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W. H. T. HOLDEN

ELECTRICAL PROTECTIVE DEVICE

Original Filed Dec. 30, 1922

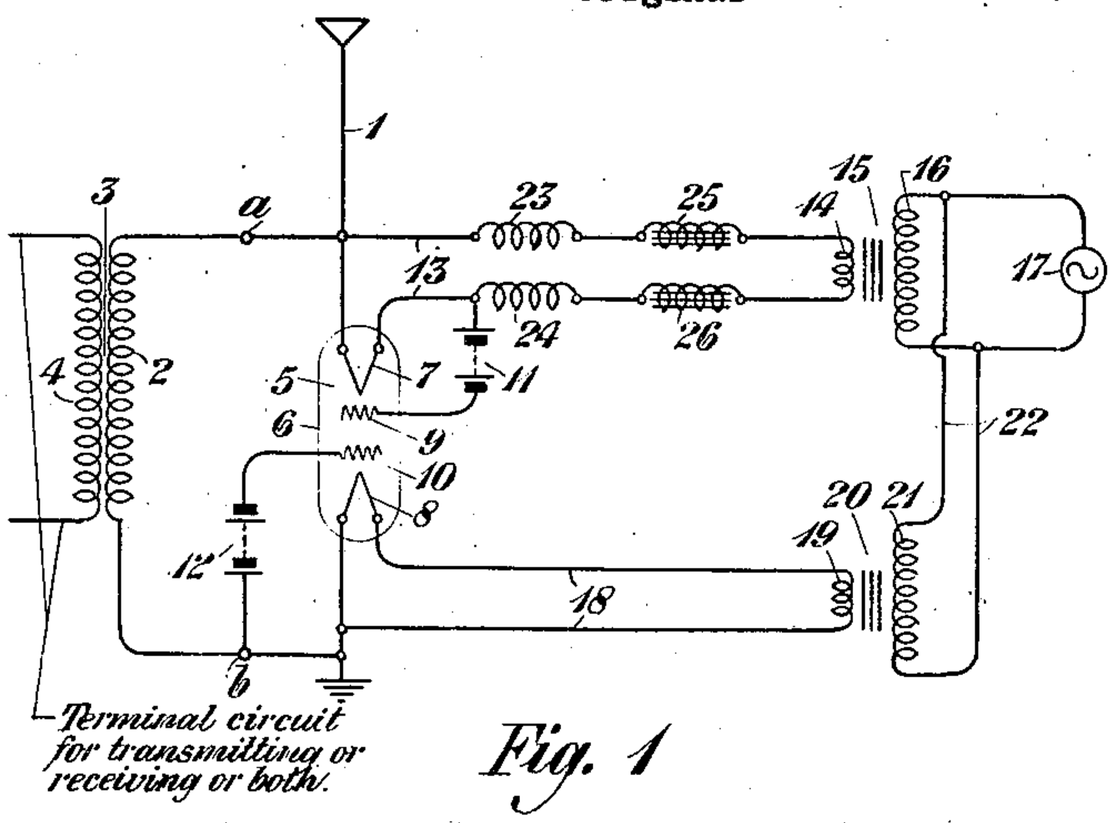

Fig. 1

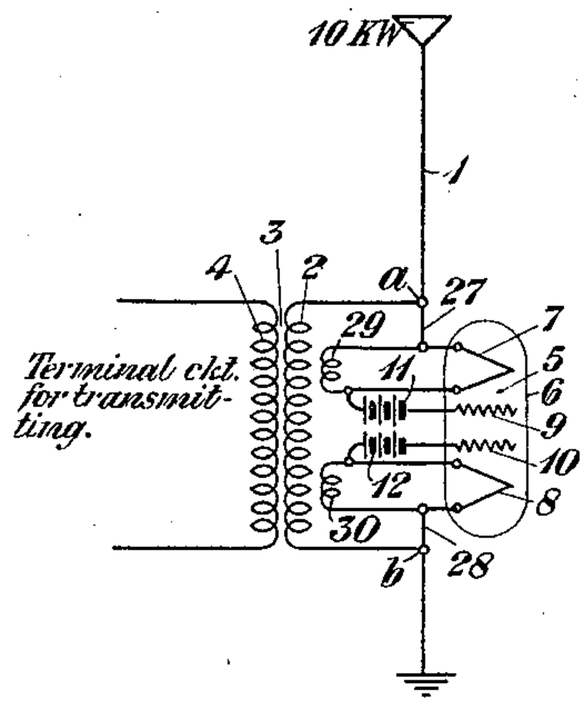

Fig. 2

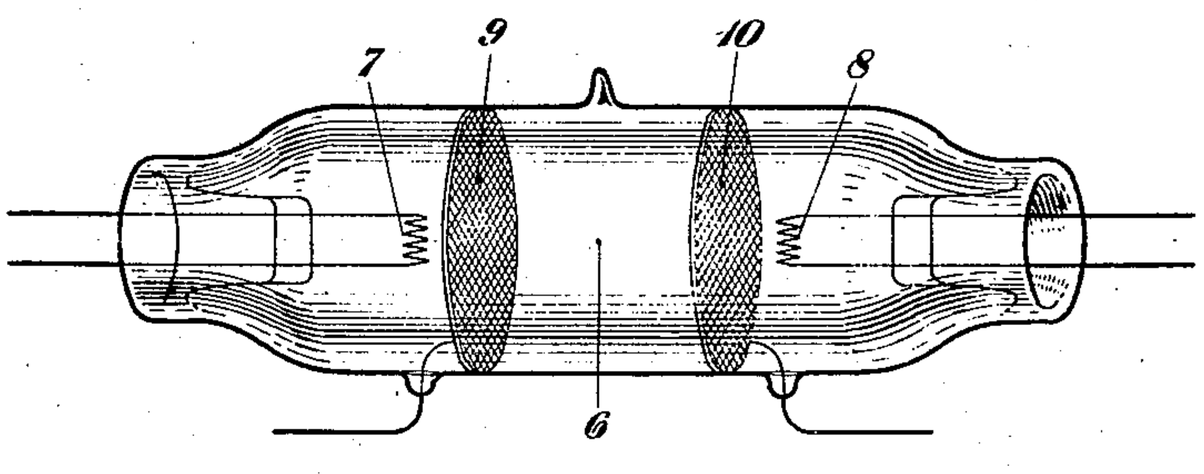

Fig. 3

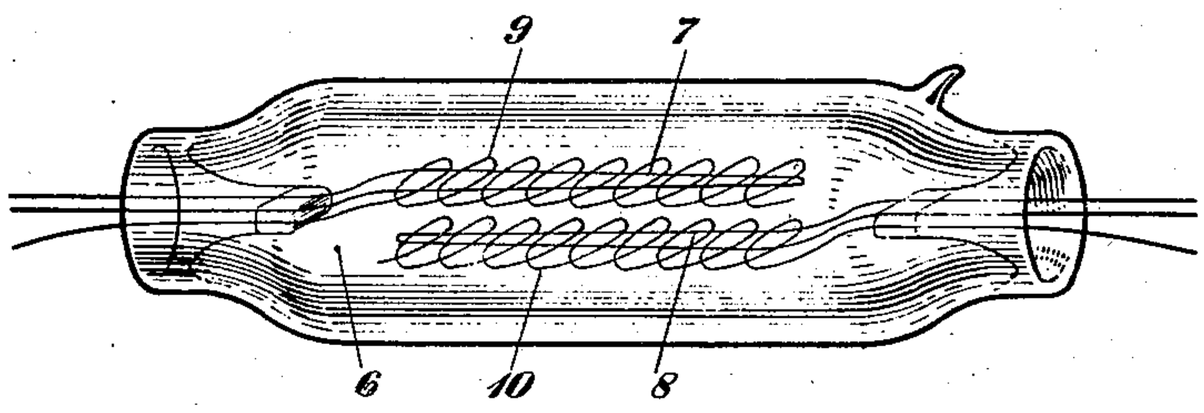

Fig. 4

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UNITED STATES PATENT OFFICE.

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ELECTRICAL PROTECTIVE DEVICE.

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To all whom it may concern:

Be it known that I, WILLIAM H. T. HOLDEN, a citizen of the United States, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Electrical Protective Devices, of which the following is a specification.

