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CIRCUIT FOR CONTROLLING TRANSMISSION IN SIGNALING SYSTEMS

Filed July 28, 1933

2 Sheets-Sheet 1

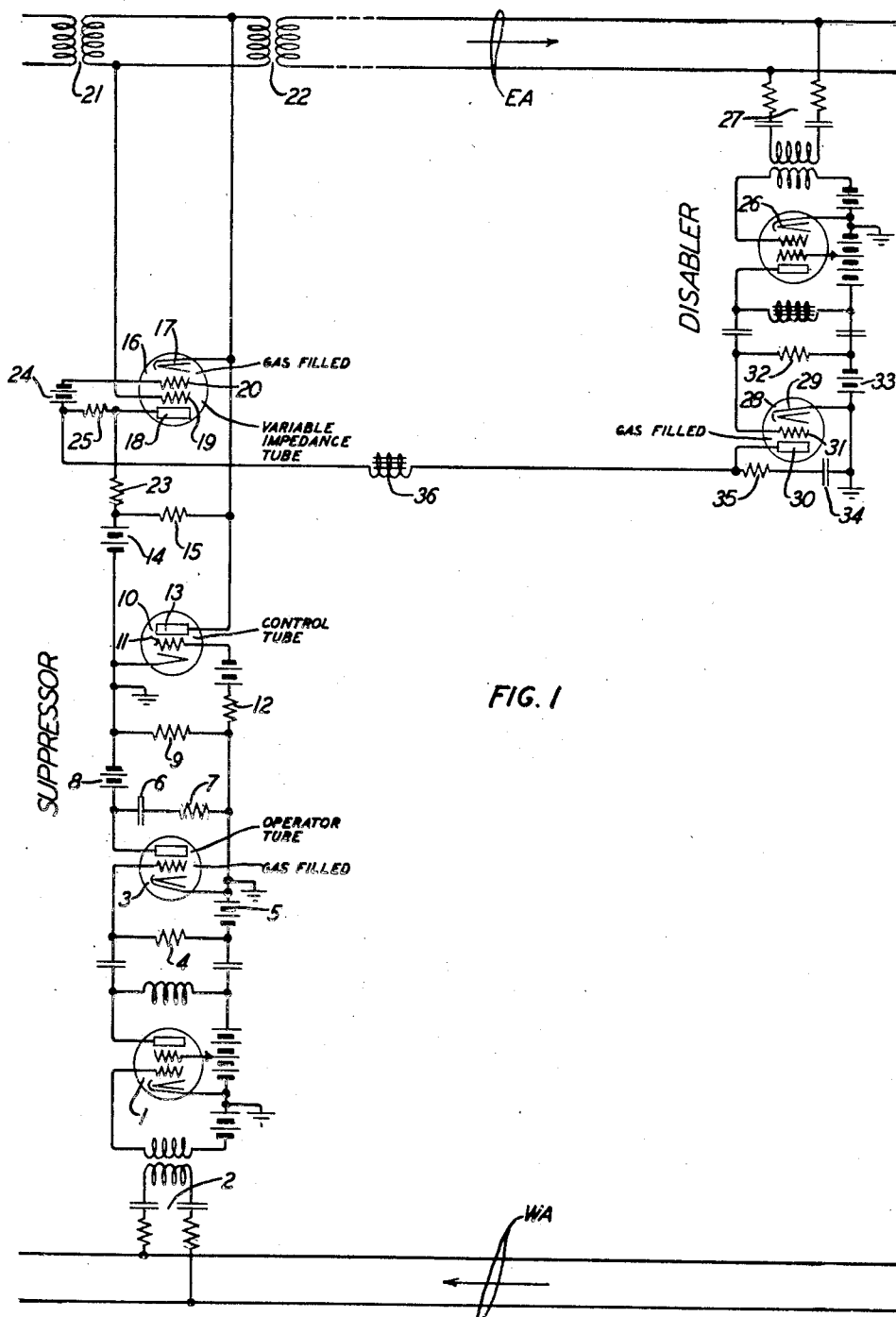


FIG. 1

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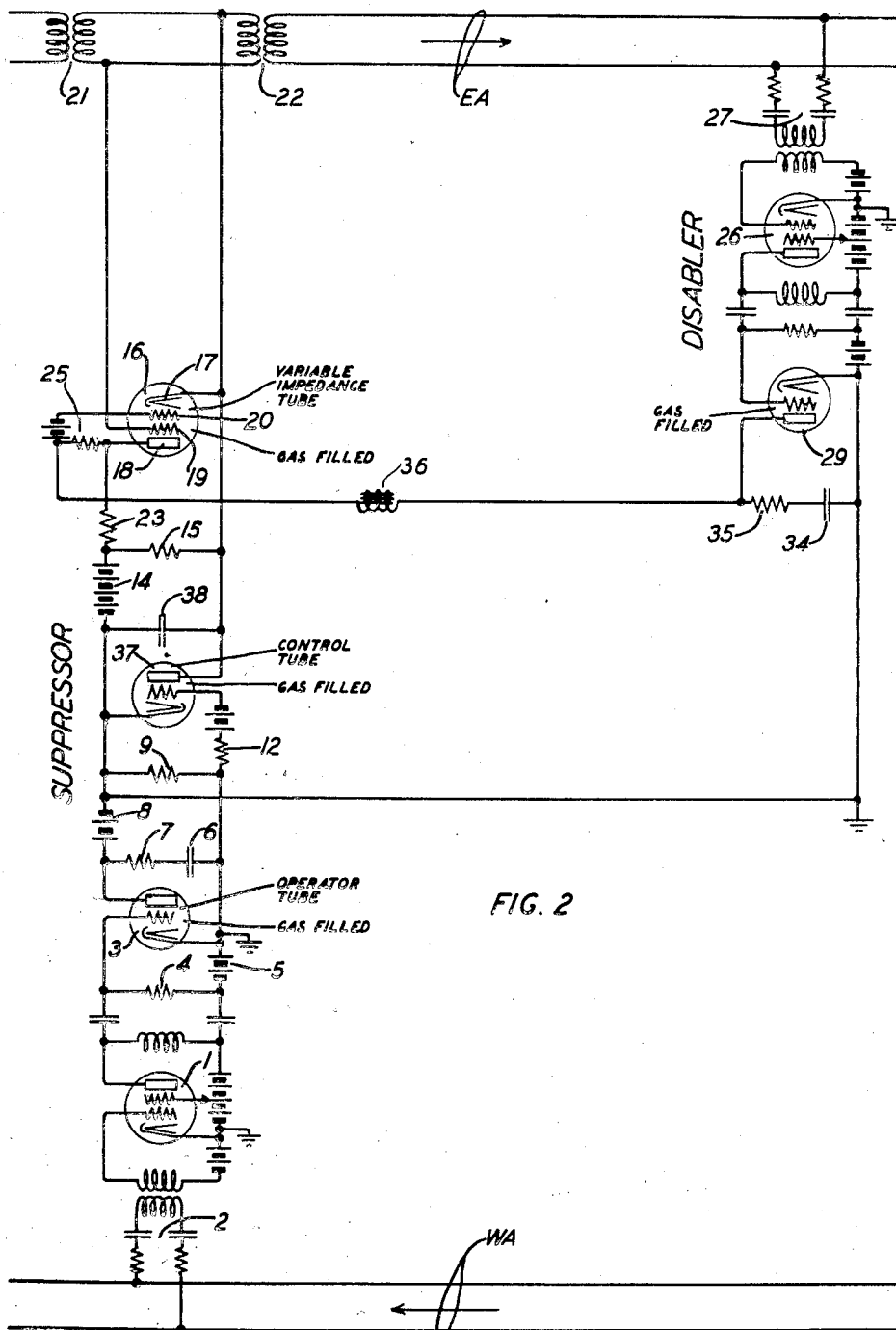


FIG. 2

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CIRCUIT FOR CONTROLLING TRANSMISSION IN SIGNALING SYSTEMS

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3 Claims. (Cl. 178-44)

The present invention relates to circuits for controlling transmission in a signal transmission system, and particularly to signal-controlled circuits for suppressing echoes and preventing singing in two-way signal transmission systems.

An object of the invention is to improve the operating characteristics of signal-controlled circuits for suppressing echoes and preventing singing in two-way signal transmission systems.

Voice-operated circuit-control apparatus, commonly called echo suppressors or anti-singing devices, are usually employed in connection with the repeating circuits of a long two-way telephone system, to insure that the system transmits in only one direction at a time, so as to suppress echoes and prevent singing. This is usually accomplished by making the circuit-control apparatus responsive to speech wave transmission in either direction over the system to disable the transmission path for the opposite direction by increasing the attenuation therein, or to render operative the transmission path for the direction of speech wave transmission by reducing the attenuation therein, or both.

