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VOLTAGE LIMITER

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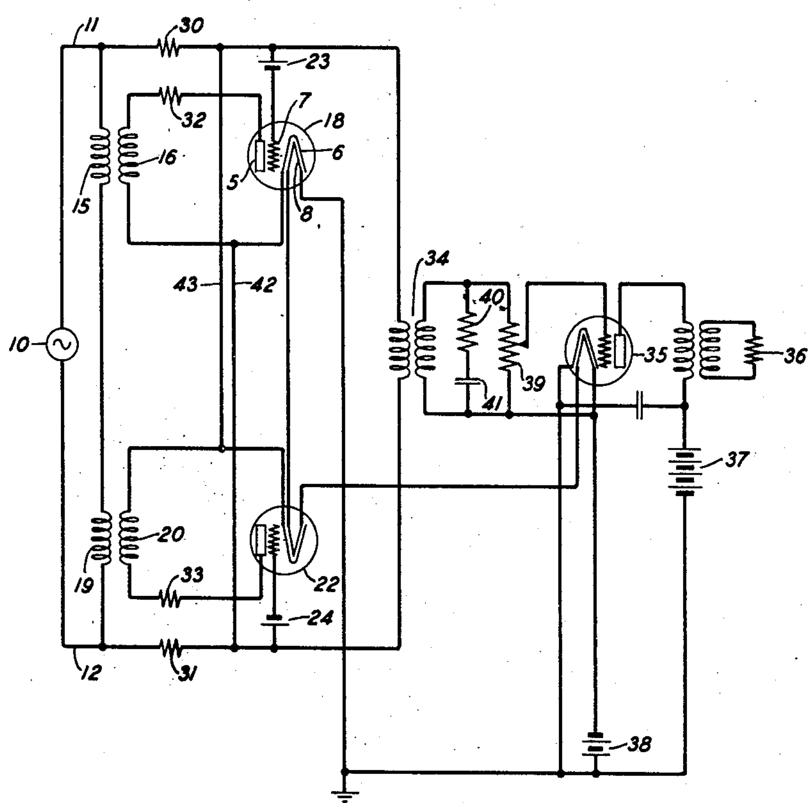

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VOLTAGE LIMITER

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This invention relates to voltage limiting apparatus, and more particularly to an arrangement including gaseous discharge devices for limiting voltages in alternating current transmission systems.

Voltage limiting circuits employing gaseous discharge devices have been used heretofore to protect alternating current transmission systems from excessive voltages. One such circuit is disclosed in the patent of A. M. Curtis No. 1,937,143 issued November 28, 1933, and comprises a pair of gaseous discharge devices each having a cathode, anode and control electrode and connected between the two branches of the system such that the control electrodes and cathodes provide bridging paths of opposite polarity for shunting excess current between the branches when discharge is instituted in the gaseous devices by voltages applied across the anodes and cathodes thereof.

A control transformer having its primary winding connected in shunt of the two branches and the secondary windings associated therewith and applied across the respective anodes and cathodes serves to supply voltage for instituting discharge in one or in both gaseous devices. Once discharge is instituted it is maintained solely by a relatively small voltage of the order of 3 volts applied to the control electrode of each gaseous device. The use of the control electrode in this manner is necessary for the reason that once discharge is instituted a substantially "dead" short circuit is established across the primary winding of the control transformer and the voltages now induced in the associated secondary winding and applied across the respective anodes and cathodes are below the amount required to maintain discharge. Hence the maintenance of the discharged condition must be placed under control of the control electrode of each gaseous device.

The present invention contemplates a voltage limiting arrangement employing gaseous discharge devices and in which discharge in the latter is not only instituted by a voltage applied across the respective anodes and cathodes but is also maintained by the voltage impressed thereon.

In a preferred embodiment the invention comprises two impedances one of which is disposed in each branch of the system between the points to which are connected the primary winding of a control transformer and the control electrodes of a pair of gaseous devices connected to provide two bridging paths across the system in the manner aforementioned. As discharge in one or in both gaseous devices is instituted both impedances are included in each bridging path to cause in the secondary winding of the control transformer the induction of a voltage that, when applied across the respective anodes and cathodes, is sufficient to maintain discharge so long as a voltage above normal value is present in the system. According to this invention, therefore, the primary winding of the control transformer is not short-circuited during discharge as both impedances are connected in the bridging paths regardless of the polarity of the voltage causing the discharge.

This invention will be more readily understood from the following description taken together with the accompanying drawing, the single figure of which is a diagrammatic circuit illustrating the preferred embodiment thereof.