This invention relates to electrical protective devices and particularly to means for protecting a radio signaling system from the effects of high potentials set up in the antenna circuit of such systems by causes usually arising from sources external to the signaling system itself.

In the operation of radio signaling systems, high potential surges or oscillations, which may be set up in such systems by static or lightning, are capable not only of producing serious effects upon the apparatus associated with the signaling circuit but also present a great hazard to the operator of such circuit. Such high, transient voltages may cause not only a burn-out in some part of the apparatus that is unable to withstand the high voltage, but also severe injury to the station operator.

It is the object of this invention to provide means for substantially eliminating the hazard to the operator as well as the effect upon the physical structure of the radio circuit of high potential surges or oscillations set up in the antenna circuit by static, lightning or other causes.

This invention will be clearly understood from the following description when read in connection with the attached drawing of which Figure 1 shows a radio signaling circuit with a thermionic protective device associated therewith constituting one form of embodiment of the invention; Fig. 2 shows another form of embodiment of the invention, and Figs. 3 and 4 show two types of thermionic discharge devices which may be used in connection with the circuits shown in Figs. 1 and 2.

In the circuit shown in Fig. 1 the antenna 1 has connected in series therewith to ground the winding 2 of the transformer 3, the other winding 4 of which is connected with a terminal circuit which may be adapted either to transmit or receive or to perform both of these functions. The circuit connected with winding 4 may be of any well-known type of terminal circuit adapted to perform any or all of the functions just mentioned. A thermionic discharge device 5 is connected with the antenna 1 and is therein effectively bridged across the terminals of the antenna winding 2 of the transformer 3. This thermionic device has a highly evacuated envelope 6 in which a plurality of electrodes are inserted and sealed so as to maintain a high degree of vacuum. The electrodes 7 and 8 are adapted to be heated by current from a source 17 of low frequency alternating current, the manner of doing which will be later made clear. As will be noticed, the filaments 7 and 8 are effectively connected with the terminals of the antenna winding 2. The cold electrodes or grids 9 and 10 are also effectively connected with the corresponding terminals of the winding 2 to which the filaments 7 and 8 are connected. These grids are biased negatively by means of the batteries or equivalent sources of direct current 11 and 12. The filament 7 is connected by the conductors 13 with one of the windings 14 of the transformer 15, the other winding 16 of which is connected with the source of low frequency alternating current 17. Connected in series with the conductor 13 are the windings 23, 24, 25 and 26 of choke coils. The transformer 15 is preferably of the iron-core type designed to readily transmit low frequency currents but to offer high impedance to high frequency currents. The object of the choke coils designated 23 to 26 inclusive is to prevent high frequency currents from passing through the transformer 15 by virtue of the capacity that may exist between the windings of this transformer. In similar manner the filament 8 is connected by the conductors 18 with the winding 19 of the transformer 20, the other winding 21 of which is connected by the conductors 22 with the source of low frequency current 17. The magnitude of the filament heating current might be controlled by proper adjustment of the voltage of the source 17 or in other ways that will readily occur to one skilled in the art.

In the operation of the afore-described system embodying my invention, when the maximum signal voltage to be transmitted is

applied by the transformer 3 across the antenna winding 2, a space current would flow between the cathodes 7 and 8 if these cathodes were heated and no potential was applied to the grids. Since it is not desired to have the protective device operate within the limits of the signaling voltage, the grids 9 and 10 are biased negatively by the direct current sources 11 and 12 in order to prevent the flow of any space current between the cathodes 7 and 8 when the voltage across the terminals of the winding 2 is not greater than the maximum signal voltage to be transmitted from the antenna 1. If, however, a high voltage surge or oscillation is set up in the antenna 1 (and consequently in the winding 2), the magnitude of which is greater than the maximum signal voltage that would be impressed across the said winding 2, the potential between cathodes 7 and 8 would cause a flow of space current therebetween which would shunt the winding 2 of the transformer 3 and greatly minimize not only the electrical stresses that might be placed upon the physical apparatus associated with the terminal circuit but would also greatly minimize the hazard to which the operator might thereby be subjected. When the voltage produced by the surge diminishes to the value for which the grids would be sufficiently negative to prevent the flow of space current between the said cathodes, the shunt across the terminals of the winding 2 would then be effectively and automatically removed.

