

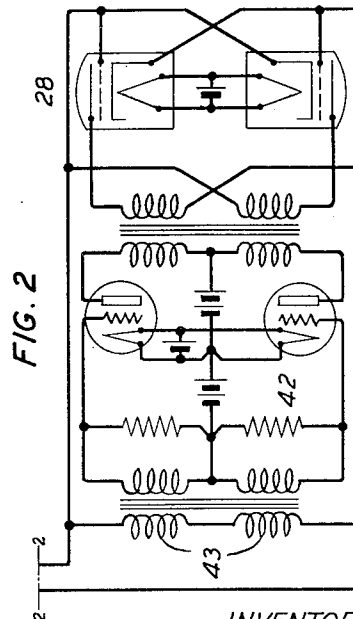
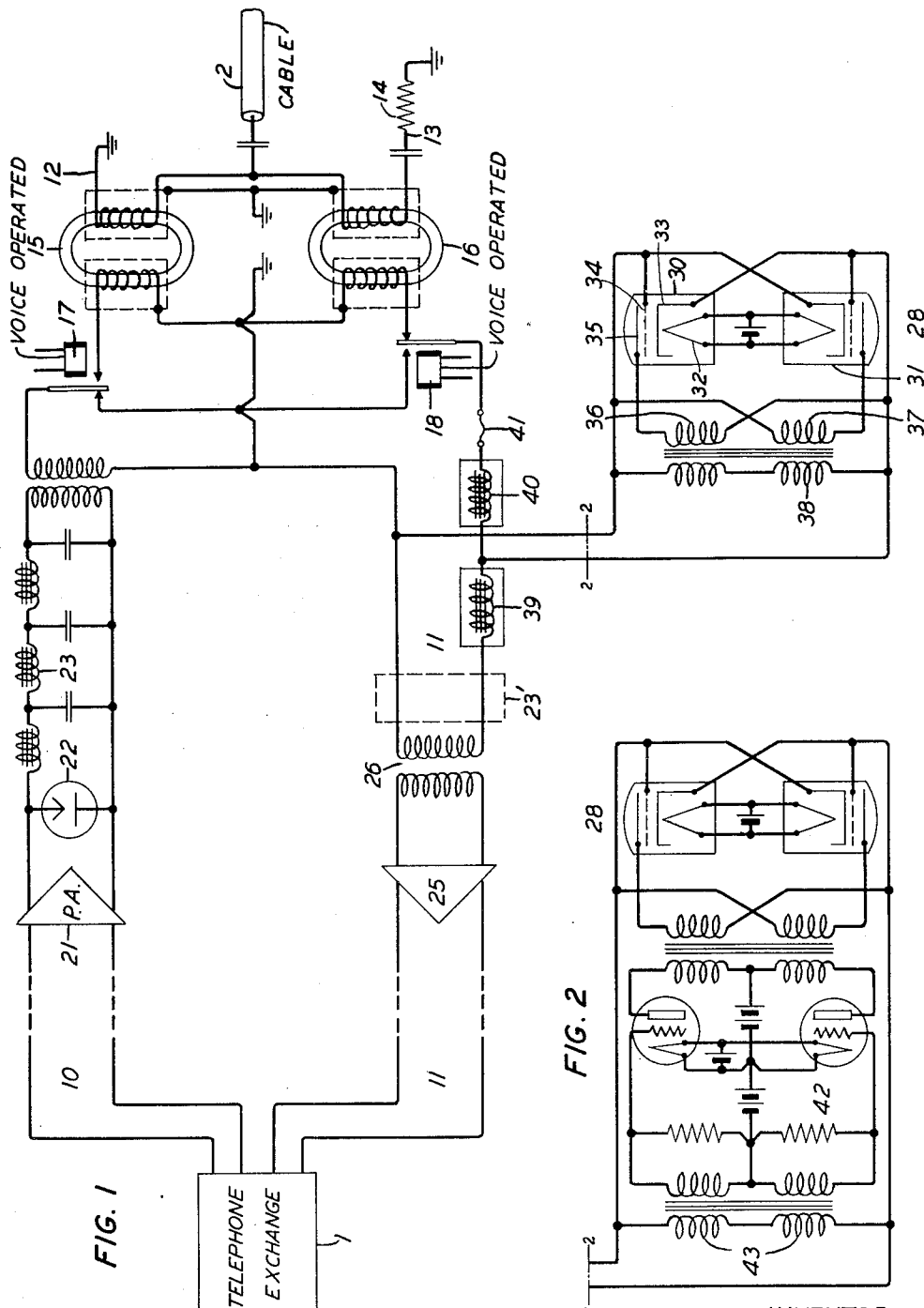
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EXCESS VOLTAGE PROTECTION CIRCUIT

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EXCESS VOLTAGE PROTECTION CIRCUIT

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6 Claims. (Cl. 179—78)

The present invention relates to circuits for protecting an electrical transmission system against excessive voltages.