Certain circuits of the above mentioned type in the prior art have been designed to operate in response to transmitted signals to properly control the attenuation in the transmission paths by varying the output impedance of a vacuum tube or tubes connected effectively in parallel with the repeating paths. By this means the attenuation in the repeating path transmitting signals is made or maintained small so that it transmits the signals freely, while the attenuation of the oppositely directed repeating path is increased to the point where disturbing echoes or reflected currents are substantially suppressed. A difficulty which may be encountered in prior art echo suppressor circuits of this type is that unbalance currents or transients may be transmitted over the transmission paths due to sudden changes of impedance or loss therein when the echo suppressor operates. These transients may result in annoying "click" disturbances in the receiving apparatus of the system, the disturbing effects being enhanced by the long time delay in very long transmission circuits.

In the echo suppressors of the invention substantial elimination of "clicks" and other disturbances, as well as fast operation, a high degree of suppression and uniform hangover in operation are attained by suitably designed circuits utilizing gas-filled tubes.

The objects and advantages of the invention will be clear from the following detailed descrip-

tion thereof when read in connection with the accompanying drawings, Figs. 1 and 2 of which show schematically portions of a four-wire toll telephone system equipped with echo suppressors embodying different modifications of the invention.

The four-wire toll telephone circuit of Fig. 1 comprises a one-way transmission path EA for repeating telephone signals in the direction from west to east, and a one-way transmission path WA for repeating telephone signals in the direction from east to west. The transmission paths EA and WA may be connected at their ends in substantially conjugate relation with each other and in energy transmitting relation with the two-way lines between which the telephone signals are to be repeated, by means of the usual hybrid coil transformers and associated balancing networks (not shown) or by any other suitable means.

As indicated in Fig. 1, each echo suppressor unit associated with the transmission paths EA and WA comprises a "suppressor" portion and a "disabler" portion.

The suppressor portion of each echo suppressor unit comprises three parts; the input circuit, the control circuit and the variable impedance or suppressing element. The input circuit of the suppressor furnishes the required amplification and selective action. It consists of, as indicated in Fig. 1, a screen grid vacuum tube amplifier 1 the input of which is bridged across the transmission path WA through a high impedance tuning network 2. The tuning network is utilized to give the proper input frequency-sensitivity characteristic to reduce the effect of noise on operation of the suppressor, that is, it is designed to produce least loss in the frequencies which predominate in speech. The output of the amplifier 1 is coupled by an impedance coupling to the input of a three-electrode gas-filled "operator" tube 3 (for example, a Western Electric Company 256-A type tube) which has a high resistance 4 in series with the negative grid biasing battery 5 in its grid circuit. A condenser 6 in series with a resistance 7 is connected in shunt with the plate and filament of the operator tube 3 and serves to smooth out irregularities in the output current of the tube. The plate of the operator tube 3 is supplied with space current from the battery 8. The resistance 9 couples the output of the operator tube 3 to the input of the control tube 10 which is a three-electrode high vacuum tube. The external plate circuit resistance of the operator tube 3 is high, and, when current flows, it provides a positive bias on

the grid 11 of control tube 10. The high resistance 12 in the grid circuit of control tube 10 serves to protect it from excessive positive voltages. Space current is supplied to the plate 13 of the control tube 10 from battery 14 through the resistance 15.

The variable impedance element of the suppressor comprises a gas-filled electric discharge tube 16 having four electrodes; a cathode 17, a plate or anode 18, a cylindrical grid 19 connected between the cathode and anode, and a spiral grid electrode 20 located between the cylindrical grid and the cathode and very close to the cathode. The cylindrical grid 19 and the cathode 17 are connected to opposite sides of the path EA between the step-up transformer 21 and the step-down transformer 22, which transformers are utilized to step-up the impedance of that portion of the path. The plate 18 and cathode 17 of the variable impedance tube 16 are connected across the resistance 15 in the plate-filament circuit of the control tube 10, so that the IR drop in the resistance 15 becomes the plate voltage for the variable impedance tube 16. The series resistance 23 in the anode-cathode circuit of the variable impedance tube 16 is provided to limit the plate current thereof to a safe value. The spiral grid 20 of the variable impedance tube 16 is connected to the plate 18 of that tube through the grid biasing battery 24 and the resistance 25, the grid biasing battery 24 being utilized to maintain the spiral grid at a fixed potential below that of the cathode when no current flows in resistances 15 and 23, which is sufficient to prevent ionization of the gas in the tube due to speech waves normally transmitted over the path EA.