Although the device 5 is represented as a four-electrode device, it is electrically equivalent to two three-electrode devices. This will be apparent if, for example, consideration be given to the conditions existing when the terminal *a* is positive and the terminal *b* negative. At this instant the electrode 7 will be positive whereas not only will the electrode 8 be negative, but also the grid 10 associated therewith will be negative. So that the electrodes 8 and 10 are, in effect, equivalent to a single electrode, and therefore under the assumed condition the thermionic device 5 is equivalent to a three-electrode device. A similar condition exists when the point *b* is positive and *a* is negative. Under this condition the electrodes 7 and 9 would both be negative, and accordingly the device 5 would be equivalent to a three-electrode device.

While the arrangement shown in Fig. 2 differs structurally from that shown in Fig. 1, it is in principle substantially the same as that shown in Fig. 1. The principal difference between the two arrangements resides in the fact that in the circuit shown in Fig. 2 the filament heating current is derived from the source of high frequency oscillations whereas in the circuit of Fig. 1 this current was obtained from a source of low frequency current 17. In the arrangement shown in Fig. 2, in which the same numerals have been used to represent parts that are the same as in Fig. 1, the transformer 3 has not only two main windings 2 and 4 which couple the terminal circuit to the antenna circuit, but also has auxiliary windings 29 and 30 which are connected with the filaments 7 and 8 of the thermionic device 5. By means of these auxiliary windings the required amount of current is obtained from the high frequency source to heat the filaments 7 and 8 in order to produce the necessary electron emission therefrom. The grids 9 and 10 which are biased negatively by the sources 11 and 12 are connected with the filaments 7 and 8 respectively. It will therefore be seen that the principle of operation of the circuit of Fig. 2 is substantially the same as that of Fig. 1 and further explanation need therefore not be given. The arrangement of Fig. 2 is, however, considered less desirable than that of Fig. 1 in view of the fact that it utilizes for the heating of the filaments the high frequency energy which as is well known is much more costly than the 60 cycle current such as would probably be used in the arrangement of Fig. 1.

Figs. 3 and 4 show two types of thermionic devices which may be used in the circuits of Figs. 1 and 2. In both of the devices shown in Figs. 3 and 4 the envelope 6 is highly evacuated, so that the resultant action of either type of device is entirely electronic and not by virtue of any gas that might be contained therein. In the arrangement shown in Fig. 3 the cathodes 7 and 8 are inserted in the ends of the tube and adapted to be connected with the external circuit by means of suitable leading-in wires. The cold electrodes or grids 9 and 10 may either be of the form shown in the figure or of any well-known type. These grids are also adapted to be connected with any external circuit by means of suitable leading-in wires. The form of tube shown in Fig. 4 is in some respects preferable to that shown in Fig. 3 in that in the former the leading-in wires for a filament and its associated grid are brought out at one end of the tube which therefore reduces the number of seals necessary and improves the construction generally.

While this invention has been shown as embodied in particular forms and arrangements of parts it is to be understood that it is not limited to the particular forms and arrangements shown but is capable of embodiment in other forms and arrangements within the spirit and scope of the appended claims.

What is claimed is:

1. In a radio signaling system, the combination with an antenna, of a terminal cir-

cuit, a coupling transformer having an antenna winding connected with the said antenna and a circuit winding connected with the said terminal circuit and a thermionic protective device bridged across the said antenna winding, the said protective device having an evacuated sealed envelope containing a cathode individual to and connected with each terminal of the said antenna winding, a grid individual to and connected with each terminal of the said antenna winding, a source of current for heating said cathodes, a source of potential to negatively bias each of the said grids with respect to the nearer cathode and means to prevent the flow of antenna currents over the circuit connecting the said source of heating current with the said cathodes.

2. In an electrical protective system, the combination with a circuit to be protected against abnormal voltages, of a source of normal voltage connected therewith for transmission thereover, a thermionic protective device connected with the said circuit having a cathode and a grid enclosed in an evacuated vessel, the said grid being biased negatively to the said cathode, a source of current to heat the said cathode, and means between the said source and the said cathode to prevent the dissipation of energy from the said source of normal voltage through the said source of heating current.

