Nov. 9, 1937. D. MITCHELL 2,098,350

CONTROL OF SIGNALING CIRCUITS

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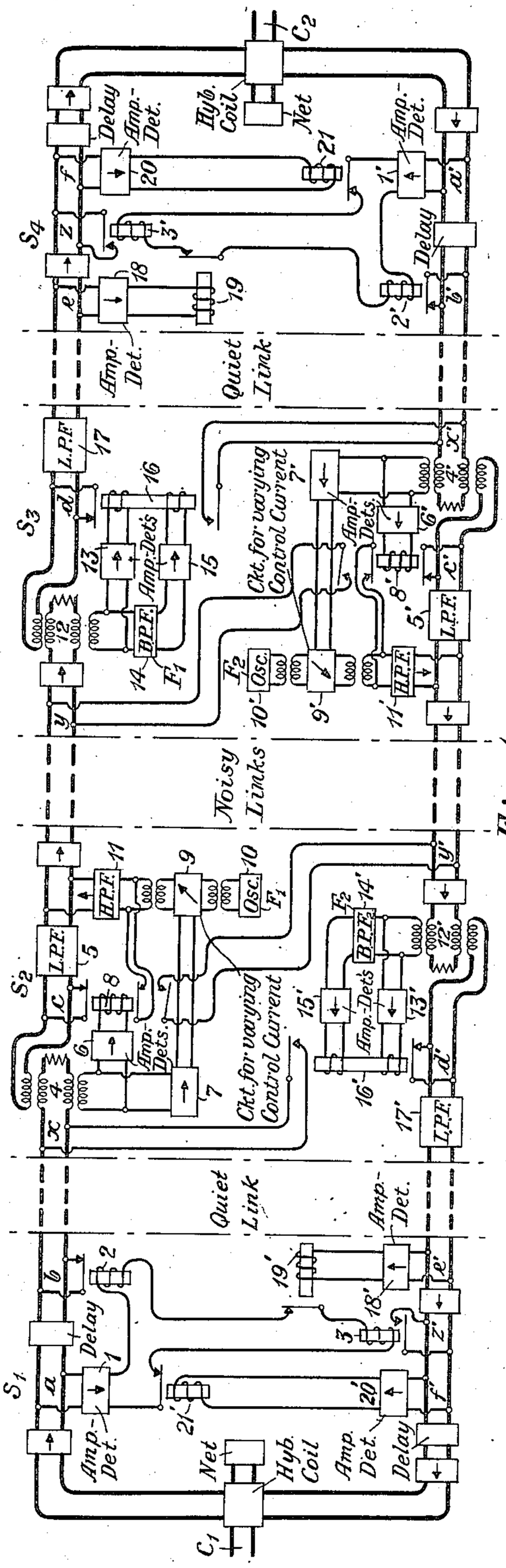

