLIFIERS OF THE ELECTRON MULTIPLIER TYPE

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VOLTAGE SUPPLY SYSTEM FOR AMPLIFIERS
OF THE ELECTRON MULTIPLIER TYPE

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Amplifiers of the electron multiplier type are distinguished from the conventional type since they are not based on the control of the stream of electrons by a grid but make use of the phenomenon of secondary emission. They consist essentially of an evacuated glass vessel equipped with a plurality of electrodes. The first electrode is made to emit a relatively small number of electrons which are made to impinge upon the second electrode where they knock out secondary electrons. The number of these secondary electrons is larger than the number of the original or primary electrons and the faculty of the tube to amplify currents or "multiply" electrons is based on this fact. The secondary electrons emitted by the second electrode are, in turn, made to impinge upon the third electrode where they knock out tertiary electrons in still larger numbers, and this is repeated at every subsequent electrode so that eventually a very high amplification factor can be obtained.

A typical multiplier tube has 10 electrodes and requires a voltage of the general order of 100 volts between two subsequent electrodes. The multiplication factor of the tube is extremely sensitive to the voltage applied between stages, and increases roughly with the 7th power of this voltage. A suitable voltage supply system should, therefore, consist of a source of D. C. of the general order of 1000 volts subdivided in 10 equal steps, for example, and these voltages must be constant and, in particular, independent of accidental line voltage fluctuations. The design of a suitable system is, therefore, not simple and systems which fulfill these conditions are liable to be complicated, physically bulky and expensive. There is also an element of danger involved since D. C. voltages of the order of 1000 volts may become quite dangerous.

It is the purpose of this invention to provide a voltage supply system for an electron multiplier tube, which meets these conditions and which, at the same time, is very simple, physically of small bulk, inexpensive, and for all practical purposes, not dangerous. This is achieved by providing a battery of series connected capacitors or condensers, a rotating switch driven by a small motor, and a source of stabilized D. C. voltage of the general order of 100 volts, i. e., approximately as large as the required voltage for one stage. This voltage, through the rotating switch, is impressed during the rotation of this switching on each individual capacitor, thereby charging it. The energy stored in each capacitor must, of course, be large as compared to the energy

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flowing out of it between subsequent revolutions of the switch so that the voltage decreases only by a relatively small amount between subsequent revolutions. Since the energy stored in the capacitors is limited, a person coming accidentally in contact with the high voltage will only be exposed to a limited amount of stored energy and, therefore, this shock will be relatively harmless.

At the present time, multiplier tubes are used predominately in connection with photo-electric applications, i. e., the first electrode receives a photo-emissive coating and becomes, upon being illuminated, a source of electrons. However, the voltage supply system described here is not necessarily limited to tubes of this type and may be broadly applied to any electron multiplier tube.

In the drawings,

Fig. 1 shows the electrical circuit of this invention; and

Fig. 2 shows diagrammatically in axiometric projection the rotating switch which forms an important part of this invention.

Referring to Fig. 1, the circuit consists of four principal parts, i. e., a source of stabilized D. C. voltage of approximately 100 volts 10, the rotating switch 11, the condenser battery 12, and the electron multiplier tube 13.

The source of stabilized D. C. voltage 10 may be of any conceivable design and composition and it will be understood that the example shown in this specification is merely a typical one and that many other circuits can be substituted without departing from the spirit of this invention. In this particular instance, I am using a transformer 14 which comprises a primary coil 15, an iron core 16 and a secondary coil 17. One end of the secondary coil 17 is connected to one end of a rectifier tube 18 which comprises a hot cathode 19 and an anode 20. The hot cathode 19 is supplied with filament current in the customary way, for example, from a separate small transformer or from an extra winding on transformer 14. These expedients are well known and are, therefore, not shown in the diagram. A capacitor 21 is provided, one terminal of which is connected to the plate 20 of the rectifier tube and the other end to the free end of the transformer secondary coil 17. The two terminals of the condenser are connected to a load circuit which consists of a resistance 22 in series with a gas filled regulator tube 23. The voltage across the regulator tube 23 is substantially constant and independent of the load and, therefore, independent of the line voltage impressed upon by the transformer pri-

mary coil 15. This is a well known expedient used extensively for radio and other applications to provide a stabilized voltage. It must again be emphasized that this expedient is only a typical example and that stabilized voltages can very well be obtained by other means. A potentiometer 24 is connected across the voltage regulator 23 by means of which the output voltage of the D. C. supply source may be conveniently adjusted.

