

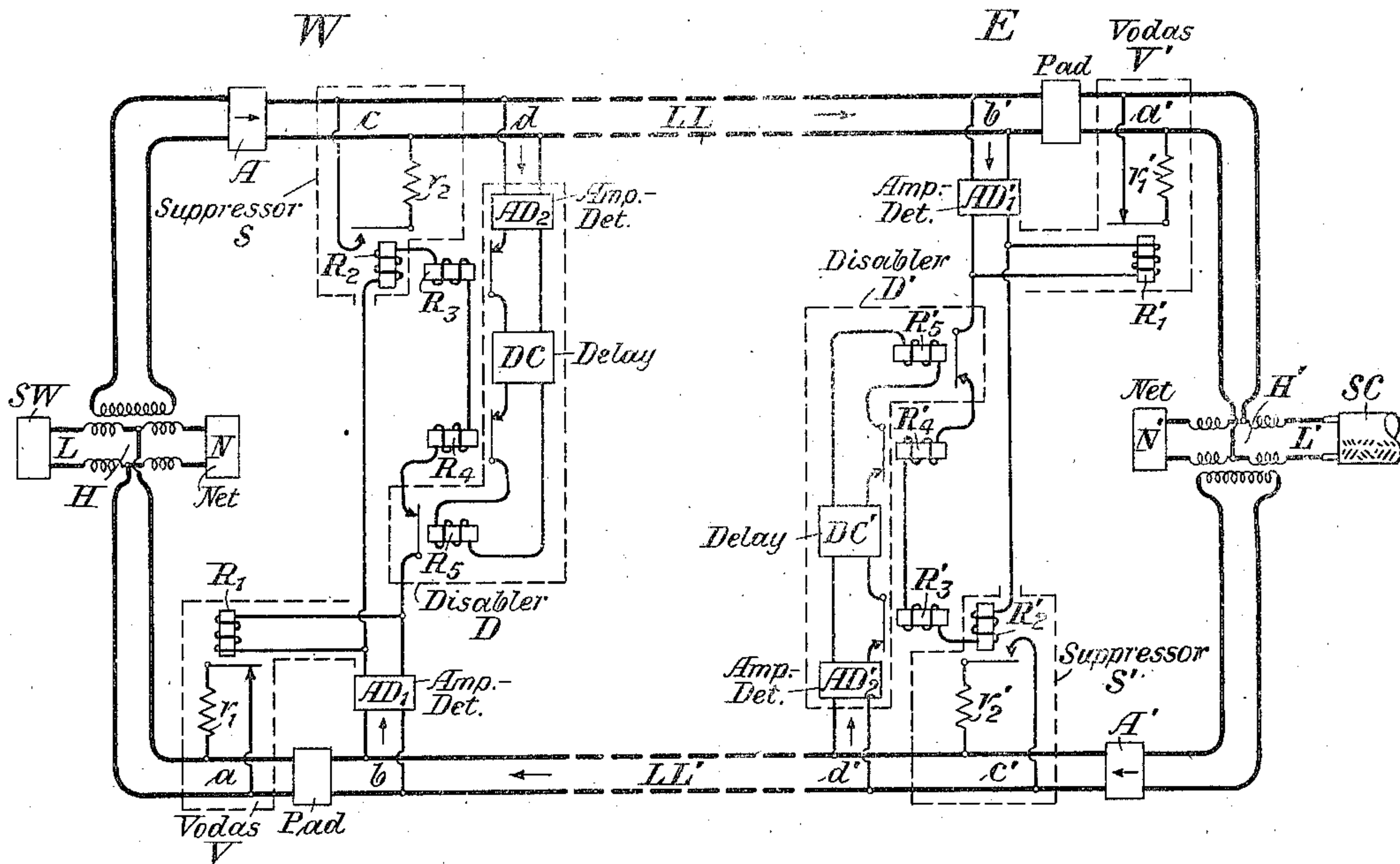
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TWO-WAY SIGNALING SYSTEM

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Delay of DC (DC') = one-way delay of LL from d to b' (LL' from d' to b).
Zero level sensitivity of R_5 (R'_5) should be lower than sensitivity of R'_2 (R_2) or R'_1 (R_1) under all conditions of net loss of the circuit.
Hangover of relay R_5 (R'_5) or of relay R_1 (R'_1) should not exceed the hangover of suppressor S (S').

