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H. C. SILENT

SUPPRESSION OF ECHOES AND SINGING IN FOUR-WIRE CIRCUITS

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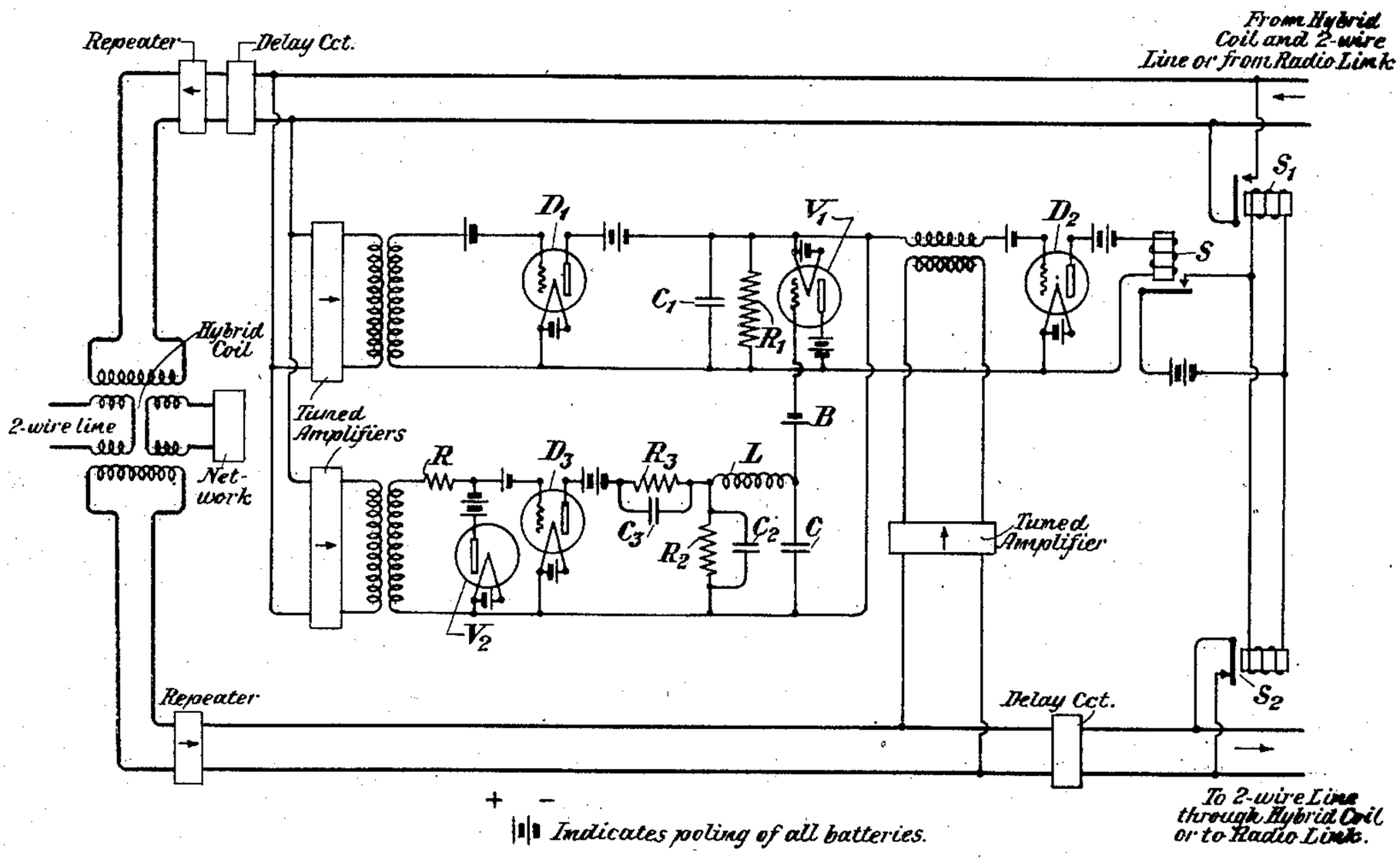