Referring to the drawing a source **10** supplies waves of alternating current voltage through a transmission system comprising branches **11** and **12** across which are bridged primary windings **15** and **19** of a control transformer whose secondary windings **16** and **20** are applied across the anodes and cathodes of the respective gaseous discharge devices **18** and **22**. The associated windings **15** and **16** step up the voltage for one-half of waves drawn from the system while the associated windings **19** and **20** step up the voltage for the other half of waves also drawn from the system. The value of the combined impedance of the primary windings **15** and **19** is such that substantially none of the current in the normal transmission range is shunted across the branches **11** and **12**.

Each of the gaseous devices is preferably of a type described in the patent of A. M. Curtis, supra, and embodies an anode **5**, a cathode **6**, a control electrode **7** and a cathode heater **8**. Also, each gaseous device has its control electrode connected to one branch and its cathode to the opposite branch so that a bridging path is provided thereby for shunting excess current across the system when discharge in instituted in a manner that will be subsequently explained. The bridging paths are normally interrupted through the gaseous devices during the transmission of voltages falling within a normal range.

The operation of the above voltage limiter is briefly as follows:

As voltages of a normal range are being transmitted in the system no shunting action takes place due to the infinitely large impedance of each gaseous device. During such intervals, however, the relatively high combined impedance of the primary windings **15** and **19** permits small amounts of current to flow therethrough so that the voltages induced in the respective secondary windings **16** and **20** are of a magnitude less than that required to break down or discharge either one or both of the gaseous devices.

As the voltages in the system rise above the normal range the current flowing in the primary windings 15 and 19 increases until eventually voltages induced in either secondary winding 16 or secondary winding 20 or both attain a value equal to at least the discharge voltage of the respective gaseous devices. As a result one or both of the gaseous devices is discharged depending on the polarity of the applied wave. The discharge produces a flow of space current between the respective control electrodes and cathodes to establish a bridging path between branches 11 and 12 whereby excess current is shunted directly across the system. This shunting of current insures that the voltage applied across the primary winding of a step-up transformer 34 will be limited to at least a predetermined maximum value notwithstanding that voltages above the normal range are present in branches 11 and 12.

In discharging, the initial infinite impedance of the control electrode-cathode path of each gaseous device is considerably reduced so that in effect a substantially "dead" short circuit is established across the primary windings 15 and 19. As the impedance of the primary windings 15 and 19 is relatively high as compared with the reduced impedance of the bridging path extending through the discharged gaseous device very little current will flow through the primary windings 15 and 19. Hence any voltage now induced in either secondary winding 16 or secondary winding 20 will be relatively small and below that amount required to maintain a discharged condition in the gaseous devices. Consequently, it is necessary to maintain the discharged condition under control of the voltages impressed on the respective control electrodes. As pointed out in the patent of A. M. Curtis, supra, a voltage of the order of three volts impressed on a control electrode is sufficient to maintain the discharge condition and therefore so long as this voltage is supplied the system will be protected against excessive voltages. When, however, the voltage applied to either control electrode falls below three volts, the gaseous device associated therewith will return to the undischarged condition and thereby terminate the flow of current in the bridging paths established as described above.

In accordance wih the present invention the discharge of gaseous devices utilized in voltage limiting circuits of the type hereinbefore described is not only instituted but also maintained by voltages applied across the respective anodes and cathodes thereof instead of by the voltage impressed on the control electrode as in the similar circuit disclosed in the patent of A. M. Curtis, supra.

To effectuate both the institution and maintenance of discharge under control of anode-cathode voltages an impedance 30 of the order of 10,000 ohms is interposed in the branch 11 between the points to which are connected one end of the primary winding 15 and the control electrode of gaseous device 18, and an impedance 31 of similar order is interposed in branch 12 between the points to which are connected the opposite end of the primary winding 19 and the control electrode of gaseous device 22. Also an impedance 32 of the order of 100,000 ohms is connected in the anode-cathode circuit of the gaseous device 18 while a similar impedance 33 is connected in the anode-cathode circuit of gaseous device 22. The impedances 32 and 33 are proportioned to limit the current flowing in the respective anode-cathode circuits. Batteries 23 and 24 are utilized to bias the control electrodes of the gaseous devices 18 and 22, respectively, so as to prevent discharge in any manner other than by that which will be hereinafter explained.

The secondary winding of the coupling transformer 34 is connected across the input of thermionic amplifier 35 whose output is connected to a load 36. Battery 37 supplies plate potential for this amplifier while battery 38 energizes the heaters associated therewith and also those associated with the gaseous devices 18 and 22. Potentiometer 39 bridged across the input of the thermionic amplifier provides an adjustment for controlling the gain thereof. Resistance 40 and condenser 41 connected in series across the secondary winding of the transformer 34 serves to even off the frequency characteristic of the thermionic amplifier.