This stabilized D. C. of approximately 100 volts is connected to two brushes 25 and 26 of the motor driven rotating switch 11. Referring to Fig. 2, this switch consists of a plate 30 made from any suitable insulating material. On this plate are mounted switch buttons 31 to 40. A small motor 41 drives through gears 42 and 43, a shaft 44 which again is made from a suitable insulating material. Mounted on this shaft are two metallic slip rings 45 and 46 which are in contact with the aforementioned brushes 25 and 26. The two other brushes 27 and 28 are mounted at the end of the insulating shaft 44 in the manner shown in Fig. 2. Brush 28 is conductively connected to ring 46 and brush 27 is conductively connected to ring 45. The insulating shaft 44 is, of course, supported in suitable bearings which, however, are not shown in the drawings. Brushes 27 and 28 rotate, therefore, and periodically connect the D. C. voltage furnished by assembly 10 to two of the buttons 31 to 40.

The condenser battery 12 consists of nine series connected individual condensers 50 to 58. These condensers are connected to the switch buttons 31 to 40 in the manner shown in Fig. 1, and also connected to the electrodes of the multiplier tube 13.

This electron multiplier tube is shown schematically and consists of the glass vessel 60, the first electrode 61, which is assumed to be photo-emissive and subsequent electrodes 62 to 70. It can be seen that the connection between the last electrode 70 and the last condenser 58 has been interrupted to form terminals 71 and 72. The output of the amplifier tube can be taken off from these two terminals and these terminals may, for instance, be connected to a micro- or milliamperemeter or to a relay or to a thyatron or to any other desired load device. I have schematically shown the streams of electrons in dotted lines, but it must be realized, of course, that in reality the stream of electrons increases much more rapidly than could be shown schematically in the drawing.

From the foregoing, the working function of the device can be readily understood. A D. C. voltage of approximately 100 volts is furnished by the assembly 10 consisting essentially of a transformer, a rectifying tube and a capacitor, and this voltage is stabilized, i. e., made independent of line voltage fluctuations, by the gas filled stabilizing tube 23. By means of the rotating switch 11, this voltage is impressed consecutively upon each of the condensers 50 to 58, thereby charging the condensers substantially to a voltage of approximately 100 volts each. The energy stored in the condensers is relatively large compared to the energy taken out of them between revolutions of the rotating switch and, therefore, the individual condenser voltages will decrease only slightly from the time they are charged during one revolution until they are being recharged during the next revolution of the switch. Each condenser impresses its voltage upon one stage of the multiplier tube, thereby accelerating the

electrons between subsequent stages. Since the voltage across stabilizing the tube 23 is constant and independent of the line voltage, the voltage impressed upon the individual condensers and also the voltage impressed upon each stage of the multiplier tube is equally independent of the line voltage and for all practical purposes, constant. The energy stored in the condenser battery is relatively small and any accidental contact with the high voltage will be relatively harmless.

As explained before, the number of electrons emitted by subsequent electrodes increases very rapidly so that the various condensers do not have to support equal currents, but the current flowing out of the first condenser 50 is extremely small, the current flowing out of subsequent condensers 52, 53, etc., becomes larger and the current flowing out of condenser 58 which energizes a load device is relatively quite large. It is, therefore, expedient to make the size of these condensers not equal, but start with a relatively small condenser 50, and make subsequent condensers 52, 53, etc. larger and larger and the last condenser 58 quite large.

It is obvious that many changes of form, proportions and minor details of construction may be resorted to without departing from the principles or sacrificing any of the advantages of the invention as defined in the appended claims.

