Q. A. BRACKETT.

EXCESS VOLTAGE PROTECTIVE DEVICE.

APPLICATION FILED AUG. 8, 1919.

1,345,066. **Patented June 29, 1920.**

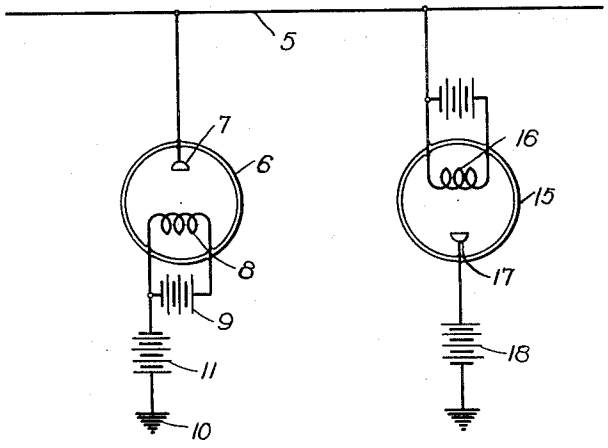


Fig. 1.

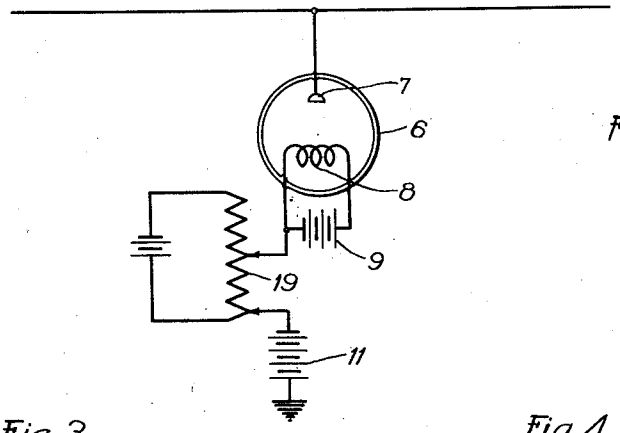


Fig. 2.

Fig. 3.

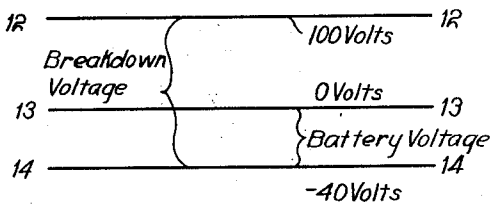
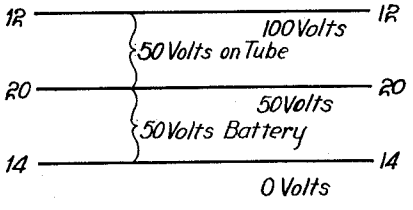


Fig. 4.



WITNESSES:

H. B. Trunk.

A. Davis

INVENTOR

Quincy A. Brackett.

BY

Wesley G. Carr

ATTORNEY

UNITED STATES PATENT OFFICE.

QUINCY A. BRACKETT, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

EXCESS-VOLTAGE PROTECTIVE DEVICE.

1,345,066. Specification of Letters Patent. Patented June 29, 1920.

Application filed August 8, 1919. Serial No. 316,076.

To all whom it may concern:

Be it known that I, QUINCY A. BRACKETT, a citizen of the United States, and a resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Excess-Voltage Protective Devices, of which the following is a specification.

My invention relates to excess-voltage protective devices, and it has for its object to provide apparatus of the character designated that shall be simple and reliable in construction and extremely sensitive in its settings, permitting the elimination of voltages very slightly in excess of normal, irrespective of the magnitude of the normal voltages.

In the accompanying drawing, Figure 1 is a diagrammatic view of a pair of units constructed in accordance with my invention and arranged to discharge excess voltages of either polarity from a line; Fig. 2 is a similar view of a unit modified in order to prevent short-circuiting of the system; and Figs. 3 and 4 are voltage diagrams illustrating the potential distribution in devices embodying my invention.

In my copending application, Serial No. 271,493 filed Jan. 16, 1919, and assigned to the Westinghouse Electric & Manufacturing Company, I describe and claim means whereby excess voltages are diverted from wireless receiving systems by vacuum electric devices connected in shunt relation to these receiving circuits, the vacuum electric devices being given a setting such as to break down at slightly above normal voltage.

According to the present invention, I also use electron tubes as valves for discharging excess voltage and I further combine electromotive force sources therewith in such manner as to adjust the discharge voltage to any desired amount, thus causing the device to be as sensitive as is desired.