Fig. 1

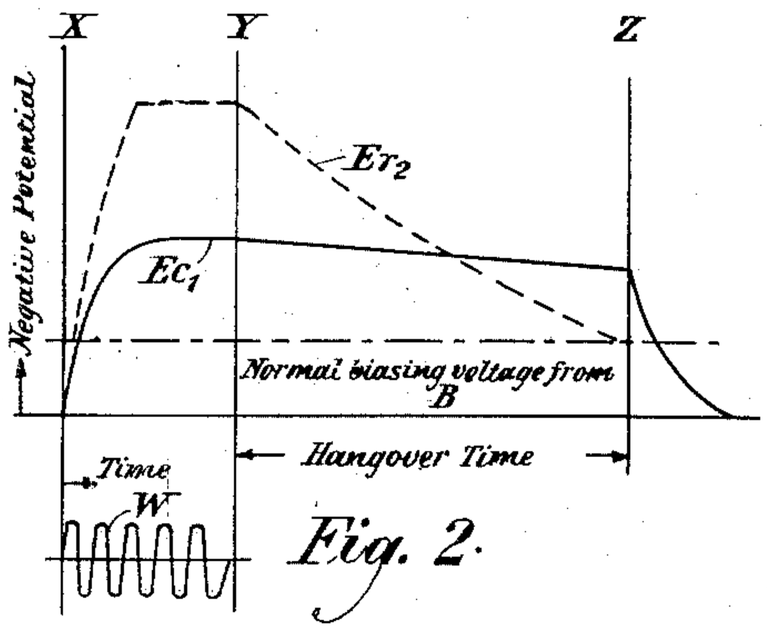

Fig. 2.

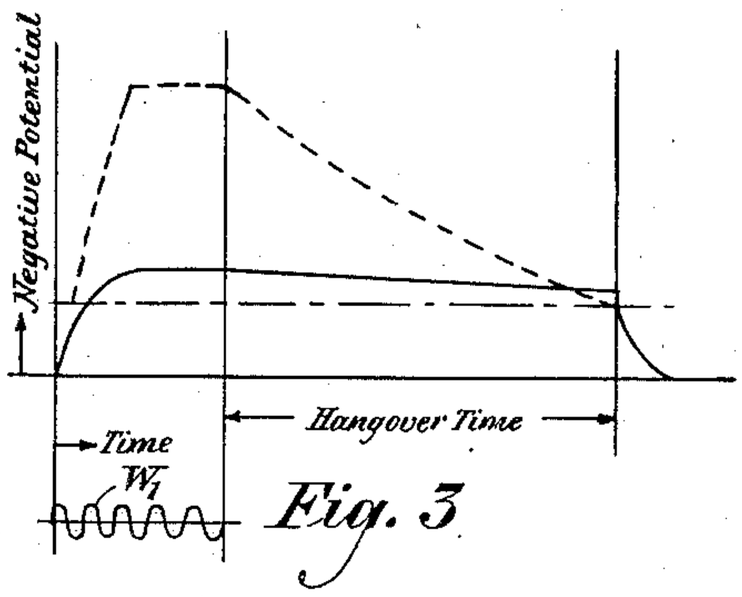

Fig. 3

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SUPPRESSION OF ECHOES AND SINGING IN FOUR-WIRE CIRCUITS.

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This invention relates to two-way communication system, and more particularly to two-way telephone systems which include, between two-wire lines, a four-wire circuit having one path adapted for transmission in one direction and another path adapted for transmission in the opposite direction and resides in improved methods of and means for suppressing echoes and singing in such systems.

The invention is applicable to systems which include, between two-wire lines, a four-wire circuit containing a radio link. It is also applicable to all-wire two-way systems in which the four-wire circuit covers the entire distance between two two-wire lines without the intervention of a radio link.

In order to simplify the discussion of a specific embodiment of the invention, it is proposed to disclose specifically only one portion of a two-way telephone system to which a set of devices for suppressing echoes and singing is connected, and this section of the communication system will be discussed as one which is connected at one end to a two-wire line and directly at the other end to a radio link. While the term "four-wire circuit" is ordinarily used in connection with such systems to denote the part of the system which connects the two distant two-wire lines and includes a radio link, if there be one, this term "four-wire circuit" will be used hereinafter, in so far as a radio link is considered, to denote that four-wire section of a half of the complete system which lies between one two-wire line and one end of the radio link.