Fig. 1

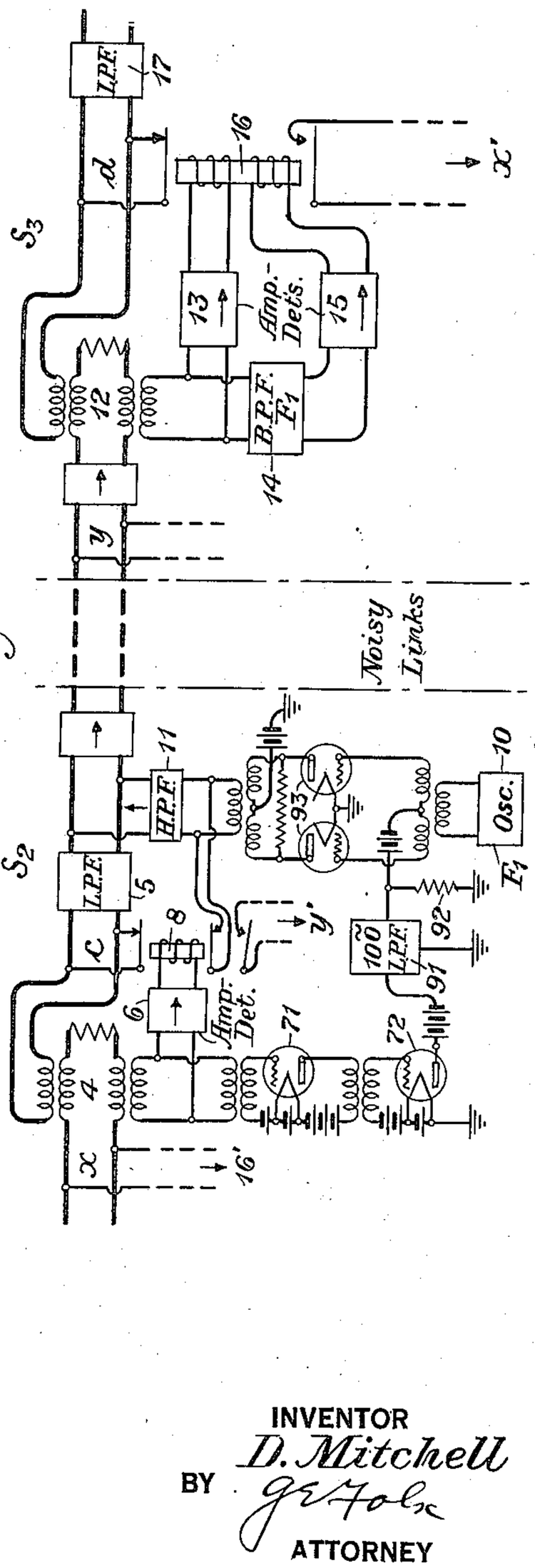

Fig. 2

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CONTROL OF SIGNALING CIRCUITS

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This invention relates to electrical signal transmission systems such as telephone systems and, more particularly, to long two-way telephone circuits equipped with wave-responsive devices for suppressing "singing" and "echoes." With greater particularity the invention is applicable to telephone circuits which are operated "anti-singing" by means of voice-operated devices and include a noisy or otherwise "mutable" link such as a radio link.

In a long telephone circuit having separate paths for transmission in opposite directions it is often desirable, in order to prevent singing, to have one or both of the one-way paths disabled at one or more points. It follows that means must be provided whereby the voice waves will cause the removal of any such disability normally found on the path over which these waves are to be transmitted. Also, it is usually desirable that the voice waves traveling in one path disable the oppositely directed path in order to prevent the return of echoes.

A telephone system such as that indicated hereinbefore may, however, include what will be termed hereinafter a "mutable" link—that is, a link capable of or liable to change (from internal or external cause) which may give rise to interfering energy, or, more specifically, a link specially subject to noise, fading (in the case of radio transmission) or change of impedance. In such a case the wave-responsive devices on the receiving side of the mutable link, when made sufficiently sensitive to operate on weak speech energy, are liable to false operation by the interfering energy originating in the mutable link.

Various methods of producing satisfactory operation of the wave-responsive devices on the receiving side of the mutable link have been devised. Examples are disclosed in United States Patents No. 1,674,695, issued June 26, 1928 to Nyquist and Wright; No. 1,675,412, issued July 3, 1928 to Holden, and No. 1,999,346, issued April 30, 1935 to Taylor and Mitchell.

It is the principal object of the present invention to provide for the positive operation of the wave-responsive transmission control devices on the receiving side of the mutable link without considerable overloading of the transmission apparatus associated with that link.

The advantage found in the accomplishment of this object and other advantages and features of the invention will be understood upon examination of the description contained hereinafter.

In general, the applicant applies to the circuit on the transmitting side of the mutable link, for transmission over that link simultaneously with the voice or other signal energy, distinctive control energy, which latter energy is adjusted as to magnitude in accordance with variation of the magnitude of the signal energy so that the load applied to the mutable link is never appreciably greater than the load which would be applied with the transmission of the voice or other signal alone. On the receiving side of the mutable link it is provided that the transmission control apparatus will respond positively to the received energy, whether the voice or other signal level be high or low, the received control energy performing the transmission controlling function in the case of low received signal energy.

The following detailed description should be read with reference to the accompanying drawing, of which Figure 1 shows diagrammatically, and in part schematically, a long two-way telephone system including arrangements in accordance with the invention, and Fig. 2 shows in a similar manner, but in somewhat greater detail, a portion of the system disclosed in Fig. 1. Like characters of reference designate corresponding elements and circuit points.