Under certain conditions, a system of the foregoing character operates substantially as a dead short-circuit on the system and, under these conditions, I may combine a source of back-electromotive-force therewith in order to hold down the discharge current, all as will hereinafter more fully appear.

Referring now to Fig. 1 for a more detailed understanding of my invention, I show a line wire at 5 and let it be assumed for the moment, for simplicity of description, that this wire is always maintained at positive potential with respect to ground. An electron tube 6 is provided having an anode 7 and an electron-emitting cathode 8, the latter being shown as of the hot-filament type and as obtaining heating current from an auxiliary battery 9. The anode 7 is connected to the line wire 5 and the cathode 8 is connected to ground at 10 through a source of unidirectional electromotive force 11, the negative pole of the latter being connected to the cathode 8. By varying the electromotive force of the source 11, the breakdown voltage of the entire system may be adjusted, as will appear from the following considerations.

Turning to Fig. 3, let the abscissa 12—12 represent the potential of the line 5, such, for example, as +100 volts. Ground or zero potential is shown by an abscissa 13—13 and, if the breakdown voltage of the device 6 be assumed at 150 volts, the electromotive-force source 11 is adjusted to provide, for example, 40 volts, so that the cathode 8 is held, for example, at —40 volts, as indicated by an abscissa 14—14. Thus, under normal conditions, the arc space within the tube 6 is subject to a strain of 140 volts, whereas, it does not break down until subject to 150 volts.

Let it now be assumed that the potential of the line 5 rises from any cause, such, for example, as lightning or switching surges. As soon as it attains a value of +110 volts, the potential difference across the tube is 150 volts and the tube breaks down, permitting discharge from the line 5 to ground, the electromotive force of the source 11 being in such direction as to assist this discharge. Thus, the energy of the line 5 is quickly removed and, if the source 11 is of insufficient electromotive force to maintain the tube 6 in an active condition, discharge ceases.

Obviously, if the source 11 were adjusted to 45 volts, it would have been necessary for the potential of the line 5 to rise to only 105 volts before discharge is initiated and thus my system is susceptible of the utmost flexibility of adjustment.

If it be assumed that the line 5 is subject to an alternating electromotive force so that, for example, it oscillates between +100 and −100 in potential, it is necessary merely to duplicate my discharge system, as further shown in Fig. 1, a tube 15 having a cathode 16 connected to the line and an anode 17 connected to ground through an electromotive force source 18 having its negative pole grounded. The operation of this last-described system upon a slight excess of negative potential will be obvious from the foregoing description and by the joint use of the tubes 6 and 15, the line 5 is protected, irrespective of the pulsating and the excess voltages applied thereto.

As above intimated, if the adjusting source 11 or 18 is of too great a magnitude, it may maintain current flow through the current tube after the excess voltage has been removed from the line and, for this reason, it is desirable to interpose a source of back electromotive force in the discharge path in order to snuff out the follow-up current. Thus, in the system of Fig. 2, a tube 8, as before, is grounded through a source 11 and also through a small source of unidirectional electromotive force 19, indicated as a potentiometer, the electromotive force impressed thereby upon the discharge circuit being in the reverse direction from that provided by the source 11.

In operation, this system is similar to that of Fig. 1, except that upon the cessation of abnormal voltage, the auxiliary source 19 tends to snuff out the follow-up current.

Up to this point, I have described the use of my system in such manner that the breakdown voltage of the tube was in excess of the normal operating voltage of the line, so that the voltage of the auxiliary or boosting battery was necessarily added to the line voltage in order to produce the desired breakdown voltage. Obviously, this arrangement may be radically modified in that a tube having a breakdown voltage less than line potential may be employed and an auxiliary electromotive force source may be connected in series therewith in such manner as to lower the net or resultant electromotive force applied to the tube rather than raising the same, as previously described. This is clearly shown by reference to Fig. 4. Thus, let the line 5 be assumed to have a potential of +100 volts, as indicated by an abscissa 12—12, and the potential of ground may be indicated by a zero abscissa 14—14. Assuming that a 60 volt tube is available, the booster battery is adjusted at 50 volts in such direction of polarity as to subject the cathode of the tube to a potential of +50 as indicated by an abscissa 20—20. Thus, the normal electromotive force impressed upon the electron tube is 50 volts and is insufficient to cause the break-down thereof but, upon the potential of the line 5 rising to 110 volts, the net electromotive force impressed upon the electron tube is sufficient to cause the breakdown thereof and the line is, therefore, discharged. Thus, in its broadest aspects, my invention may be stated as employing an electron tube having a breakdown potential of "M" volts for the protection of a system having a normal potential of "N" volts by the use of a booster battery in series with said tube and across said system, said booster battery having a value somewhat in excess of the algebraic difference between "M" and "N", this excess being the desired margin of operation before the tube discharges to protect the system.