While the circuits of the invention are applicable to any type of electrical transmission system they will be disclosed herein as applied to a transatlantic telephone cable system. In such a system, it is necessary to prevent application to the cable from the transmitting circuit of excessive voltages which might injure the insulation or have a deleterious effect on the loading material of the cable. It is necessary also to protect the receiving circuit from excessive voltages which may accidentally be applied to it from the transmitting circuit.

The present invention gives effective protection at both of these points in a terminal circuit for a deep sea telephone cable.

The invention will be more fully understood from the following detailed description when read in connection with the attached drawing of which:

Fig. 1 shows in diagrammatic and simplified form the manner in which the invention may be applied to a terminal circuit for a deep sea telephone cable; and

Fig. 2 shows a modification of the protective circuit for the receiving side of the system.

In Fig. 1 two one-way telephone transmission lines 10 and 11 are shown interconnecting the telephone exchange 1 with the two-way deep sea telephone cable 2. Each of the lines 10 and 11 is a one-way transmission line which may include repeaters, equalizers, filters and various other transmission apparatus commonly employed in a long four-wire telephone circuit. The telephone exchange 1 may be located a great distance away from the terminal circuit for the cable, this separation being indicated in the drawing by the use of dotted lines in the transmission circuits 10 and 11.

The cable 2 is provided with a sending earth 12 and a receiving earth 13 the latter of which will ordinarily be located at some distance at sea and provided with a balancing impedance 14. A pair of coupling transformers 15 and 16 are shown for respectively coupling the transmitting line 10 between the cable 2 and the sending earth 12 and the receiving line 11 between the cable 2 and the receiving earth 13, 14.

It will be assumed that the connection between lines 10 and 11 and the cable is controlled by the speech waves being transmitted over the system and the control is so exercised that circuits 10 and 11 may be connected one at a time to the

cable for either transmitting or receiving but in the normal operation of the apparatus lines 10 and 11 are never both connected to the cable at the same instant. Voice operated relays 17 and 18 are diagrammatically indicated on the drawing for performing the necessary switching operations. For simplicity the details of the switching circuits are omitted from the drawing but they may be of any suitable type such, for example, as disclosed and claimed in U. S. Patent No. 1,356,654 to Charles N. Nebel, granted May 3, 1932. As disclosed in the Nebel application the system is normally in condition to receive from the cable while the output of the transmitting branch 10 is short-circuited by armature contact of relay 17. When it is desired to transmit, the speech waves in circuit 10 operate both relays 17 and 18 to shift their armatures to their opposite positions so that the receiving circuit is disconnected from the cable and short-circuited while the transmitting circuit is connected to the cable. It will be understood that suitable singing suppressor and echo suppressor equipment will ordinarily be provided for the system.

The final amplifier in the transmitting circuit 10 is a power amplifier 21 for raising the speech amplitude to the proper volume for transmission into the cable. In the case of a transatlantic telephone cable system power amplifier 21 may be capable of applying a peak voltage of 250 volts to the cable.

Bridged across the output of power amplifier 21 is a cold-electrode gas-filled protector tube 22 which normally transmits no current but is designed to break down when a voltage in excess of normal is impressed across its terminals. Experience has shown that there is a certain time lag inherent in these devices which permits a voltage wave to overshoot by a considerable amount the voltage at which the protector tube breaks down. Under extreme cases with very steep wave fronts applied a tube of this kind which normally limits the voltage to 100 volts has been observed to permit the voltage to reach 500 volts for a few microseconds and an overshoot of 25% beyond the nominal break-down voltage is by no means uncommon at lower frequencies. The effect of this overshoot is to produce a very short, sharp peak near the top of the wave and just before limitation occurs. This sharp peak in the wave is the equivalent of superposing harmonics on the fundamental.

In accordance with the present invention these excess peak voltages resulting from the time lag in the arrester 22 are attenuated by the low-pass

filter 23 which passes the fundamental components of the waves to be transmitted over circuit 10 but effectively suppresses the harmonic components represented by these sharp peaks in the output of protector 22. In the case of speech if the band to be transmitted is below 3,000 cycles the filter 23 may be given a cut-off frequency of about 3,000 cycles and may be designed to have high attenuation for frequencies above 3,000 cycles.

