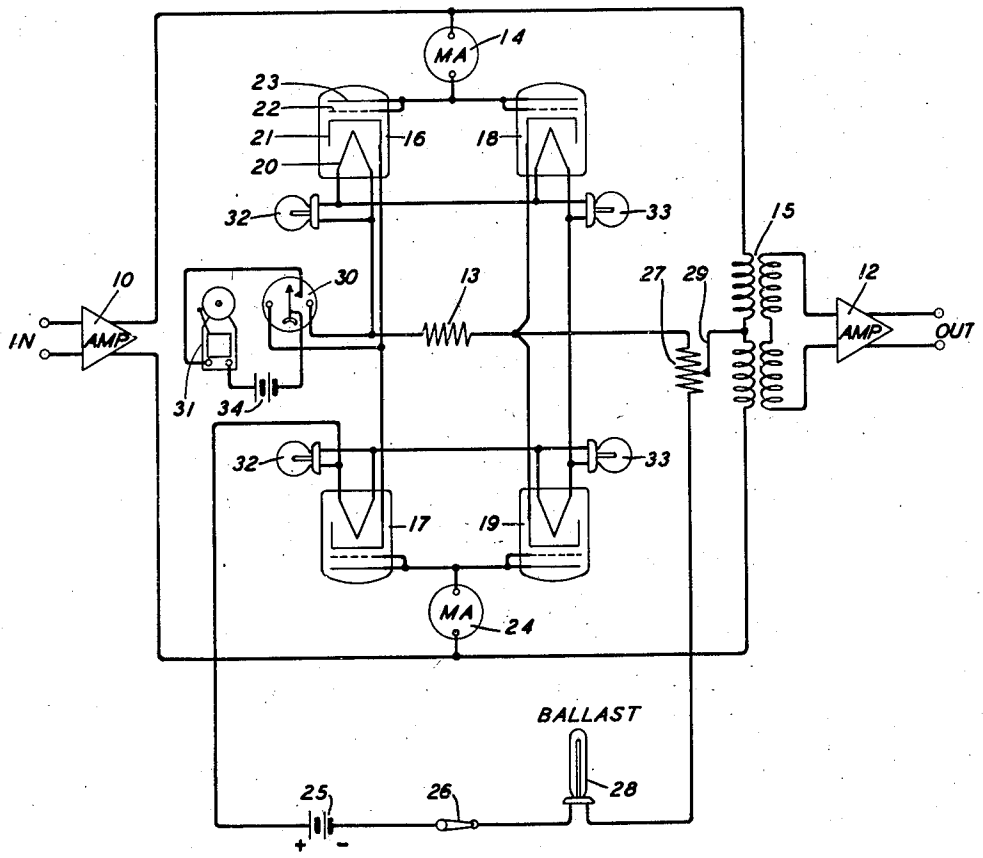
Aug. 2, 1932. I. E. COLE 1,869,466

VOLTAGE LIMITER

Filed June 25, 1931

11



INVENTOR
I. E. COLE
BY H. A. Burgess
ATTORNEY

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IRA E. COLE, OF MONTCLAIR, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

VOLTAGE LIMITER

Application filed June 25, 1931. Serial No. 546,681.

The present invention relates to peak voltage limiting circuits employing space discharge devices and has particular reference to voltage limiters for use in circuits carrying alternating current for signaling purposes such, for example, as speech currents.

The present invention is in the nature of an improvement on the peak voltage limiter disclosed and claimed in application for United States Letters Patent Serial No. 523,682 of William A. Knoop, filed March 19, 1931. The present specification will be confined for the most part to the features of improvement and the Knoop application may be referred to for a complete disclosure of the voltage limiting circuit as a whole, its mode of operation and the general characteristics which it possesses.

That application discloses the use of a plurality of gas-filled discharge tubes connected in shunt relation across the line on which the peak voltage is to be limited. It is pointed out in that application that if the pairs of tubes have slightly different operating characteristics, the pair of tubes of lower breakdown voltage will normally act as limiters, and the other pair or pairs will be held in reserve in case of failure of the first pair of tubes.

The main object of the present invention is to provide a definite biasing agency permitting tubes of the same characteristic to be used and at the same time insuring that a pair of tubes will be held in reserve, the normal limiting function being carried out by another pair of tubes.

The nature of the present invention will be more fully understood from the following detailed description in connection with the attached drawing, the single figure of which shows a schematic circuit diagram of a peak voltage limiter of the type disclosed in Fig. 1 of the Knoop application referred to, with the improvement feature of the present invention added thereto.

Referring to the drawing, the peak voltage limiting part of the circuit, 11, is included between the incoming amplifier 10 and the outgoing amplifier 12, as in the case of the Knoop application disclosure. Also, the gas-filled discharge tubes 16, 17, 18 and 19 may be identical with the correspondingly numbered discharge tubes of the Knoop application. For example, space discharge tube 16 may be taken as typical, comprising a cathode 21 equipped with a heating element 20 in the form of a filament, a grid or control element 22 and a plate or anode 23, the last two elements being indicated as connected together. Each of the other tubes is similar. The manner in which these four discharge tubes are connected across the line is the same as that disclosed in the Knoop application, except that applicant has shown included in the connection two milliammeters 14 and 24 which may, however, be omitted if desired. These meters show the total discharge current when the tubes are operating. The general manner of association of the tubes 16 and 18 with the upper half of the primary of output transformer 15 and the manner of association of the tubes 17 and 19 with the lower half of this winding, is similar to the disclosure of the Knoop application. However, the connection between the elements of the cathode heating circuit and the cathodes themselves as well as the association of these elements with the remaining portions of the system, are different from the Knoop application disclosure and constitute the improvement features of the present invention. These will now be described in detail.