What I claim as new, is:

1. An amplifying system, comprising an amplifying tube, a condenser battery, a rotating switch, and a source of direct current, said amplifying tube being of the electron multiplier type including an evacuated glass vessel and a number of electrodes, said battery consisting of series connected condensers large enough to store sufficient energy to substantially maintain a constant voltage between adjacent electrodes of the multiplier tube for the length of time required for one revolution of the rotating switch, the number of said condensers being one less than the number of tube electrodes, said switch comprising a number of stationary, insulated and circularly disposed switch buttons, said number being equal to the number of said tube electrodes, and a rotatably supported assembly comprising two insulated contact brushes and two insulated slip rings, one contact brush connected to one and the other contact brush to the other of said slip rings, means to rotate said assembly continuously during the operation of the device, said contact brushes being so disposed as to contact during their rotation two adjacent switch buttons, respectively, and two stationary contacts cooperating with said rotating slip rings, the first terminal of the first condenser being connected to the first tube electrode and to the first switch button, the second terminal of the first condenser being connected to the first terminal of the second condenser and to the second tube electrode and to the second switch button, the second terminal of the second condenser being connected to the first terminal of the third condenser and to the third tube electrode and to the third switch button, and subsequent condenser terminals, tube electrodes and switch button connected in like manner, the second terminal of the last condenser being connected to the last switch button, the connection between said last condenser terminal and the last tube electrode being interrupted for the insertion of a load device, said source of direct current supplying a voltage substantially as high as that required between two adjacent tube electrodes, and being connected to the aforementioned

tioned two stationary contacts cooperating with said two slip rings.

2. An amplifying system, comprising an amplifying tube, a condenser battery, a rotating switch, and a source of direct current, said amplifying tube being of the electron multiplier type including an evacuated glass vessel and a number of electrodes, said battery consisting of series connected condensers large enough to store sufficient energy to substantially maintain a constant voltage between adjacent electrodes of the multiplier tube for the length of time required for one revolution of the rotating switch, the number of said condensers being one less than the number of tube electrodes, said switch comprising a number of stationary, insulated and circularly disposed switch buttons, said number being equal to the number of said tube electrodes, and a rotatably supported assembly comprising two insulated contact brushes and two insulated slip rings, one contact brush connected to one and the other contact brush to the other of said slip rings, means to rotate said assembly continuously during the operation of the device, said contact brushes being so disposed as to contact during their rotation two adjacent switch buttons, respectively, and two stationary contacts cooperating with said rotating slip rings, the first terminal of the first condenser being connected to the first tube electrode and to the first switch button, the second terminal of the first condenser being connected to the first terminal of the second condenser and to the second tube electrode and to the second switch button, the second terminal of the second condenser being connected to the first terminal of the third condenser and to the third tube electrode and to the third switch button, and subsequent condenser terminals, tube electrodes and switch button connected in like manner, the second terminal of the last condenser being connected to the last switch button, the connection between said last condenser terminal and the last tube electrode being interrupted for the insertion of a load device, the individual condensers of said condenser battery being of unequal size, the condenser connected to the first electrode being quite small, subsequent condensers being larger, and the last condenser which is connected to the load device and to the last electrode being the largest, said source of direct current supplying a voltage substantially as high as that required between two adjacent tube electrodes, and being connected to the aforementioned two stationary contacts cooperating with said two slip rings.

3. An amplifying system, comprising an amplifying tube, a condenser battery, a rotating switch, and a source of direct current adapted to be energized from an ordinary A. C. power line, said amplifying tube being of the electron multiplier type including an evacuated glass vessel and a number of electrodes, said battery consisting of series connected condensers large enough to store sufficient energy to substantially maintain a constant voltage between adjacent electrodes of the multiplier tube for the length of time required for one revolution of the rotating switch, the number of said condensers being one less than the number of tube electrodes, said switch comprising a number of stationary, insulated and circularly disposed switch buttons, said number being equal to the number of said tube electrodes, and a rotatably supported assembly comprising two insulated contact brushes and two insulated slip rings, one contact brush connected to one