3. In an electrical protective system, the combination with a circuit to be protected against abnormal voltages, of a source of normal voltage connected therewith for transmission thereover, a thermionic protective device connected with the said circuit having a plurality of cathodes and a plurality of grids enclosed in an evacuated vessel, one of said cathodes and one of said grids being connected with one side of said circuit, and another cathode and another grid being connected with the other side of the said circuit, each grid being biased negatively to the nearer cathode, a source of current to heat the said cathodes, and means between the said source and one of said cathodes to prevent the dissipation of energy from the source of normal voltage through the source of heating current.

4. In an electrical protective system, the combination with a circuit to be protected against abnormal voltages, of a source of signaling potential connected therewith for transmission thereover, a thermionic protective device connected with the said circuit having a cathode and a grid enclosed in an evacuated vessel, a source of current connected with the said cathode to supply heating current thereto, means to bias negatively the said grid to prevent the passage through the thermionic device of currents of the normal signaling potential, and means connected between said cathode and the said source of heating current to prevent the dissipation of energy from the signaling source through the said source of heating current.

5. In an electrical protective system, the combination with a circuit to be protected against abnormal voltages, of a source of signaling potential connected therewith, a thermionic protective device having a plurality of cathodes and a plurality of grids in an evacuated vessel, one of said cathodes and one of said grids being connected with one side of the said circuit, another cathode and another grid being connected with the other side of the said circuit, a source of current connected with the said cathode to supply heating current thereto, means to negatively bias each of the said grids with respect to the nearer cathode to prevent the passage through the thermionic device of normal signaling currents, and means connected between the said cathode and the said source of heating current to prevent the dissipation of energy from the said signaling source through the source of heating current.

6. In a radio signaling system, the combination with an antenna, of an impedance connected in series therewith, and a thermionic protective device bridged across the said impedance, said device having an evacuated sealed envelope containing a heated electrode individual to and connected with each terminal of the said impedance and a cold electrode likewise individual to and connected with each terminal, both cold electrodes being within the space between the heated electrodes, and each cold electrode being negatively biased with respect to that heated electrode connected with the same terminal of said impedance to prevent the flow of space current between the said heated electrodes when the voltage across the said impedance does not exceed a certain critical value.

7. In a radio signaling system, the combination with a grounded antenna, of a coupling transformer having an antenna winding connected with said antenna and a circuit winding connected with a terminal circuit and a protective device also connected with the said antenna in parallel with the said antenna winding, the said protective device having an evacuated sealed envelope containing a heated electrode individual to and connected with each terminal of the said winding and a cold electrode likewise individual to and connected with each terminal, both cold electrodes being within the space between the heated electrodes, and each cold electrode being negatively biased with respect to that heated electrode connected with the same terminal of said impedance to prevent the flow of space current between

the said heated electrodes when the voltage across the said antenna winding is less than a certain critical value.

8. In a radio signaling system, the combination with an antenna, of a terminal circuit, a coupling transformer having an antenna winding connected with the said antenna and a circuit winding connected with the said terminal circuit, and a thermionic protective device having an evacuated sealed envelope containing a heated electrode individual to and connected with each terminal of the said antenna winding and a cold electrode likewise individual to and connected with each terminal, both cold electrodes being within the space between the heated electrodes, and each cold electrode being negatively biased with respect to that heated electrode connected with the same terminal to prevent the flow of space current between the said heated electrodes when the voltage across the said antenna winding is less than a certain critical value.

9. In a radio signaling system, the combination with an antenna, of a terminal circuit, a coupling transformer having an antenna winding connected with the said antenna and a circuit winding connected with the said terminal circuit and a thermionic device having a cathode individual to and connected with the terminals of the said antenna winding, a grid individual to and connected with the said terminals of the said antenna winding, the said grids being spaced between the said cathodes, means for heating said cathodes to produce electron emission and means for negatively biasing each of the said grids with respect to the nearer cathode to prevent the flow of space current between the said cathodes when the voltage across the said antenna winding is less than a certain critical value.

In testimony whereof, I have signed my name to this specification this 27th day of December, 1922.

WILLIAM H. T. HOLDEN.