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TWO-WAY SIGNALING SYSTEM

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This invention relates to two-way transmission systems and more particularly to two-way telephone systems including a long four-wire section having separate paths for transmission in opposite directions.

In a four-wire circuit such as that contemplated there arise certain problems. Each end of the circuit may be connected to an extending circuit, which is often a two-wire line. It is the usual practice to connect the end of the four-wire circuit and the extending two-wire line together through a hybrid coil or the equivalent and to provide an artificial network designed to "balance" the impedance of the two-wire line. This "balance" is at the best an approximation, and the inevitable lack of perfect balance between the impedance of the two-wire line and the impedance of the artificial network results in the reflection of energy, which is normally transmitted in one direction over one side of the four-wire circuit, back over the oppositely directed path. As a result of this reflection there arise, as is well understood in the art, various transmission problems, including those of "echoes" and "singing". For the purpose of preventing "singing" and the objectionable transmission of "echoes," it is the practice to utilize certain transmission control apparatus usually responsive to energy such as that representing the voice in the case of a telephone system. The use of such apparatus, however, leads to further problems, such as those of unduly difficult "breaking" and mutual lockout.

In the applicant's Patent No. 2,060,008 issued November 10, 1936 (application Serial No. 740,518) there is disclosed an arrangement of transmission control apparatus which for many purposes solves or satisfactorily approaches a solution of the problems indicated hereinbefore. With that arrangement, however, there may be an appreciable chance of sustained singing, as will be indicated hereinafter. The principal object of the present invention is to eliminate or substantially eliminate this possibility of singing, which possibility may be tolerable in many instances of the use of such a system, but quite intolerable in the exceptional case.

The present invention contemplates, as indicated hereinbefore, a four-wire circuit, which may be of great length, and transmission control apparatus located at or near the terminals of the four-wire circuit. It is to be understood, furthermore, that the invention is applicable to many different types of two-way circuit. For instance, it is applicable to a four-wire circuit which

is extended at one end by a land two-wire line and at the other end by a submarine cable circuit. Again, the four-wire circuit to the terminals of which the transmission control apparatus is directly applied may include sections intermediate to which are hybrid coils or the equivalents, no intermediate transmission control apparatus being applied. Also it will be clear to those skilled in the art that the oppositely directed paths of the four-wire circuit may include a radio link or radio links.

In general, the applicant's terminal arrangements include at or near each terminal of the four-wire circuit a "vodas", an echo suppressor and a disabler. As is well understood in the art, the term "vodas" is now generally applied to the voice-operated device anti-singing and represents the words describing such apparatus. Briefly, with reference to the application to the present invention, each one-way path of the four-wire circuit is normally disabled or includes an appreciable transmission loss at a point near its receiving end, such disability or loss having the primary purpose of preventing the completion of a singing path. When the voice energy, for example, reaches the receiving end of the one-way path, the vodas operates to remove the disability or other loss, and thus to permit the completion of the transmission. The echo suppressor, as applied in the present case, serves to disable the oppositely directed transmitting path under certain conditions simultaneously with the clearing of the receiving path. The disabler is a device which permits outgoing voice energy, for example, which passes the point in the transmitting path at which the echo suppressor may take effect to prevent the subsequent interruption of the outgoing waves in response to later arriving energy in the incoming path. Such an arrangement of terminal transmission control apparatus is disclosed and claimed in the applicant's Patent No. 2,060,008, issued November 10, 1936, referred to hereinbefore.

As will appear more clearly hereinafter, the arrangement just described, without more, may permit sustained singing—if the two subscribers connected to the ends of the transmission system begin to speak at approximately the same time. In general, it is the outstanding feature of the present invention that there is introduced into the operation of the disabler a definite delay, which by itself, or in cooperation with certain other arrangements to be discussed hereinafter, serves to eliminate, or reduce as far as

is feasible, the chance of the singing condition which may be so produced.