and the other contact brush to the other of said slip rings, means to rotate said assembly continuously during the operation of the device, said contact brushes being so disposed as to contact during their rotation two adjacent switch buttons, respectively, and two stationary contacts cooperating with said rotating slip rings, the first terminal of the first condenser being connected to the first tube electrode and to the first switch button, the second terminal of the first condenser being connected to the first terminal of the second condenser and to the second tube electrode and to the second switch button, the second terminal of the second condenser being connected to the first terminal of the third condenser and to the third tube electrode and to the third switch button, and subsequent condenser terminals, tube electrodes and switch button connected in like manner, the second terminal of the last condenser being connected to the last switch button, the connection between said last condenser terminal and the last tube electrode being interrupted for the insertion of a load device, said source of direct current supplying a voltage substantially as high as that required between two adjacent tube electrodes, and being connected to the aforementioned two stationary contacts cooperating with said two slip rings.

4. An amplifying system, comprising an amplifying tube, a condenser battery, a rotating switch, and a source of direct current including a stabilizing device rendering the output voltage substantially constant and independent of small line voltage fluctuations, said amplifying tube being of the electron multiplier type including an evacuated glass vessel and a number of electrodes, said battery consisting of series connected condensers large enough to store sufficient energy to substantially maintain a constant voltage between adjacent electrodes of the multiplier tube for the length of time required for one revolution of the rotating switch, the number of said condensers being one less than the number of tube electrodes, said switch comprising a number of stationary, insulated and circularly disposed switch buttons, said number being equal to the number of said tube electrodes, and a rotatably supported assembly comprising two insulated contact brushes and two insulated slip rings, one contact brush connected to one and the other contact brush to the other of said slip rings, means to rotate said assembly continuously during the operation of the device, said contact brushes being so disposed as to contact during their rotation two adjacent switch buttons, respectively, and two stationary contacts cooperating with said rotating slip rings, the first terminal of the first condenser being connected to the first tube electrode and to the first switch button, the second terminal of the first condenser being connected to the first terminal of the second condenser and to the second tube electrode and to the second switch button, the second terminal of the second condenser being connected to the first terminal of the third condenser and to the third tube electrode and to the third switch button, and subsequent condenser terminals, tube electrodes and switch button connected in like manner, the second terminal of the last condenser being connected to the last switch button, the connection between said last condenser terminal and the last tube electrode being interrupted for the insertion of a load device, said source of direct current supplying a voltage substantially as high as that required between two

adjacent tube electrodes, and being connected to the aforementioned two stationary contacts cooperating with said two slip rings.

5. An amplifying system, comprising an amplifying tube, a condenser battery, a rotating switch, and a source of direct current adapted to be energized from an ordinary A. C. power line, said amplifying tube being of the electron multiplier type including an evacuated glass vessel and a number of electrodes, said battery consisting of series connected condensers large enough to store sufficient energy to substantially maintain a constant voltage between adjacent electrodes of the multiplier tube for the length of time required for one revolution of the rotating switch, the number of said condensers being one less than the number of tube electrodes, said switch comprising a number of stationary, insulated and circularly disposed switch buttons, said number being equal to the number of said tube electrodes, and a rotatably supported assembly comprising two insulated contact brushes and two insulated slip rings, one contact brush connected to one and the other contact brush to the other of said slip rings, means to rotate said assembly continuously during the operation of the device, said contact brushes being so disposed as to contact during their rotation two adjacent switch buttons, respectively, and two stationary contacts cooperating with said rotating slip rings, the first terminal of the first condenser being connected to the first tube electrode and to the first switch button, the second terminal of the first condenser being connected to the first terminal of the second condenser and to the second tube electrode and to the second switch button, the second terminal of the second condenser being connected to the first terminal of the third condenser and to the third tube electrode and to the third switch button, and subsequent condenser terminals, tube electrodes and switch button connected in like manner, the second terminal of the last condenser being connected to the last switch button, the connection between said last condenser terminal and the last tube electrode being interrupted for the insertion of a load device, the individual condensers of said condenser battery being of unequal size, the condenser connected to the first electrode being quite small, subsequent condensers being larger, and the last condenser which is connected to the load device and to the last electrode being the largest, said source of direct current supplying a voltage substantially as high as that required between two adjacent tube electrodes, and being connected to the aforementioned two stationary contacts cooperating with said two slip rings.