Assuming current of requisite polarity flowing in primary winding 15 so as to induce in its associated secondary winding 16 a voltage which is at least adequate to institute discharge of gaseous device 18, then current will flow in a bridge circuit comprising branch 11, impedance 30, control electrode and cathode of gaseous device 18, lead 42, impedance 31 and branch 12. Since the primary windings 15 and 19 and the impedances 30 and 31 are connected in parallel, the voltage developed across the impedances 30 and 31 will also be applied across the primary windings 15 and 19. Now, the bridging paths including the impedances 30 and 31 supplant the substantially "dead" short circuit that was established across the primary windings 15 and 19 in the prior art circuit hereinbefore described. Therefore, a portion of the current that would flow in the bridging path in accordance with the prior art circuit will now be diverted into windings 15 and 19.

This additional current causes in associated secondary winding 15, the induction of a voltage of the same polarity that initially caused the discharge of gaseous device 18 and to an amount that maintains the gaseous device 18 in the discharged state. So long as sufficient current of requisite polarity flows through the bridging path extending through the gaseous device 18 to cause in the secondary 16 the induction of a voltage which is at least equal to the discharge voltage of the gaseous device 18, this condition will be maintained. When, however, the current of requisite polarity flowing in the branches 11 and 12 falls to the normal range, current flowing in the bridging path and primary winding 15 will be correspondingly reduced. Hence the voltage induced in the associated secondary winding 16 will be reduced to the cut-off level of the gaseous device 18 to discontinue the discharge thereof. Obviously, when this occurs the bridging path mentioned above is interrupted and transmission in the system again proceeds on a normal basis.

Assuming a current of requisite polarity flowing in the primary winding 19 to cause the discharge of gaseous device 22 in the manner similar to that hereinbefore mentioned in connection with gaseous device 18, current will flow in a bridging path comprising branch 12, impedance 31, control electrode and cathode of gaseous device 22, lead 43, impedance 30 and branch 11. This bridging path shunting current across the system develops across impedances 30 and 31 a voltage that will increase the flow of current of requisite polarity in primary winding 19 in the manner hereinbefore mentioned relative to a gaseous device

18. Hence the increased voltage induced in associated secondary winding 20 maintains the gaseous device 22 in the discharged state. When the current of the polarity that caused the initial discharge of gaseous device 22 falls to within a normal range, this gaseous device will return to the undischarged state and, of course, the bridging path extending therethrough will be interrupted. Thereafter transmission will proceed on a normal basis.

It is seen therefore that impedances 30 and 31 together with the primary windings 15 and 19 and associated secondary windings 16 and 20, cause anode-cathode voltages that both institute and maintain the discharge of the gaseous devices regardless of the voltage impressed on the respective control electrodes. In the arrangement according to this invention, minimum amounts of anode-cathode voltage of opposite polarity required for maintaining discharge are attained before the minimum amounts of voltage applied to the control electrode for the same purpose are reached. Consequently, the present invention provides an extremely sensitive and quick-acting voltage limiting arrangement for protecting an alternating current transmission system from excessive voltages.

Amplifier 35 is utilized to compensate for whatever losses occur in impedances 30 and 31 when the invention is employed in a signaling transmission system and may be omitted when the invention is otherwise utilized.

It is understood that the invention is capable of modifications other than that disclosed herein and the scope thereof together with such modifications is defined in the appended claims.

What is claimed is:

1. In an alternating current transmission system including in combination means for protecting the system from excessive voltages of either polarity comprising a pair of gaseous discharge devices each having a cathode, anode and control electrode and connected in the system such that the control electrodes and cathodes provide bridging paths of opposite polarity for shunting excess current across the system when discharge therein is instituted by an adequate voltage impressed on the respective anodes and cathodes, a circuit connected in shunt of the system for receiving a voltage therefrom, means for coupling the circuit to the anode and cathode of each gaseous device to apply thereto a higher voltage than is received from the system so as to institute discharge in one or in both gaseous devices as the voltage in the system rises above a normal value; means included in the bridging paths and responsive to the current flowing therein for supplying voltage to the circuit and thereby to the coupling means to maintain discharge in one or in both gaseous devices so long as the voltage in the system continues in excess of a normal value.

2. The alternating current transmission system according to claim 1 in which the last-mentioned means is an impedance connected in each branch of the system between the points to which the circuit and control electrodes are connected.

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