In a telephone system of this class, in which the two paths of the four-wire circuit are adapted for transmission in opposite directions, it is, under certain conditions, a requirement, if the best possible results are to be secured, that one path of the four-wire circuit be normally blocked and consequently normally disabled. This arrangement serves to prevent singing in the circuit in its normal condition. In addition, in association with each transmission path of the four-wire circuit there must be provided means responsive to waves in this path for blocking the transmission over the other path or for preventing the removal of a short-circuit already on the path, in order to secure the suppression of echoes returning from the two-wire line over that other path. The arrangement of the four-wire circuit which is ordinarily preferable is that in which the outgoing path—that is, the one adapted for transmission to the radio link—is normally blocked, while the path adapted for reception from the radio link is normally cleared. With this arrangement it is, of course, necessary to provide means responsive to voice waves in the outgoing path for clearing this transmission path.

In the arrangement of four-wire circuits which has been found comparatively successful in all-wire systems, an amplifier-detector device is associated with each path of the circuit. Voice waves in the transmitting (or outgoing) path enter the associated amplifier-detector, and the output of the detector causes the operation of a relay or relays to place a short circuit on, or otherwise block, the receiving path, and also to clear the transmitting path. Voice waves in the receiving path, provided this path is not blocked at the time, enter the associated amplifier-detector, and the output causes the operation of a relay or relays to block the transmitting path or to prevent the removal of a short-circuit on that path.

One of the chief objects of the applicant's improved arrangement for controlling the paths of a four-wire circuit is to provide protection against echoes which is directly proportional in degree to the strength of the transmission which causes the echoes.

Another object of the invention is to give a positive hangover to the protection afforded by the voice operated devices which may be adjusted as to time of duration.

A further object of the invention is to provide protection against echoes which may be adjusted either to be practically constant during the hangover period or to decrease gradually to a value just sufficient to take care of the decreased amplitude of the echoes.

Furthermore, one of the chief objects of the invention is to provide for protection against echoes which is abruptly removed at the end of the hangover period.

In attaining the objects stated above, the applicant, in general, employs a detector associated with both transmission channels of the four-wire circuit for controlling the transmission path clearing and blocking switches, impresses a negative voltage on the grid of this detector in response to waves in the path adapted for transmission from the radio link, this voltage being sufficient to

prevent operation or the detector by echoes returning in the opposite path, automatically stores a quantity of energy to maintain this negative voltage on the detector grid, and provides for the abrupt discharge of the maintaining energy at the termination of the hangover period, the length of this period being readily adjustable.

By virtue of the arrangement briefly described above and to be more fully described and discussed hereinafter, the protection against operation of the controlling detector by echoes in the outgoing path is directly proportional to the strength of the transmission in the incoming path. Furthermore, the length of the hangover period is quite independent of the amplitude of the waves flowing in the incoming path of the four-wire circuit toward the two-wire line.

These and other advantages of the invention will be more clearly understood when the following detailed description of one desirable embodiment of the invention is read with reference to the accompanying drawing.

Figure 1 of the drawing shows diagrammatically a four-wire circuit connected at one end directly to a two-wire line and at the other end, as indicated, to a two-wire line either directly or through a radio link, and having associated with it the improved apparatus for controlling the clearing and blocking of the one-way paths of the circuit.

Fig. 2 shows a curve diagram indicating the voltages which control the hangover in the case of a wave of relatively great amplitude in the incoming path of the four-wire circuit.

Fig. 3 shows in like manner the voltages which determine the hangover in the case of a wave of relatively small amplitude in the incoming path.

With reference first to the details of Fig. 1, there are shown a four-wire circuit connected at its left end to a two-wire line, through the usual hybrid coil, and a network approximately balancing the two-wire line. As indicated in this figure of the drawing, the four-wire circuit is connected at its right end to a radio link, for instance. The lower path of the circuit is adapted for transmission from the two-wire line to the radio link, and the upper path is adapted for transmission from the radio link to the two-wire line. In each path, there is the usual one-way repeater.