The "disabler" portion of the echo suppressor comprises the screen grid vacuum tube amplifier 26, the input of which is coupled across the path EA on the low side of the step-down transformer 22 by means of the high impedance tuning network 27 which is designed to give the same input frequency-sensitivity characteristic to the disabler as given to the suppressor by the network 2. The output of the amplifier 26 works into the input of the three-electrode gas-filled "disabler" tube 28, similar to the operator tube 3, through an impedance coupling. The gas-filled disabler tube 28 comprises a cathode 29, a plate or anode 30, and a cylindrical grid 31 therebetween. The tube 28 has a high resistance 32 in series with the negative grid biasing battery 33 in its cylindrical grid circuit. A condenser 34 in series with a resistance 35 is connected directly across the plate 30 and cathode 29 of the disabler tube 28 and serves to smooth out irregularities in the output current of the tube. The external plate circuit resistance of the disabler tube 28 is connected in the spiral grid circuit of the variable impedance tube 16 of the suppressor by a connection from the plate 30 of the tube 28 through the choke coil 36 to a point between the resistance 25 and the positive terminal of the battery 24, thus serving as a source of negative bias when plate current flows in the disabler tube 28.

The operation of the suppressor portion of the echo suppressor of Fig. 1 will now be described. It will be assumed that speech currents are being transmitted over the path WA in the direction from east to west and at the time of their arrival at the point therein where the input of the suppressor is connected, no west to east speech currents in the path EA have reached the point

therein where the input of the disabler is connected. The portion of the speech currents diverted from the path WA into the input of the suppressor will be amplified in the screen grid vacuum tube amplifier 1 therein and impressed on the input of the operator tube 3 across the resistance 4. When the positive peak voltage on the grid of the operator tube 3 becomes sufficiently high as determined by the bias on the grid, the gas in the tube 3 will ionize and current flow will be established in the resistance 9 in the plate circuit of that tube. Since the value of the resistance 9 is high the current in tube 3 is small thereby allowing control of the plate current by the grid of the tube. The current in tube 3 is irregular, due to the transient nature of the voice voltage applied to the grid but is smoothed out by the charging action of the resistance condenser arrangement connected between the plate and cathode of the tube. Before ionization starts in the operator tube 3 the condenser 6 is charged to the voltage of the plate battery 8. Upon ionization in the tube 3, the condenser 6 discharges through the resistance 7 and the tube 3 at a very rapid rate to a value determined by the normal voltage drop across the tube.

The fairly steady IR drop in the resistance 9 swings the grid 11 of the control high vacuum tube 10 from a high negative value to a positive value, the excess voltage being dissipated in the series resistance 12. Under these conditions the plate current of the control tube 10 is quite independent of the input level and also of fluctuations of current in the resistance 9. Practically instantaneously after plate current starts to flow in the control tube 10, current is established in the variable impedance tube 16 due to the IR drop in the resistance 15 connected across the plate 18 and the cathode 17 of the latter tube. As stated above, the series resistance 23 in the anode-cathode circuit of the variable impedance tube 16 limits the plate current to a safe value. The change in the variable impedance tube 16 to the ionized condition establishes a low impedance between the cylindrical grid 19 and the cathode 17 of that tube. This provides a low impedance shunt across the high impedance portion of the path EA between the transformers 21 and 22. The high loss thus inserted in the path EA effectively disables that path for transmission of echoes and reflected currents due to the voice currents in the path WA.

Now let it be supposed that speech currents for transmission from west to east are initiated in the path EA and that a portion of these currents is transmitted through the high impedance portion of that path before the low impedance shunt has been established thereacross by operation of the variable impedance tube 16. A portion of the current in the path EA will be diverted into the disabler and will be amplified by the screen grid vacuum tube amplifier 26 therein. The amplified speech currents in the output of the amplifier 26 will be impressed upon the input electrodes of the gas-filled disabler tube 28 across the resistance 32 in its input circuit. When the impressed voltage reaches a sufficiently high level determined by the bias on the grid 31 of that tube, the tube 28 will break down and current will flow in its plate circuit which includes the choke coil 36, and the resistances 25 and 23 in the spiral grid circuit of the suppressor circuit. The resultant voltage drop in resistance 25 and 23 will add negative bias to the spiral grid 20 of the variable impedance tube 16. This negative bias will not be suffi-

cient to stop the operation of the variable impedance tube if it is already operated for the spiral grid loses control of the plate current when the tube is ionized. However, if variable impedance tube 16 is not operated at the time the negative bias is added, the spiral grid controls the plate current and this additional bias will prevent the variable impedance tube 16 from being ionized by the subsequently received current from the control tube 10. Thus it will be seen that the disabler effectively stops operation of the suppressor in response to the west to east speech currents in the path EA if the latter currents are initiated therein a definite time before east to west speech currents are received by the input of the suppressor over the path WA.