The following description of one desirable embodiment of the invention is to be read with reference to the accompanying drawing, which shows diagrammatically and in part schematically the four-wire circuit, including the application at or near each terminal thereof of the applicant's transmission control apparatus with the above indicated delay suitably provided for.

With reference to the drawing there is shown a four-wire circuit extending between two widely separated stations W and E. This four-wire circuit is extended at its left end by a two-wire line L, which furnishes the connection to the station of the west subscriber labeled "SW". At the right end the four-wire circuit is extended by a two-wire line L' which may form the circuit of a submarine cable SC. The connections between the four-wire circuit and the lines L and L' are through hybrid coils H and H', respectively, the artificial networks N and N' furnishing an approximate balance with the lines L and L', respectively.

The four-wire circuit extending between stations W and E comprises the two-wire path LL adapted for transmission from west to east, for example, and the two-wire path LL' adapted for transmission from east to west. The inclusion of suitable amplifying elements is indicated at A and A'. It will be understood from the statements made hereinbefore that the paths LL and LL' may not be continuous, but may involve the inclusion of different links, including one or more radio links. It is to be understood, furthermore, that for the best results from the applicant's present arrangement the system is one which does not involve transmission control apparatus intermediate to stations W and E.

At station W the transmission control apparatus comprises the vodas V, including relay R₁, the echo suppressor S, including relay R₂, and the disabler D, including the relay R₅. Correspondingly, the apparatus at station E comprises the vodas V' with relay R'₁, the suppressor S' with relay R'₂ and the disabler D', including relay R'₅. Thus it appears in the arrangement specifically disclosed that the system is symmetrical with respect to the transmission control apparatus at the two terminal stations of the four-wire circuit. While such arrangement is usually to be preferred, it will be understood from an examination of the appended claims that the invention is not necessarily limited in its scope to this symmetrical arrangement.

It is believed that the arrangement and operation of the transmission control apparatus of the present invention and the nature of the improvement now made over the applicant's system disclosed in Patent No. 2,060,008 issued November 10, 1936 will be best understood from the following detailed description, which is based on the operation of the apparatus.

When the subscriber at SW talks, the energy representing his voice travels over line L and divides in hybrid coil H, the useful portion traveling on over path LL. This energy is amplified at A and will reach point d, unless it is blocked by reason of the fact that the suppressor relay R₂ is operated. At point d a small portion of the energy travelling from west to east in path LL is diverted to operate the amplifier-detector AD₂. Connected to the output of the amplifier-detector is a delay circuit DC, which, in the specific disclosure now made, would be a direct current delay

circuit. To the output of the circuit DC is connected the winding of the disabler relay R₅. It will be noted that the operation of relay R₅ breaks a circuit associated with the output of an amplifier-detector AD₁, which is operated by energy diverted from the path LL' at point b. Accordingly, if relay R₅ operates before the operation of the suppressor relay R₂, there will be no change in the transmission loss introduced in path LL at point c. In other words, if energy traveling from west to east passes point c and causes the operation of the disabler relay R₅ before energy traveling in the opposite direction in path LL' causes the operation of the suppressor relay R₂, then the subscriber at SW has control of the circuit and the energy representing his voice will travel on to station E. However, it is to be borne in mind that the circuit DC introduces a considerable delay in the operation of relay R₅, which feature will be considered in greater detail hereinafter.

Once the energy representing the west subscriber passes the point d, it will travel on to the east end of the four-way circuit, regardless of the presence or absence of energy traveling in the opposite direction over path LL'. This feature of the applicant's arrangement will be readily understood when it is considered that a portion of the west-east energy is diverted at point b' to operate amplifier-detector AD'₁ and relay R'₁. It may be that energy traveling from east to west in path LL' will prevent the operation of the suppressor relay R'₂ in response to the operation of amplifier-detector AD'₁, but this disabling operation has no effect on the operation of relay R'₁, which is the relay of the vodas V'. For the purpose of suppressing singing, the path LL is normally disabled, or has an appreciable transmission loss, at point a'. As specifically disclosed, this loss is introduced by the shunt circuit including the resistance r'₁. When the vodas relay R'₁ operates in response to the incoming signal energy in path LL, this shunt normally applied at point a' is removed and the signal energy is free to pass on to the extending two-wire circuit L'.