When speech comes from the two-wire line, the voice currents pass over the lower path of the four-wire circuit which is normally blocked by a short circuit under the control of a relay S_2. The voice currents in this outgoing path enter the tuned amplifier associated with the path and act on a detector D_2 to operate a switching device specifically shown as a relay S. When this relay operates, it closes a circuit through a battery and the windings of relay S_2 and a relay S_1 which controls the upper transmission path. This upper path, adapted for transmission from the radio link, is normally cleared, but a short circuit may be placed on it by the operation of relay S_1. A delay circuit, positioned in the outgoing path as shown, delays the voice currents in the transmitting path until the detector D_2 has had time to effect the switching operations discussed above. Thus, when voice currents come over the two-wire line, the normally blocked outgoing path is cleared and the normally cleared incoming path is blocked; thus the talker over the two-wire line is automatically given control of the circuit.

There is, however, danger that voice currents, or currents due to static or other disturbing causes, may enter the upper path of the four-wire circuit from the radio link and be reflected back from the two-wire line over the lower or outgoing transmission path of the four-wire circuit, since the balance of the two–wire line by the associated network is not perfect. It will readily be understood that if these echoes in the outgoing path are permitted to operate the detector D_2 and the switches controlled thereby, transmission over the telephone system will be seriously interrupted.

The applicant associates two tuned amplifiers with the upper or incoming transmission path and interposes between these amplifiers and the detector D_2, which controls the switches, an arrangement of vacuum tubes and related circuits as described below. It is believed that the apparatus involved will be most clearly understood when discussed in connection with the operation of the circuits in response to waves in the upper transmission path.

A portion of the speech or other current coming into the upper path of the four-wire circuit from the radio link enters the tuned amplifiers. The current entering the upper one of the amplifiers associated with the incoming path causes a detector D_1 to charge a condenser C_1 connected across the filament-plate circuit and impresses a negative biasing voltage on the grid of the detector D_2, which is added to a small normal biasing voltage from the grid battery. This negative voltage impressed on the grid of D_2, it will be readily understood, is directly proportional in its value to the strength of the transmission in the upper path and accordingly is directly proportional to the strength of any echo currents caused by the incoming currents and reflected from the two-wire line over the lower path. Thus, there is automatically placed on the grid of D_2 a negative voltage sufficient to prevent the operation of D_2 by the returning echoes.

Associated with the condenser C_1 in the output of D_1 is a resistance R_1. This resist-

ance is a high resistance and serves to maintain on the grid of D_2 a negative voltage for the biasing of the grid during idle periods. If the value of this resistance were infinite, the charge on C_1 would continue indefinitely or until released by some auxiliary action. The release of the charge on C_1 and the consequent removal of the protection bias on the detector D_2 is the function of the vacuum tube V_1 and the lower set of vacuum tubes and associated circuits (with reference to Fig. 1). The current entering the lower of the tuned amplifiers causes a charge to be placed on a condenser C_2, placing a potential across the associated resistance R_2. This lower circuit is associated with the vacuum tube V_1, upon the grid of which a normal negative voltage is impressed by the battery B. The charge on the condenser C_2 makes the grid of V_1 quite negative with respect to the filament of V_1, and consequently, no current can flow in the plate circuit of V_1. The value of the resistance R_2 is so chosen that the charge on the condenser C_2 leaks off gradually. Consequently, the negative biasing voltage on the grid of V_1 is gradually reduced. When the charge on C_2 has leaked off sufficiently, so that the grid of V_1 is practically at the normal biasing voltage from the battery B, the filament-plate circuit of the tube V_1 becomes conducting and the condenser C_1 is immediately discharged through that circuit. Thus, it will be seen that the negative voltage applied to the grid of the detector D_2 to prevent operation of the detector and the controlled switches by echoes in the lower path is maintained through a period of time determined by the action of the circuit C_2—R_2—that is, by the values of the condenser and the resistance. Also it will be seen that at the end of this period, or "hangover" time, the protection is abruptly removed and the detector D_2 again becomes operative.