In Fig. 1 the two-wire circuits C_1 and C_2 are connected by a long "four-wire" circuit having the upper path adapted for transmission from left to right and the lower path adapted for transmission from right to left. This extended circuit lying intermediate to the two-wire circuits C_1 and C_2 comprises the "terminal" stations S_1 and S_4 and the "control" stations S_2 and S_3. It will be understood that S_1 and S_2 and S_4 and S_3 may be widely separated, but it is contemplated that the connecting link is quiet—as distinguished from the mutable link defined hereinbefore. Stations S_2 and S_3, however, are connected by one or more noisy or otherwise mutable links. It will be understood by those skilled in the art that such a "link" may be a radio link or some type of wire link, or a combination of radio and wire links, the characteristic with which the invention is concerned being that which results in interfering energy.

The circuit C_1 and the oppositely directed paths at station S_1 are connected through the usual arrangement of hybrid coil and balancing network, and the circuit C_2 and the paths of station S_4 are similarly connected.

At each of the stations S_1 and S_4 there is found a suitable arrangement of wave-responsive transmission control devices which are usually termed collectively "voice operated device anti-singing" (vodas).

At the stations S_2 and S_3 are located the devices for applying the control current in accordance with the applicant's invention and the apparatus for producing the positive transmission control in response to the energy received from the distant control station over the noisy link.

It will be noted that in the arrangement specifically disclosed in Fig. 1 each one-way path is normally disabled at the transmitting vodas station and at each of the control stations S_2 and S_3.

The details of the system disclosed in Fig. 1 will be best understood, it is believed, by tracing the operation in response to signal transmission from left to right, for instance, that is, from the circuit C_1 to the circuit C_2. The waves divide in the hybrid coil, the useful portion of the energy passing upward and through the one-way amplifier to point *a*. At this point a portion of the energy is diverted to operate an amplifier-detector **1** which may be termed the vodas amplifier-detector. If there has been no operation of amplifier-detectors responsive to transmission in the opposite direction, the operation of amplifier-detector **1** results in the operation of relays **2** and **3**. Relay **2**, in operating, removes from the upper transmission path the disability normally applied at point *b*, and thus the voice waves which have been subjected to a slight delay by a suitable circuit are free to pass on over the quiet link to station S_2. The operation of relay **3** disables transmission over the lower path at point *z'*, thus preventing the return of echo currents and any interference with the transmission from left to right which might be produced thereby.

Upon reaching station S_2 the transmitted signal energy divides in a hybrid coil **4**. Part of this energy passes through a low-pass filter **5** and on to the noisy link, provided the disability normally applied at point *c* is removed. The portion of the divided energy passing downward from the hybrid coil **4** operates amplifier-detectors **6** and **7**. The output circuit of amplifier-detector **6** includes the winding of a relay **8** which has among its functions that of removing, upon operation, the disability at point *c* and thus clearing the upper path for the transmission of the voice or other signal waves. The relay **8** may also apply a suppressing disability to the opposite path at a point *y'*. Furthermore, this relay, upon operation, removes a short circuit normally applied between the oscillator **10** and the high-pass filter **11**. Thus, as a result of the operation of relay **8**, there is applied to the upper transmission path, simultaneously with the signal energy, control energy from the oscillator **10**, the high-pass filter **11** being included, as shown. This control energy is of a distinctive frequency which may be termed F_1. Associated with the output of amplifier-detector **7** is a device **9** (to be described in greater detail hereinafter) which responds to variation of the magnitude of the signal energy and adjusts the amount of control current applied to the circuit from oscillator **10**. The variation of the magnitude of the control current introduced by this device **9** is inverse with respect to the variation of signal energy magnitude and, as indicated hereinbefore, the adjustment should be such that at no time will the load applied to the noisy link be substantially greater than the load which would be applied in the case of the signal energy alone. In other words, if the signal energy level is high there is applied to the oscillator **10** control energy of low magnitude, while if the signal energy is relatively low the control energy applied is of correspondingly greater magnitude.

The hereinbefore described arrangement including the controls exercised by relay **8**, permits the application to the signal path and the removal therefrom of the control energy without the introduction of transients of the signal frequencies.