Similarly when the subscriber connected to the right (east) end of the system begins to speak, the energy representing his speech travels over path LL' and passes point c', unless the echo suppressor relay R'₂ is operated. It is understood, of course, that if this relay is operated, there is closed a shunt including a resistance r'₂, which circuit introduces an appreciable loss at point c'. After passing point c', the east-west energy operates amplifier-detector AD'₂, and after the period determined by the delay circuit DC', operates the disabler relay R'₅, unless such operation is prevented. After passing the east end of path LL', the east-west energy will pass on without fail (provided only it is of sufficient magnitude) to the west end of the circuit, operating amplifier-detector AD₁ and the vodas relay R₁, which removes the disability at point a. This disability, as specifically disclosed, is produced by the application of the shunt including resistance r₁.

It will be understood by those skilled in the art that various factors, including the relative operating time of the various transmission control devices, enter into the satisfactory operation of this system. It will be understood that without a suitably timed delay in the operation of the disabler, it is possible for a condition of sustained singing to be set up—if the subscribers at the ends of the circuit happen to start speaking at about the same time and if the circuit

net loss and terminal balances are low at that time. If this should happen, the west-east energy might operate the disabler at W to prevent the operation of the echo suppressor at W, and, of course, remove the disability in the receiving section at station E, while the oppositely directed energy operated the disabler at E, preventing the operation of the echo suppressor at E, and, of course, passed on to remove the disability normally applied in the receiving section at W. While such a condition is not likely to occur at any given time, it is likely to occur eventually, and it is highly important for the proper operation of some transmission circuits that this possibility be eliminated or rendered quite remote.

Accordingly, the applicant proposes to introduce into the operation of the disabler D a delay which is equal to the one-way delay of the four-wire circuit; that is, for example, the delay of path LL' between points d' and b. Likewise it is proposed to introduce an equal delay in the disabler D' at the opposite end of the circuit which will, of course, equal the delay between W and E, or from point d to b'. It will be noted that the output of amplifier-detector AD₁ includes not only the winding of relay R₂ but also the windings of relays R₃ and R₄. These relays are designed to break the disabler circuit, to prevent the operation of the disabler relay R₅ after amplifier-detector AD₁ has operated. The purpose of this arrangement, including the delay in the operation of the disabler, is to give control of the circuit to the subscriber who first begins to speak. If the west subscriber begins before the east subscriber, he will, of course, get through at point c, and the energy diverted at point d will operate the disabler relay R₅, after a delay which is completed before the later originating energy from E can operate the suppressor relay R₂ at W, or the relays R₃ and R₄, which will affect the operation of the disabler relay R₅. Thus, while the west-east energy upon reaching E will cause the removal of the disability at point a', the disability at W applied at point c remains to prevent the completion of a singing path.

It is necessary to a complete understanding of the present invention and the features of the applicant's circuit to consider the various relay sensitivities and the hangover periods involved. In accordance with the invention in the form specifically disclosed, the zero level sensitivity of the disabler relay R₅ should be slightly lower than the sensitivity of the suppressor and vodas relays R₂ and R₁, respectively, at the opposite end of the four-wire circuit, under all conditions of circuit net loss. Correspondingly, the sensitivity of relay R₅ at the east end should be slightly lower than the sensitivity of relays R₂ and R₁ at the west end of the circuit. The hangover of the disabler relay R₅ at station W—and that of the vodas relay R₁—should not exceed the hangover of the suppressor S, which will be largely determined by the hangover of relay R₂.

With greater refinement, it appears that the desirable sensitivities for the suppressor relay R₂ and the vodas relay R₁ are sensitivities which are equal; then if the transmission control apparatus applied to the whole four-wire circuit is symmetrical, the sensitivity of the disabler relay R₅ should be somewhat lower than the sensitivities of R₂ and R₁. In other words, the sensitivities should be so related that the zero level sensitivity of the disabler relay will never become greater than the zero level sensitivity of the vodas relay, which latter sensitivity in turn should

never be greater than the zero level sensitivity of the suppressor relay.