In order to make the length of the hangover period independent of the amplitude of the incoming wave in the upper transmission path, a device is provided to fix the maximum charge which may be placed on the condenser C_2. A desirable volume limiting circuit is formed by the two-electrode vacuum tube V_2 and the resistance R connected in the input circuit of detector D_3 as shown in Fig. 1.

In order that the condenser C_2 may be quickly charged without the application of excessively high voltages, the condenser C_3 and the resistance R_3 are included in the output circuit of the detector D_3 to permit the operation of the detector on that part of its characteristic which is most favorable to such quick charging without the application of excessively high voltages to the plates of the detector.

The inclusion of the inductance L and the capacity C provides a tuned circuit for filtering out the voice frequencies which might otherwise pass into the switch control circuit through the tube V_1.

It has been stated that the length of the hangover period is independent of the amplitude of the waves in the upper or incoming transmission path. This will be more clearly understood if consideration is given to Figs. 2 and 3 of the drawing. Considering in detail, first, the diagram of Fig. 2, time is plotted against negative voltage. The curves Ec_1 and Er_2 indicate the voltages which control the hangover of the detector D_2. The curve Ec_1 corresponds to the charge on the condenser C_1, which controls the biasing voltage on the grid of tube D_2. The curve W represents the wave in the upper transmission channel. The mixed line indicates the normal biasing voltage placed on the grid of V_1 by the battery B. By means of the broken line Er_2, there is represented the potential placed across the resistance R_2 upon the charging of the condenser C_2. The wave in the transmission path, represented by W, causes the charge on the condenser C_1 to be proportional to the amplitude of W and the charge on C_2 to reach the maximum value. These charges hold up until the wave ceases. Then, it is noted, the voltage Er_2 drops off gradually on the usual condenser-resistance discharge curve. The voltage Ec_1, however, has an almost imperceptible drop, since the resistance R_1 is very large, or may be made to have any desired drop. As long as the voltage on the grid of V_1 is greater than the normal biasing voltage thereon, the voltage maintained on the grid of D_2 by the charge on the condenser C_1 holds up. As soon as the voltage on the grid of V_1 reaches the value at which the filament plate circuit of that tube becomes conducting, then the protection voltage on the grid of D_2 is abruptly removed, as is indicated by the curve Ec_1, condenser C_1 being discharged through the tube V_1. In other words, with reference to Fig. 2, from X to Y, the charge on C_1, represented by the curve Ec_1, is raised to the maximum and held there in response to the wave in the transmission path, represented by W; from Y to Z, this charge drops off only slightly, the grade of the drop being steeper as the value of the resistance R_1 is removed from infinity; and at Z, the charge is abruptly reduced to zero when the charge on C_2, represented by Er_2, reaches the value of zero, and the voltage on the grid of V_1 reaches the normal biasing voltage from the battery B. The effective hangover time is that represented between Y and Z.

An examination of Fig. 3, in connection with Fig. 2, will show clearly that the length of the effective hangover period is quite independent of the amplitude of the wave in the incoming transmission path. The wave W_1 of Fig. 3 is much smaller in amplitude than

the wave W of Fig. 2; yet, the values of C_2 and R_2 giving the broken curve in Fig. 3 similar to the curve Er_2 of Fig. 2, the hang-over in the case of Fig. 3 is of the same length as in the case of Fig. 2, the maintaining charge on the condenser C_1 being abruptly removed when the potential on the grid of V_1 is reduced to the limit fixed by the normal biasing voltage from battery B.

While the invention has been disclosed in one specific embodiment, which is deemed desirable, it is to be understood that it may be embodied in many other and widely different forms within the scope of the appended claims.

What is claimed is:

1. In a two-way telephone system including a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, the first path being normally blocked and the second path being normally cleared, a two-wire line connected to said circuit at one end thereof, switching means for simultaneously clearing said first path and blocking said second path, and a three-electrode vacuum tube detector associated with both of said paths for controlling said switching means; the method of preventing the operation of said switching means by echoes of waves in said second path which are reflected from the two-wire line over said first path, which consists in impressing on the grid of the detector in response to waves in the second path a negative voltage sufficient to prevent operation of the detector by the echoes, simultaneously storing a quantity of energy to maintain said voltage on said grid, abruptly discharging said maintaining energy at the termination of a certain period of time, and causing the length of said period to be determined independently of the amplitude of the waves in the second path.