The receiving circuit 11 is designed to receive signaling voltages from the cable 2 as low as the order of microvolts. This circuit will ordinarily have a high gain amplifier 25 suitable for operating at these very low voltages and the amplifier will be coupled to the cable through a step-up transformer of high voltage ratio, shown at 26. It is seen, therefore, that in case of failure of the voice operated switching apparatus, if some of the transmitter output voltage should be impressed across on the input of the receiving channel, voltages of the order of 10,000 volts might be impressed on the input to the amplifier 25 resulting in possible destruction of the tube or transformer or in other harmful effects.

In accordance with the invention there is bridged across the receiving circuit 11 ahead of the step-up transformer 26 a protection circuit generally indicated at 28.

This protection circuit 28 comprises a pair of oppositely poled gas-filled hot-cathode space discharge devices similar to those disclosed in U. S. Patent No. 1,869,484, to W. A. Knoop, granted Aug. 2, 1932, for a peak voltage limiter. These discharge devices may have a construction such as that disclosed in U. S. patent to A. L. Samuel No. 1,921,004, granted Aug. 8, 1933, or in an article entitled "Gas-filled thermionic tubes" by Albert W. Hull, published in the Transactions of the American Institute of Electrical Engineers, vol. 47, July 1928, pages 753 to 763, and known in the art as "Thyratron". Discharge tubes of this type transmit no current for impressed positive anode voltages lower than a certain critical voltage. As the anode voltage is increased and the discharge voltage is reached, the tube immediately breaks down and transmits current. With further tendency towards an increase in anode voltage there is an increase in current but practically no increase in anode-to-cathode voltage. Tubes of this type are therefore very effective in holding the voltage across a circuit at a fixed maximum value.

Referring more specifically to the protecting circuit 28 the tubes in question are shown at 30 and 31. Each tube comprises a heater 32, a cathode 33, a control electrode 34 and an anode 35. It will be observed that each tube is shunted across the circuit to be protected, by having its cathode connected to one side of the circuit and its control electrode 34 connected to the opposite side. The anode 35 in the case of each tube is connected to one of the secondaries 36 or 37 of a transformer, the primary 38 of which is bridged across the line.

Transformers 36, 37, 38 have a sufficiently high impedance to insure that substantially none of the current in the normal voltage range are shunted across the line. This transformer gives a step-up in voltage from primary 38 to secondaries 36 and 37.

It has been found that when a sufficiently high positive voltage is placed on anode 35 with respect to cathode 33 to cause the tube to break down, the tube then becomes capable of carrying

a very large amount of current between control electrode 34 and cathode 33 with only a relatively small positive voltage impressed on the electrode 34 with respect to the cathode. In a particular case where approximately 25 volts were applied between the electrode 35 and the cathode and 3 volts positive on the electrode 34 with respect to the cathode, the impedance of the space between the electrode 34 and the cathode became as low as 20 ohms and the current in the space between elements 34 and 33 was from five to ten times as high as the current between electrode 35 and cathode 33. The positive potential of 3 volts on electrode 34 was not sufficient, however, to break down the tube and cause it to transmit in the first instance. With no voltage impressed on electrode 35 a voltage of the order of 18 volts would have been necessary on electrode 34 to cause the tube to break down.

The operation of the circuit 28 is as follows: When voltages of the normal range are present on circuit 11 practically no shunting action takes place by circuit 28 on account of the practically infinite impedance of the tubes 30 and 31, and the high impedance of transformer 38. There is, however, a slight current in primary winding 38 sufficient to induce voltages in the secondary windings 36 and 37 which are impressed in turn on the cathode-to-anode circuit of the tubes 30 and 31.

When the voltages in circuit 11 rise above normal value the voltages impressed on the anodes 35 of tubes 30 and 31 cause one or the other of these tubes to break down depending upon the polarity of the applied wave. The breaking down of the tube renders the space between the electrode 34 and the cathode capable of carrying current and since this space is directly shunted across the circuit, a large amount of excess current is thus shunted directly across the circuit. In this way the voltage on the circuit will be limited to a much smaller maximum value than would be the case if the electrodes 35 were directly connected across the circuit and if no step-up transformer were used. To illustrate this, let it be supposed that a step-up ratio of 1 to 5 is employed in the transformer and that a voltage of 20 between the cathode and electrode 35 is necessary to break down the tube. When the line voltage exceeds 4 volts, the tube will break down and thereafter in accordance with the example given above, the connection of electrode 34 to the line will tend to limit the voltage to the order of 3 volts, this being sufficient to maintain the discharge through the tube once it is broken down.