False operation of the disabler by initial echoes is prevented by slowing up the disabler operation. This is accomplished by the action of the choke coil 36 in the plate current of the disabler tube. The operation of the suppressor is practically instantaneous after the first positive peak of input voltage becomes sufficient to start ionization in the control tube 10. The disabler operation time is somewhat longer.

It is desirable to have the suppressor and also the disabler remain operated for about $\frac{1}{10}$ second after the input thereto is removed. This allows for the suppression of weak endings of syllables and echoes. This hangover is obtained in the suppressor by giving the proper value to the condenser 6 which is charged up by current from the plate battery 8 after the input to the operator tube ceases. The disabler hangover is obtained similarly by giving the proper value to the condenser 34 connected between the plate 30 and the cathode 29 of the disabler tube 28 which is charged up by current from the plate battery 14 through resistances 23 and 25, choke coil 36 and resistance 35 when the input to the disabler tube 28 is removed.

It will be noted that there is no battery in the cylindrical grid-cathode mesh of the variable impedance tube 16 which is shunted across the path EA, and that, therefore, little or no current will flow in that path when the variable impedance tube is ionized. It has been found that the current which will be produced in the path EA due to the change of impedance therein between the conditions of suppression and non-suppression is so small that "click" disturbances in the receiving circuits of the system are practically eliminated.

The particular variable impedance tube described above has a normal resistance between its cylindrical grid and its cathode of about 150 ohms. It was found that by using such a variable impedance tube and by stepping up the impedance of the portion of lines across which the variable impedance element of the tube 16 was connected, by means of transformers as indicated in Figs. 1 and 2, a suppression loss of 60 decibels or more and a transmission loss of 2.5 decibels or less could easily be obtained. In a 4,000 mile cable circuit, a suppression loss of 50 decibels or more is satisfactory.

Other advantages of the circuit which has just been described is the speed in operation which is obtainable by the use of the gas-filled tubes, the possibility of attaining any desired hangover time in the manner pointed out, and the lack of moving adjustable parts making the circuit quite simple and requiring small mounting space.

The echo suppressor circuit of Fig. 2 differs from that of Fig. 1 essentially only in that a

three-electrode gas-filled electric discharge tube 37 is used in place of the three-electrode high vacuum control tube 10 of the latter circuit, for controlling the plate current of the variable impedance tube 16 in response to operation of the operator tube 3. To make possible the control of the necessary high plate current of the variable impedance tube requires the connection of the condenser 38 between the plate and cathode of the gas-filled tube 37.

The operation of the suppressor of Fig. 2 is quite similar to that of Fig. 1: Speech frequencies entering the suppressor from the transmission path WA are selectively amplified in the input circuit thereof, the frequencies which are dominant in speech being amplified most thus discriminating against noise frequencies to some extent. When the positive peak voltage on the grid of the operator tube 3 becomes sufficiently high, as determined by the grid bias supplied by the grid battery 5, the gas in the tube ionizes and plate current is established in the output circuit flowing through the resistance 9. This current is small making grid control possible. The irregular current produced by the tube 3 is greatly smoothed out by the charging action of the resistance-condenser arrangement comprising the condenser 6 and resistance 7 connected between the plate and filament of the operator tube, so that the voltage across resistance 9 will never fall below a given value as long as tube 3 is operated. When the voltage across the resistance 9 reaches a certain value a high oscillatory plate current is established in the gas-filled control tube 37, but voltage in excess of that value does not affect the plate current of the control tube to any extent. The frequency of this oscillating current by proper selection of the value of the condenser 38 and of the external impedance in the plate circuit of tube 37, is set above the telephone frequency range. Before ionization starts in the control tube 37, the condenser 38 connected between the plate and cathode thereof is charged to the voltage of the plate battery 14. Upon ionization of the control tube 37, the condenser 38 discharges through the tube 37 at a very rapid rate to a value determined by the normal drop across the tube. This rapid discharge produces, for a short time, a large number of positive and negative ions. The large positive ions, which are relatively slow to leave the field, establish a space charge which tends to continue with the discharge of the condenser 38 after the voltage drop of the tube 37 (which is the voltage required to maintain the ionization in that tube) has been reached. Ionization must then stop only to start again when the voltage across the condenser 38 builds up slightly higher than the ionization voltage. The charging action of condenser 38 during the time ionization is stopped tends to maintain the current in the plate circuit external to the tube. Only a ripple is found in this plate current which for the most part can be held above the audio range by the proper value for the condenser 38. With such an oscillatory circuit, it is evident that negative bias applied to the cylindrical grid of the control tube will stop the flow of plate current.