The hangover of the suppressor relay (R₂, for example) should be determined from the maximum delay expected in any echo, with reference to the path between the input of the suppressor and the point at which the disability or increased transmission loss is applied. The hangover of the vodas relay (R₁, for example) should be determined by the speech characteristics and, as indicated hereinbefore, should not be greater than the hangover of the suppressor relay.

The arrangement disclosed with the definite delay of the disabling action and the sensitivity and hangover relations indicated, appears to give an operation which is quite satisfactory from the standpoint of singing suppression, and reasonably satisfactory with respect to other considerations, such as breaking and lockout.

While the invention has been disclosed specifically in one desirable embodiment for the purpose of illustration, it is to be understood that the scope of the invention is to be determined from the appended claims.

What is claimed is:

1. In a two-way system for the transmission of energy, comprising two separated stations connected by two paths adapted for transmission in opposite directions, the method of transmission control which consists in normally introducing an appreciable loss in each path near its receiving end, causing the energy approaching the receiving end of either path to remove said loss therefrom independently of the presence or absence of energy in the opposite path, applying a portion of said first mentioned energy to introduce an appreciable loss in the opposite transmitting path, applying a portion of the energy traveling over either transmitting path to prevent the subsequent introduction of loss in said path, and introducing a delay in said preventive action substantially equal to the one-way delay between the stations.

2. In a two-way telephone system, two separated stations, two paths connecting said stations and adapted for transmission in opposite directions, means associated with the receiving section of each of said paths for normally introducing an appreciable loss in said section, means responsive to voice waves reaching the receiving section of either of said paths for removing the loss normally introduced therein independently of the presence or absence of voice waves in the opposite path, means responsive to voice waves reaching the receiving section of either of said paths for closing a circuit designed to introduce an appreciable loss in the transmitting section of the opposite path, and means responsive to earlier arriving voice waves in said transmitting section for opening said circuit but only after a delay approximately equal to the one-way delay of the system between said stations.

3. In a two-way telephone system, two separated stations, two paths connecting said stations and adapted for transmission in opposite directions, and corresponding sets of transmission control apparatus located one at each of said stations, each of said sets comprising a vodas for controlling the receiving path independently of the presence or absence of voice waves in the opposite transmitting path, an echo suppressor for introducing an appreciable loss in the transmitting path in response to incoming voice waves, and a disabler for disabling the

associated echo suppressor in response to outgoing voice waves which succeed in passing the same, said disabler including means for delaying its action for a period of time substantially equal to the one-way delay of the system between said stations.

4. In a two-way telephone system, two separated stations, two paths connecting said stations and adapted for transmission in opposite directions, and sets of transmission control apparatus located one at each of said stations, one of said sets comprising a vodas for controlling the receiving path independently of the presence or absence of voice waves in the opposite transmitting path, an echo suppressor for introducing an appreciable loss in the transmitting path in response to incoming voice waves, and a disabler for disabling the associated echo suppressor in response to outgoing voice waves which succeed in passing the same, said disabler including means for delaying its action for a period of time substantially equal to the one-way delay of the system between said stations.

5. In a two-way telephone system, two separated stations, two paths connecting said stations and adapted for transmission in opposite directions, and sets of transmission control apparatus located one at each of said stations, each of said sets comprising a vodas for controlling the receiving path independently of the presence or absence of voice waves in the opposite transmitting path, an echo suppressor for introducing an appreciable loss in the transmitting path in response to incoming voice waves, and a disabler for disabling the associated echo suppressor in response to outgoing voice waves which pass said suppressor, said disabler including means for delaying its action for a period of time substantially equal to the one-way delay of the system between said stations, the sensitivity of the disabler being lower than the sensitivity of the vodas or the echo suppressor, the hangover of the disabler apparatus not exceeding the hangover of the echo suppressor.

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