A system of the character described is susceptible of the widest variety of application and of the utmost flexibility of design. Thus, the electron tubes 6 and 15 may be of the gas-filled type and have a breakdown voltage of but a few volts, so as to be well adapted for the protection of very low-potential systems, as used in wireless and in other forms of signaling; or the electron tubes may be of the highly-exhausted type and have a breakdown potential of many thousand volts, thus rendering the system applicable for use in connection with high-voltage transmission systems.

While I have shown my invention in its preferred forms, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various minor changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereoupon as are imposed by the prior art or specifically set forth in the appended claims.

I claim as my invention:

1. In a protective system, the combination with two conducting members between which a given potential is normally maintained and between which it is undesirable that a voltage materially in excess thereof shall obtain, of a circuit therebetween, said circuit including an electron tube having a breakdown voltage in excess of said normal voltage and a source of electromotive force connected in such direction as to lower the net breakdown voltage of the discharge path to a value nearer said normal voltage.

2. The combination with a line wire normally maintained at a given potential from another conducting member, of a rectifying electron tube and a source of electromotive force connected between said line wire and said member, said tube being connected in such direction that said normal potential tends to produce current flow from the anode to the cathode thereof, the breakdown voltage of said tube being in excess of said normal voltage, and a source of electromo-

tive force further connected in said circuit in such direction as to raise the resultant electromotive force impressed upon said tube to an amount slightly less than its breakdown value.

3. The combination with two conducting members subject to a predetermined difference of potential of either polarity, of two conducting paths therebetween, one of said conducting paths including a rectifying electron tube having a breakdown voltage greater than the normal electromotive force between said conducting members and having its anodes connected to one of said members and its cathode connected to the other thereof in series with a source of electromotive force connected in such direction as to raise the net electromotive force on said tube nearer to its breakdown value and the other of said conducting paths including a similar electron tube and electromotive-force source connected in the opposite polarity with respect to said conducting members, whereby, upon the potential difference between said members exceeding the normal amount in each direction, one of said discharge paths breaks down to protect the system.

4. The combination with a line wire maintained at a predetermined potential difference from a conducting member, of a discharge path therebetween comprising an electron tube having a breakdown potential greater than said normal line-wire potential and connected in such direction as to permit current flow therethrough in response to said line-wire potential, a source of unidirectional electromotive force in series with said tube and connected in such direction that it raises the effective electromotive force on said tube to a value nearer breakdown potential, and an additional source of unidirectional electromotive force connected in said discharge path in opposition to the first named source of electromotive force and tending to suppress the follow-up currents.

5. The method of operating an electron tube as a discharge device to protect a circuit having a normal potential less than the breakdown voltage of said tube which comprises connecting said tube across said circuit in series with a source of electromotive force of such magnitude and in such direction as to raise the effective voltage upon said tube nearer to breakdown value.

6. The method of operating an electron tube having a given breakdown voltage in the protection of a line of given voltage, wherein the breakdown voltage of the tube is different from the desired breakdown voltage of the system, which comprises combining with said tube a source of electromotive force of such magnitude and polarity that the resultant voltage impressed upon the tube shall be nearer the breakdown voltage of the tube.

7. The combination with an electric circuit having a normal potential difference thereacross of "M" volts, of a rectifying electron tube having a breakdown voltage of "N" volts connected across said circuit and a booster battery in series with said rectifying device and having a normal voltage slightly less than the algebraic difference of the "M" and "N" volts, whereby, upon the increase of "M" to a slight degree, said rectifying device discharges.

8. The combination with an electrical circuit having a normal potential of "M" volts thereacross, of a protective electron tube of the rectifier type connected thereacross and having a breakdown potential of "N" volts, a booster battery connected in series with said tube and having a normal voltage slightly less than the algebraic difference between "M" and "N," and an additional source of unidirectional electromotive force also connected in the discharge path and having such value as to tend to prevent the flow of follow-up currents through the tube after the breakdown thereof by a surge of excess voltage in said circuit.

In testimony whereof, I have hereunto subscribed my name this 30th day of July, 1919.

QUINCY A. BRACKETT.