It is to be borne in mind that the voice or other signal waves and the control energy pass simultaneously over the mutable link to station S_3. On the receiving side of the mutable link, unless the upper path has been disabled at point *y* in response to transmission in the lower path, the received energy passes through a one-way amplifier to the hybrid coil **12**. The principal part of the energy is to pass the point *d*, at which there is normally applied a disability. It is the function of the part of the energy passing downward from the coil **12** to remove this disability positively. Of the two amplifier-detectors shown, the upper one, **13**, is tuned to respond to voice waves and is set to be comparatively insensitive and thus to operate only in response to comparatively high voice energy. If, then, the received voice energy is of high level the upper winding of relay **16** will be energized and the singing suppressing disability normally applied at point *d* will be removed to permit the passage of the energy from the mutable link. If, on the other hand, the received signal energy is of low level the relay will not operate in response to the output of amplifier-detector **13**. The band-pass filter **14** is designed to pass substantially only the control current, this feature helping to discriminate against noise. The amplifier-detector **15** is thus affected substantially only by the control current and is designed to operate on all values of control energy except the lower ones. In other words, this amplifier-detector **15** is adjusted to operate on the values of control current corresponding to low signal level and not on the values of control current corresponding to the higher signal levels which will cause the energization of the upper winding of relay **16**. Upon the operation of amplifier-detector **15** the lower winding of relay **16** is energized and the disability removed from point *d*.

The relay **16**, whether operated in response to signal or control energy, may have the additional function of applying a disability to the lower transmission path at point *x'*.

The filter **17** in the upper transmission path at station S_3 is a low-pass filter designed to pass the voice or other signal energy and to suppress the control energy, which has now completed its work.

Upon reaching station S_4 the signal energy operates the receiving amplifier-detector **20**, which may be set to be very sensitive since noise from the mutable link is present at this point only when signals are coming in. The operation of this amplifier-detector **20** disables the output of the transmitting amplifier-detector **1'** and thus prevents false operation at this vodas point in response to echoes. The control obtained by the operation of amplifier-detector **18** and relay **19** in response to energy diverted at point *e*, contributes to the desirable result of confining the lockout zone to the noisy link (in cooperation with the control which may be established at point *y*, for example); that is, the operation of relay **19** enables the waves passing from left to right to take control at point *z*. In the absence, however, of transmission from left to right the

transmitting amplifier-detector at station S_4 (1') will cause the operation of relay 3' and disable the upper path at point *z*. While a portion of the received energy in the upper path is diverted at point *f* to operate the receiving amplifier-detector 20, the balance of the energy passes on through a delay circuit and a one-way amplifier to the terminal apparatus where the useful portion is applied to the two-wire circuit C_2.

The one-way amplifier shown between points *e* and *z* permits the operation of relay 18 regardless of the condition of relay 3'.

It will be understood that transmission from right to left in the circuit specifically disclosed is the same with respect to transmission control operations as in the case of transmission from left to right, just described.

As indicated hereinbefore, the complete arrangements of transmission control shown in Fig. 1 serve to suppress cross-transmission if it is present and limit the lockout zone to the minimum length. Such arrangements are well understood in the art, and, apart from their combination with the special control energy arrangements described herein, form no part of the present invention.

In Fig. 2 of the drawing there is disclosed in somewhat greater detail the control energy arrangements associated with the upper transmission path at stations S_2 and S_3. It will be understood that the control energy arrangements disclosed in Fig. 1, in association with the lower transmission path, may take the form corresponding to that shown in detail in Fig. 2. As has been indicated hereinbefore, voice waves passing the point *x* divide in the hybrid coil 4, a part of the energy passing upward and through the low-pass filter 5 (upon removal of the disability at point *c*). The remaining part of the divided energy passes downward to operate amplifier-detector 6 and amplifier-detector 71—72. Amplifier-detector 6 is set to be very sensitive and, accordingly, to operate on all values of speech. Therefore, when speech is transmitted relay 8 operates and removes the disability normally applied at point *c*, and also removes the short circuit normally applied between oscillator 10 and filter 11. Such operation permits the application to the transmission circuit of the output of oscillator 10, which generates a single-frequency control wave having frequency F_1. It is the function of the remaining apparatus disclosed at station S_2 in Fig. 2 to vary the magnitude of the control energy applied to the transmission circuit inversely with variation of the magnitude of the transmitted signal energy. Amplifier-detector 71—72 is normally adjusted so that there is no current flowing in the detector tube 72 and, accordingly, no voltage drop across the resistance 92. With this normal condition the push-pull amplifier 93 will have only its normal biasing voltage on the grids, and this voltage is such that a high value of control current will be transmitted from oscillator 10 through the high-pass filter 11, to be applied to the transmission path when relay 8 operates, but not otherwise.