The IR drop established in the resistance 15 by the flow of plate current in the control tube 37 practically instantaneously breaks down the gas-filled variable impedance tube 16 by making the cathode thereof negative with respect to the plate and spiral grid. When plate current flows

in the variable impedance tube, the impedance between the cylindrical grid and the cathode thereof becomes relatively low. With the line impedance stepped up by means of the transformers 21 and 22 in the path EA, the loss introduced therein by the low impedance between the cathode and cylindrical grid of the tube 13 shunted across the path EA, may be made quite large (in the neighborhood of 60 decibels which will be sufficient suppression for a 4000 mile cable circuit).

When the operator tube 3 is no longer operated, the negative bias on the grid of the control tube stops ionization therein and hence also in the variable impedance tube 16. When the disabler tube 29 breaks down in response to the amplified speech voltages diverted into the disabler current from the path EA, the voltage drop in resistance 23 and 24 adds negative bias to the spiral grid 20 of the variable impedance tube. This negative bias will prevent the suppressor from operating, but will not stop its operation if it is already operated. False operation due to initial echoes is prevented by the slowing up of the action of the disabler tube 29 provided by the choke coil 36 inserted in the plate circuit thereof.

For simplification, only one of the pair of echo suppressors which are usually associated with a four-wire transmission circuit has been illustrated in the system of Figs. 1 and 2. It is to be understood, of course, that another echo suppressor identical with the one illustrated would be provided to suppress echoes when the signal transmission is from west to east. The input of the suppressor portion of the latter suppressor would be connected to the path EA and the disabler portion thereof to the path WA.

The circuits of the invention as illustrated and described employ a particular type of gas-filled electric discharge device comprising four electrodes as the variable impedance device for controlling the transmission characteristics of the signal transmission paths. However, it is to be understood that in accordance with the invention any other type of gas-filled electric discharge device normally having a high impedance between the two of its electrodes which are connected directly in shunt or effectively in shunt of the transmission path to be controlled, and which is changed to a low impedance when current flow is established between certain of its electrodes, may be utilized in place of the devices illustrated and described.

In the circuit of the invention illustrated and described the various tubes have been shown

as utilizing heater type cathodes. For simplification, the details of the cathode circuits have not been illustrated. Of course any other type of cathode may be used in place of those shown. Other modifications may be made in the circuits of the invention without departing from the spirit and scope thereof as defined in the appended claims and will, of course, occur to persons skilled in the art.

What is claimed is:

1. In combination, a transmission circuit, a source of alternating current signal waves, a normally unoperated gas-filled electric discharge device having a cathode, an anode, a grid electrode located between said cathode and said anode, and circuits therefor, the normal high impedance between the cathode and grid electrode being connected effectively in shunt with said transmission circuit, and means for establishing and maintaining at least while signal waves are being received from said source a direct current between the cathode and anode of said device sufficient to reduce said shunt impedance to a low value, said means comprising a three-electrode electric discharge device having its anode-cathode circuit in series with the anode-cathode circuit of said gas-filled device, and adapted to produce a substantially steady anode-cathode current of the required value whenever a direct current voltage above a certain minimum value is applied to its input circuit, and a third electric discharge device supplied with said alternating current signals and operating in response thereto to apply at least said minimum voltage to the input circuit of said three-electrode device.

2. The combination of claim 1 and in which said three-electrode electric discharge device comprises a high vacuum tube adapted to actuate when said minimum direct current voltage is applied to its input circuit, and said third electric discharge device comprises a three-electrode gas-filled tube having its output circuit coupled in tandem to the input circuit of said high vacuum tube through a resistance, and having a condenser in series with a resistance connected directly across its output electrodes.

3. The combination of claim 1 and in which said three-electrode device comprises a gas-filled tube having a cathode, an anode, a grid electrode and circuits therefor, and adapted to oscillate above the signal frequency range which allows control of the plate current therein by said grid electrode to produce a substantially steady anode-cathode current when said minimum direct current voltage is applied to its input circuit.

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