6. An amplifying system, comprising an amplifying tube, a condenser battery, a rotating switch, and a source of direct current adapted to be energized from an ordinary A. C. power line including a stabilizing device rendering the output voltage substantially constant and independent of small line voltage fluctuations, said amplifying tube being of the electron multiplier type including an evacuated glass vessel and a number of electrodes, said battery consisting of series connected condensers large enough to store sufficient energy to substantially maintain a constant voltage between adjacent electrodes of the multiplier tube for the length of time required for one revolution of the rotating switch, the number of said condensers being one less than the number of tube electrodes, said switch comprising a number

switch buttons, said number being equal to the number of said tube electrodes, and a rotatably supported assembly comprising two insulated contact brushes and two insulated slip rings, one contact brush connected to one and the other contact brush to the other of said slip rings, means to rotate said assembly continuously during the operation of the device, said contact brushes being so disposed as to contact during their rotation two adjacent switch buttons, respectively, and two stationary contacts cooperating with said rotating slip rings, the first terminal of the first condenser being connected to the first tube electrode and to the first switch button, the second terminal of the first condenser being connected to the first terminal of the second condenser and to the second tube electrode and to the second switch button, the second terminal of the second condenser being connected to the first terminal of the third condenser and to the third tube electrode and to the third switch button, and subsequent condenser terminals, tube electrodes and switch button connected in like manner, the second terminal of the last condenser being connected to the last switch button, the connection between said last condenser terminal and the last tube electrode being interrupted for the insertion of a load device, said source of direct current supplying a voltage substantially as high as that required between two adjacent tube electrodes, and being connected to the aforementioned two stationary contacts cooperating with said two slip rings.

7. An amplifying system, comprising an amplifying tube, a condenser battery, a rotating switch, and a source of direct current adapted to be energized from an ordinary A. C. power line including a stabilizing device rendering the output voltage substantially constant and independent of small line voltage fluctuations, said amplifying tube being of the electron multiplier type including an evacuated glass vessel and a number of electrodes, said battery consisting of series connected condensers large enough to store sufficient energy to substantially maintain a constant voltage between adjacent electrodes of the multiplier tube for the length of time required for one revolution of the rotating switch, the number of said condensers being one less than the number of tube electrodes, said switch comprising a number of stationary, insulated and circularly disposed switch buttons, said number being equal to the number of said tube electrodes, and a rotatably supported assembly comprising two insulated contact brushes and two insulated slip rings, one contact brush connected to one and the other contact brush to the other of said slip rings, means to rotate said assembly continuously during the operation of the device, said contact brushes being so disposed as to contact during their rotation two adjacent switch buttons, respectively, and two stationary contacts cooperating with said rotating slip rings, the first terminal of the first condenser being connected to the first tube electrode and to the first switch button, the second terminal of the first condenser being connected to the first terminal of the second condenser and to the second tube electrode and to the second switch button, the second terminal of the second condenser being connected to the first terminal of the third condenser and to the third tube electrode and to the third switch button, and subsequent condenser terminals, tube electrodes and switch button connected in like manner, the second terminal of the last condenser

being connected to the last switch button, the connection between said last condenser terminal and the last tube electrode being interrupted for the insertion of a load device, the individual condensers of said condenser battery being of unequal size, the condenser connected to the first electrode being quite small, subsequent condensers being larger, and the last condenser which is connected to the load device and to the last electrode being the largest, said source of direct current supplying a voltage substantially as high as that required between two adjacent tube electrodes, and being connected to the aforemen-

tioned two stationary contacts cooperating with said two slip rings.

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