If the voice waves in amplifier-detector 71—72 represent weak speech, only small current will flow through the 100-cycle low-pass filter 91 and there will be only a small voltage drop in resistance 92. Consequently, the control current from oscillator 10 will be applied to the transmission path, for transmission into the noisy link simultaneously with the signals, at practically its full strength. If, on the other hand, the voice waves represent strong speech a comparatively large amount of current will pass through the low-pass filter 91 and there will be a large voltage drop in resistance 92. Consequently, there will be a considerable addition to the biasing voltage applied to the grids of the push-pull amplifier 93 and the value of the control current passing through filter 11 for application to the transmission path will be low.

The 100-cycle low-pass filter 91 is included in the circuit in order to make the control current variation follow the speech envelope rather than the individual waves of speech. This arrangement serves to prevent the excessive modulation of the control waves in the mutable link by the speech and also tends to prevent the control energy from varying over unnecessarily wide ranges of magnitude.

The operation of the control apparatus shown at station S_3 in Fig. 2 has been generally described in connection with Fig. 1. Amplifier-detector 13 is adjusted to operate only on the higher values of speech energy. Accordingly, this apparatus will not be affected by noise, etc., from the mutable link unless the noise or other interfering energy is so high that it practically renders the circuit useless for commercial transmission. The band-pass filter 14 designed to pass substantially only the control frequency F_1 may be tuned quite sharply. Amplifier-detector 15, as has been indicated hereinbefore, is adjusted to operate on control energy corresponding to the values of speech energy which are too low to produce dependable operation of amplifier-detector 13. Accordingly, when energy of considerable value is received at station S_3 relay 16 will operate either on the energization of the upper winding by speech, or on the energization of the lower winding by the control energy corresponding to the lower values of speech. The operation of relay 16 clears the upper transmission path at point *d* and may also disable the opposite path at point *x'*, as indicated.

It will be understood that with the applicant's arrangement, while the desired operation of the transmission control apparatus on the receiving side of the mutable link is practically assured, the load applied to the mutable link is never appreciably greater than the load which would be applied by the signal alone. When the voice energy is in the neighborhood of the maximum value the control current may be from 15 to 20 decibels below the signal in magnitude, and the combined effect of the two types of energy will be only a small fraction of a decibel greater than the effect of the voice alone. On the other hand, if the voice energy is, for example, from 10 to 15 decibels below the maximum value, the control energy will approach its maximum value and the total load will exceed by only a small fraction of a decibel the load due to the control energy alone.

While the invention has been disclosed specifically for the purpose of illustration, it is to be understood that it may be embodied in many other and widely different forms without departure from the true invention as defined in the appended claims.

What is claimed is:

1. In a signaling system including a transmitting section, a receiving section and an intermediate link, means associated with the transmitting section and responsive to signal energy therein for applying distinctive control energy to the system, and means for varying the magnitude

of the applied control energy inversely with variation of the magnitude of said signal energy.

2. In a signaling system including a transmitting section, a receiving section and a mutable intermediate link, means associated with the transmitting section and responsive to signal energy therein for applying distinctive control energy to the system, means for varying the magnitude of the applied control energy inversely with variation of the magnitude of said signal energy, and transmission control means associated with the receiving section and responsive to relatively strong signal energy or, if the signal energy is weak, to the control energy.

3. In a signaling system including a transmitting section, a normally disabled receiving section and a mutable intermediate link, the method of effecting positive control of the receiving section which consists in applying control energy to the transmitting section when signal energy is transmitted thereover, causing the magnitude of the applied control energy to vary inversely with variation of the magnitude of the signal energy, and causing the clearing of the receiving section for transmission thereover to be effected either by relatively strong signal energy or, if the signal is weak, by the control energy.

4. In a telephone system including a transmitting section, a normally disabled receiving section and a mutable intermediate link, means associated with the transmitting section and responsive to voice waves therein for applying to the system for transmission over said intermediate link simultaneously with the voice waves distinctive control energy of magnitude inversely related to the magnitude of the voice energy, and means associated with the receiving section for clearing the same, said last stated means being responsive to voice waves of relatively high amplitude or, if the amplitude of the voice waves is low, to the control energy.

5. In a signaling circuit designed to be operated anti-singing and including a mutable link, means at the transmitting end of the mutable link for impressing distinctive control energy on the circuit for transmission over said link only simultaneously with the signal energy, and means for varying the magnitude of the control energy impressed on the circuit inversely with variation of the magnitude of the signal energy.