2. In a two-way telephone system including a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, the first path being normally blocked and the second path being normally cleared, a two-wire line connected to said circuit at one end thereof, switching means for simultaneously clearing said first path and blocking said second path, and a three-electrode vacuum tube detector associated with both of said paths for controlling said switching means; the method of preventing the operation of said switching means by echoes of waves in said second path which are reflected from the two-wire line over said first path, which consists in impressing on the grid of the detector in response to waves in the second path a negative voltage directly proportional to the strength of transmission over said path, simultaneously storing a quantity of energy to maintain said voltage on said grid, abruptly discharging said maintaining energy at the termination of a certain period of time, and causing the length of said period to be determined independently of the amplitude of the waves in the second path.

3. In a two-way telephone system including a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, the first path being normally blocked and the second path being normally cleared, and a two-wire line connected to said circuit at one end thereof; a three-electrode vacuum tube detector associated with both of said paths, switching means controlled thereby for clearing the first path and simultaneously blocking the second path, means for operating said detector in response to voice waves originating in the two-wire line and passing over the first path, means for impressing on the grid of the detector in response to waves in the second path a negative voltage sufficient to prevent operation of the detector by echoes of said waves in the first path, means for maintaining said voltage on said grid for a period of time independent of the amplitude of the waves in the second path, and means for abruptly removing said voltage at the termination of said period.

4. In a two-way telephone system including a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, the first path being normally blocked and the second path being normally cleared, and a two-wire line connected to said circuit at one end thereof; a three-electrode vacuum tube detector associated with both of said paths, switching means controlled thereby for clearing the first path and simultaneously blocking the second path, means for operating said detector in response to voice waves originating in the two-wire line and passing over the first path, means for impressing on the grid of the detector in response to waves in the second path a negative voltage directly proportional to the strength of transmission over the second path, means for maintaining said voltage on said grid for a period of time independent of the amplitude of the waves in the second path, and means for abruptly removing said voltage at the termination of said period.

5. In a two-way telephone system including a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, the first path being normally blocked and the second path being normally cleared, and a two-wire line connected to said circuit at one end thereof; a three-electrode vacuum tube detector associated with both of said paths, switching means controlled thereby for clearing the first path and simultaneously blocking the second path, means for

operating said detector in response to voice waves originating in the two-wire line and passing over the first path, means for impressing on the grid of the detector in response to waves in the second path a negative voltage sufficient to prevent operation of the detector by echoes of said waves in the first path, means for simultaneously storing a quantity of energy to maintain said voltage on said grid, a three-electrode vacuum tube having its filament-plate circuit connected across said storing means, means responsive to the waves in the second path for impressing a negative voltage on the grid of said vacuum tube to prevent conduction over the filament-plate circuit thereof and the consequent discharge of the stored energy, and means for gradually reducing the negative voltage on said last-named grid to the point of conduction over said filament-plate circuit, the period of reduction having a length independent of the amplitude of the waves in the second path.

6. In a two-way telephone system including a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, the first path being normally blocked and the second path being normally cleared and a two-wire line connected to said circuit at one end thereof; a three-electrode vacuum tube detector associated with both of said paths, switching means controlled thereby for clearing the first path and simultaneously blocking the second path, means for operating said detector in response to voice waves originating in the two-wire line and passing over the first path, means for impressing on the grid of the detector in response to waves in the second path a negative voltage directly proportional to the strength of transmission over the second path, means for simultaneously storing a quantity of energy to maintain said voltage on said grid, a three-electrode vacuum tube having its filament-plate circuit connected across said storing means, means responsive to the waves in the second path for impressing a negative voltage on the grid of said vacuum tube to prevent conduction over the filament-plate circuit thereof and the consequent discharge of the stored energy, and means for gradually reducing the negative voltage on said last-named grid to the point of conduction over said filament-plate circuit, the period of reduction having a length independent of the amplitude of the waves in the second path.

In testimony whereof, I have signed my name to this specification this 7th day of September 1927.

HAROLD C. SILENT.