The heating circuit for the cathodes of the tubes is as follows: Battery 25, right-hand terminal, normally closed switch 26, ballast lamp 28, resistance 27, resistance 13, filament 20 of tube 16 and thence through the corresponding filaments of tubes 18, 19 and 17 in series, back to the left-hand pole of battery 25. Lamps 32 and 33, one in shunt to each

of the filaments, are also included in the circuit above traced, but so long as the heating elements 20 are intact, the current which flows through the lamps is too small to illuminate them. When one of the heating filaments such as 20, however, burns out, the associated lamp 32 carries the total current in the circuit and this is sufficient to illuminate it, giving an indication of which tube has failed.

In the above traced circuit for supplying current to the heaters of the tubes 16 to 19, the resistance 27 is a counterpart of resistance 27 in the Knoop application disclosure. Lead 29 connecting to the midpoint of the primary winding of output transformer 15 is attached to a movable point on this resistance. The direction of current flow through the resistances 27 and 13 is such that the cathode end of resistance 27 is positive and the end of resistance 13 connected to the cathodes of tubes 16 and 17 is positive. Meter 30 is connected between resistance 13 and the cathodes of tubes 16 and 17 for a purpose to be described presently. As in the Knoop application, the limiting voltage may be adjusted by varying the amount of resistance 27 that is included between the lead 29 and the cathodes of the discharge tubes.

The use of resistance 13 in accordance with the present invention enables the potential of tubes 18 and 19 to be fixed definitely with respect to the cathodes of the tubes 16 and 17. Let it be assumed that all of the discharge tubes have incidentally the same characteristics. Resistance 13 may have, let us say, a very small value such as one-half ohm. For a heating current of 1.5 amperes the drop across resistance 13 would then be 0.75 volt. The cathodes of the tubes 16 and 17 are, therefore, slightly positive with respect to the cathodes of tubes 18 and 19, the actual voltage difference being the IR drop through resistance 13 produced by the flow of the filament heating current therethrough. The cathode-anode voltage across each of tubes 16 and 17 in the direction to make the anodes position is, for a given line voltage, under the conditions assumed, three-quarters of a volt less than the cathode-anode voltage across the other two devices 18 and 19 in the same direction. An increase in voltage across the line, such as to cause either device 18 or 19 to become conducting, will leave the corresponding tube 16 or 17 with too low a terminal voltage to break it down. As soon as either tube 18 or 19 breaks down, its internal resistance falls to a small fraction of its former value and any tendency to increase the voltage across it results in increased current flow with little, if any, change in anode-cathode voltage drop, as is pointed out more fully in the Knoop application. On account of this fact, a very small difference in normal potential between the cathodes of the pair of tubes 16 and 17 and those of tubes 18 and 19 will serve to insure that the tubes 18 and 19 act exclusively as the voltage limiting tubes, while tubes 16 and 17 are held in reserve.

With continued use, the tubes will show a lowering of cathode efficiency which may prevent a tube, say tube 18, from breaking down at its normal anode voltage. Reserve tube 16 will then take up the limiting action at a slightly higher voltage, as above described. Similarly, reserve tube 17 acts when tube 19 fails. Whenever tube 16 or 17 transmits current, the current passes through contact-making milliammeter 30 causing it to close its contact and actuate the alarm 31 by current from battery 34. This is notice to an attendant to test and possibly replace either or both tubes 18 and 19.

The burning out of a filament of any tube is shown by illumination of the corresponding lamp 32 or 33.

What is claimed is:

1. In a voltage limiting circuit, two hot-cathode gas-filled space discharge devices each having its discharge space terminals connected in shunt relation to the circuit on which the voltage is to be limited, and means applying a steady difference of potential between an electrode of one device and an electrode of the other to give a lower breakdown voltage to one than to the other device.

2. The combination with a circuit on which the voltage is to be limited, of a plurality of pairs of space discharge devices, each pair being connected in respectively reverse direction across said circuit, and means applying a steady difference of potential between corresponding electrodes of different pairs to give one pair a different breakdown voltage from that of another pair.

3. In a voltage limiting circuit for a line, two pairs of space discharge tubes, each pair having its discharge spaces connected serially and in respectively opposed direction in shunt relation to said line, the tubes of each pair being connected respectively between one side of the line and a neutral point, and means causing one pair to have a lower breakdown voltage than the other comprising a source of potential normally biasing the tubes of one pair.

4. A voltage limiting circuit according to claim 3, in which said tubes include cathodes adapted to be heated, a cathode heating circuit common to both pairs of tubes, and a steady source of voltage supplying heating current to said circuit, said source also supplying said bias potential.

5. A voltage limiting circuit for a line comprising an inductance shunting said line and provided with a mid-tap, a plurality of hot-cathode gas-filled discharge tubes similarly connected between said mid-tap and one side of said line, a plurality of hot-cathode gas-filled discharge tubes similarly connected

between said mid-tap and the other side of the line, a common cathode heating circuit for said tubes and a resistance included in said heating circuit and connected between the cathodes of certain of said tubes whereby two of said tubes on opposite sides of said mid-tap are biased to possess a lower breakdown voltage than the remaining two tubes.

In witness whereof, I hereunto subscribe my name, this 23d day of June, 1931.

IRA E. COLE.