6. In a signaling circuit designed to be operated anti-singing and including a mutable link, means at the transmitting end of said link for applying distinctive control current to the circuit for transmission over said link only simultaneously with the signal, means for varying the magnitude of the applied control energy inversely with variation in magnitude of the signal energy, and means at the receiving end of said link for controlling transmission over the circuit, said controlling means being responsive to relatively high signal energy or, if the signal energy is of low value, to the control energy.

7. The method of transmitting control energy over an electrical signal transmission circuit without overloading which consists in applying a distinctive wave to the circuit for transmission thereover only simultaneously with the signal and causing the amplitude of said wave to vary inversely with the strength of the signal.

8. In a system for the transmission of electrical signal waves, said system including a mutable link and a normally disabled receiving section, the method of controlling transmission without applying an excessive load to the mutable link which consists in impressing a distinctive wave on the system for transmision over said link only simultaneously with the signal, causing the amplitude of said wave to vary inversely with the strength of the signal, and effecting the desired transmission control at the distant end of said link, including the clearing of the receiving section, in response to the received signal energy if it is comparatively great and in response to the received control energy if said signal energy is comparatively small.

9. The method of controlling transmission over a telephone circuit including an intermediate mutable link and a normally disabled receiving section, which consists in applying to the circuit at the transmitting end of said link for transmission thereover only simultaneously with the voice distinctive control energy of magnitude varied inversely with variation of the magnitude of the voice energy, and clearing the normally disabled section at the receiving end of said link in response either to received voice energy of relatively high level or to the received control energy if the signal energy level is low.

10. The method of controlling transmission over a signaling circuit including an intermediate mutable link and a normally disabled receiving section, which consists in applying to the transmitting end of the mutable link simultaneously the transmitted signal energy and distinctive control energy varying in magnitude inversely with variation of the magnitude of said signal energy, and producing transmission control at the distant end of said link, including the clearing of the receiving section, by the combined effect of the received signal energy and the received control energy.

11. In a two-way signaling system having separate paths for transmitting in opposite directions, each of said paths including two extended wire sections and an intermediate mutable link, apparatus near each terminal of the system responsive to transmitted signal energy for preventing singing, means associated with each path for transmitting over the mutable link simultaneously with the signal energy distinctive control energy varying in magnitude inversely with variation of the magnitude of the signal energy, and means associated with each path near the output from the mutable link for controlling the transmission over the system, said controlling means being responsive to strong received signals and, if the signals are weak, to the received control energy.

12. The method of controlling transmission over a signaling circuit including a mutable link which consists in transmitting distinctive control energy over the mutable link only simultaneously with the signaling energy, and adjusting the magnitude of the control energy with relation to variation of the signal energy so that the combined magnitude of the energy of the two types is below the overloading point of the apparatus at the terminals of the mutable link.

13. The method of controlling transmission over a signaling circuit including a mutable link and a normally disabled receiving section, which consists in transmitting distinctive control energy over the mutable link only simultaneously with the signal energy, adjusting the magnitude of the control energy with relation to variation of the signal energy so that the combined magnitude of the energy of the two types is below the overloading point of the apparatus at the ter-

minals of the mutable link, and effecting the desired transmission control on the receiving side of the mutable link, including the clearing of the disabled section, in response to received energy of sufficiently high level, whether said energy be predominantly signal or control energy.

14. In a two-way telephone circuit including separate paths for transmission in opposite directions, two terminal stations, two control stations and a mutable link intermediate to the control stations, voice-operated apparatus at each terminal station for suppressing echoes and singing, means at each control station for transmitting over the mutable link simultaneously with the voice waves a control wave of distinctive frequency, said wave varying in amplitude inversely with variation of the amplitude of the voice waves, and means at each control station in association with the receiving side of the mutable link for controlling transmission over the paths at that station in response to voice waves of sufficient amplitude or, if the voice energy is low, in response to the received control energy.

15. In a two-way telephone circuit including separate paths for transmission in opposite directions, two terminal stations, two control stations and a mutable link intermediate the control stations, voice-operated apparatus at each terminal station for suppressing echoes and singing, means at each control station for transmitting over the mutable link simultaneously with the voice waves a control wave of distinctive frequency, said wave varying in amplitude inversely with variation of the amplitude of the voice waves, and means at each control station in association with the receiving side of the mutable link for controlling transmission over the paths at that station, said last stated means including two amplifier-detectors of which one responds to high voice energy and the other to control energy corresponding to low voice energy.

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