While the shunt limiter 28 alone may be used, it may be desirable in some cases to include elements such as 39, 40 and 41 in series in the circuit in addition to the shunt protecting circuit. Elements 39 and 40 may be any desired type of current limiting devices and are shown in the form of saturating inductances containing iron or other magnetic cores. At normal signaling current amplitudes, the permeability of the cores is low and the choking effect of the inductances is correspondingly low. Excess current raises the permeability of the cores and increases the inductive reactance so as, effectively, to oppose the increase in current. Element 41 is a fuse which will give added protection in case of excess current flow.

Since it requires finite time for the tubes 30 and 31 to discharge, there may be some slight tendency for the protecting circuit 28 to permit very short peak voltage impulses to pass into the circuit that is to be protected, in which case a filter indicated

in dotted outline 23' corresponding to filter 23 in circuit 10 may be employed to attenuate the higher frequencies represented by such short peaks of voltage or current.

5 In an actual test the applied line voltage without the protective circuit 28 and without elements 39 and 40 in the circuit rose to 75 volts. When the protective circuit 28 was employed it began to operate at 2.4 volts and prevented the voltage
10 from exceeding 5.25 volts. The fuse 41 blew out in .003 seconds. Elements 39 and 40 were not used in this test.

Fig. 2 shows a modified type of protecting circuit which may be substituted for that shown in
15 Fig. 1 below the broken line 2—2. The circuit of Fig. 2 differs from that previously described by including a push-pull amplifier 42 between the transformer that is bridged across the line, in this case 43, and the protecting circuit 28. By controlling the amount of gain in the amplifier 42 as
20 well as the step-up ratio of the transformers that are present in the circuit, the limiting voltage of the circuit as a whole may be readily determined. With the same type of tube in the limiting circuit 28 and with the same voltage ratio in trans-
25 formers 43 and 38 the circuit of Fig. 2 will hold the circuit voltage to a lower maximum than the circuit disclosed in Fig. 1 on account of the gain in the amplifier 42 which enables the tubes
30 of the circuit 28 of that figure to be broken down with a smaller voltage across the terminals of the circuit 11.

It will be understood that the numerical values that have been given throughout the description
35 are for illustrative purposes and are not to be taken as limiting the invention. Various modifications of the invention will occur to those skilled in the art and the invention is not to be taken as limited by the various details disclosed
40 but only by the scope of the appended claims.

What is claimed is:

1. In an alternating current transmission circuit a peak voltage limiting device in shunt of
45 said circuit, requiring finite time to operate whereby voltage peaks may pass said device during such finite operating time, and a low-pass filter following said protective device for highly
50 attenuating the frequencies corresponding to such voltage peaks while allowing the alternating current waves of the fundamental frequency to pass.

2. The combination with a circuit to be protected against excess voltage of either polarity,

of a pair of hot-cathode gas discharge devices each having cathode, anode and a second cold electrode, each such device having its cathode and anode bridged across said circuit in respectively opposite polarity, a second circuit in bridge
80 of said circuit to be protected arranged to receive a voltage therefrom, said second circuit being coupled to the cathode and second cold electrode of each of said devices to impress thereon a higher voltage than is present on said circuit to be protected.
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3. A system as claimed in claim 2 in which said second circuit includes a vacuum tube amplifier.

4. In a receiving circuit for a system of excessively high attenuation in which the received current is of the order of microvolts, means for protecting the receiver from excess voltage or current of either polarity comprising a pair of
90 hot-cathode gas-filled tubes having cathode, anode and a third electrode in which discharge current is maintained at low voltage between anode and cathode when ionization is started by application of high voltage between said third
95 electrode and cathode, said tubes having their anode-cathode paths oppositely connected in bridge of said receiving circuit, and a circuit responsive to excess voltage for multiplying such
100 excess voltage and applying it to the third electrode to cause ionization in one or other of said tubes.
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5. In a protection circuit for an alternating current line, series current-limiting means in said line and a shunt circuit across said line comprising oppositely poled gas-filled space
110 discharge tubes having zero current characteristic for applied voltages below a predetermined limiting voltage and substantially flat voltage characteristic independent of the space current for all impressed voltages in excess of said limiting voltage.
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6. In a receiving circuit for a deep sea cable having a transmitter associable with the cable at the same location, a high voltage ratio step-up
120 transformer connected to said cable, a high gain amplifier having its input connected to said transformer, and a peak voltage limiter connected between said cable and said transformer for limiting the maximum voltage impressed on
125 said transformer to a value small in comparison with the normal output voltage of said transmitter.

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