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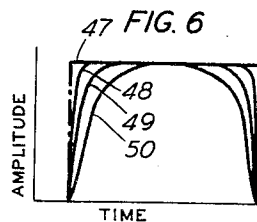
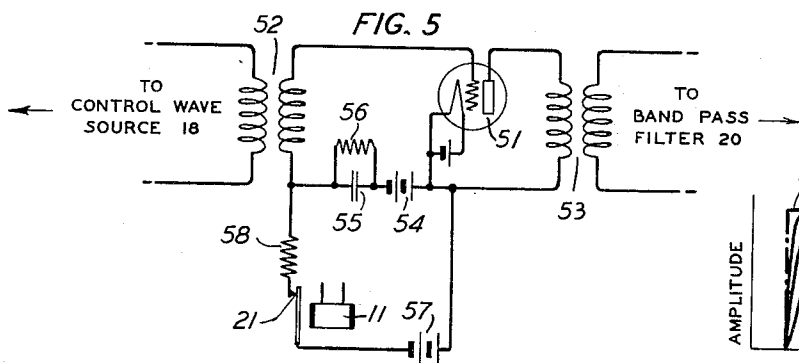
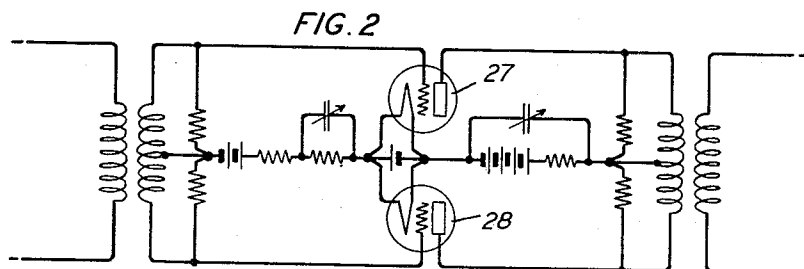
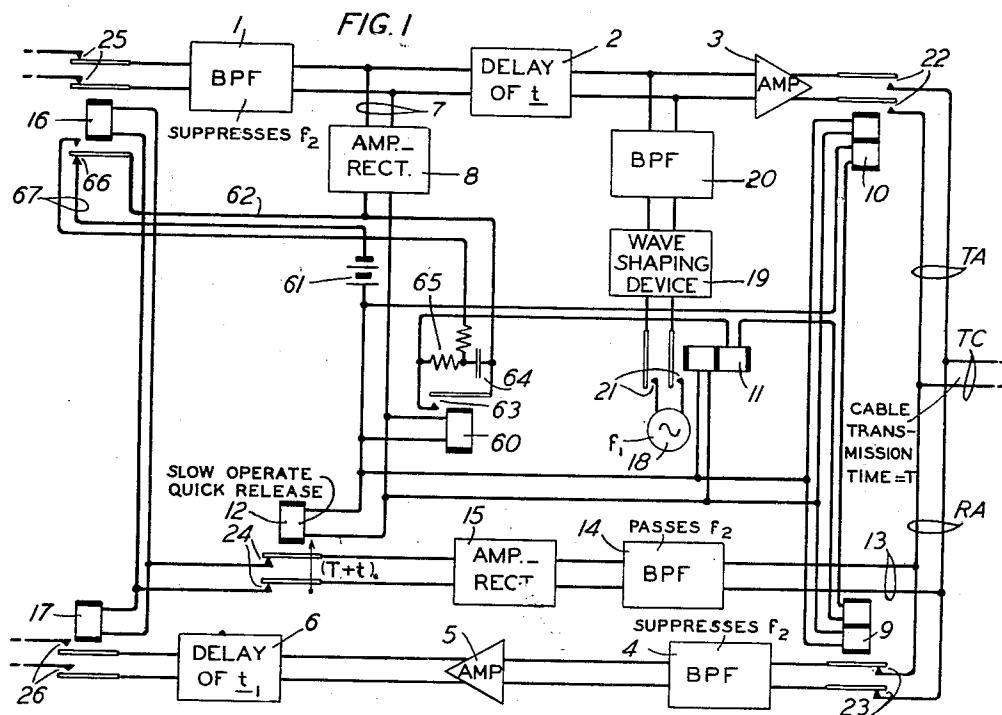
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1,926,880

TRANSMISSION CONTROL IN TWO-WAY SIGNALING SYSTEMS

Filed Oct. 28, 1932

2 Sheets-Sheet 1



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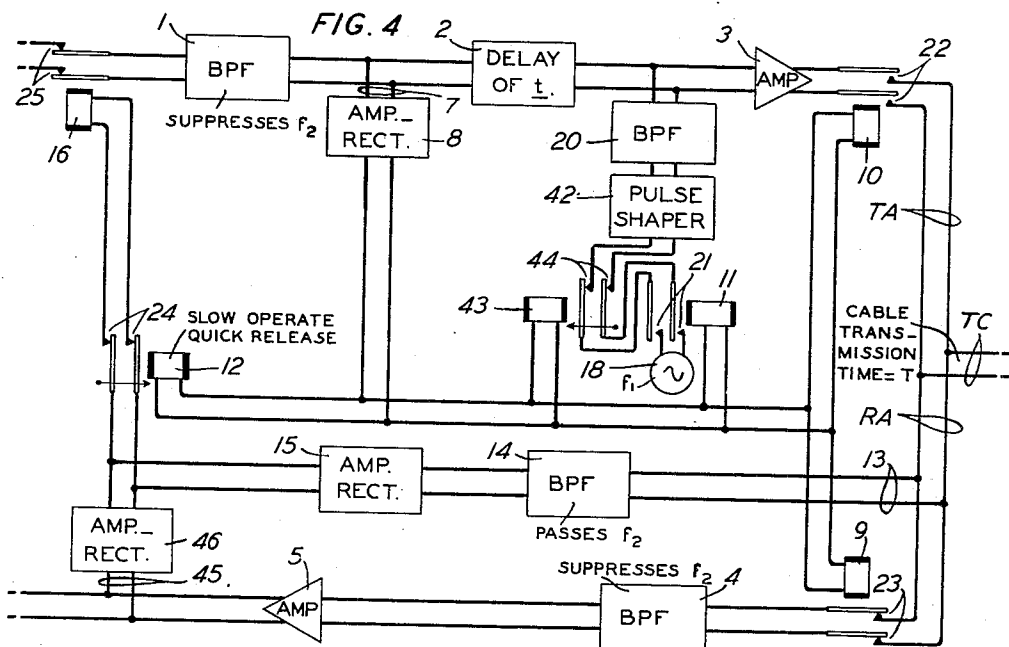
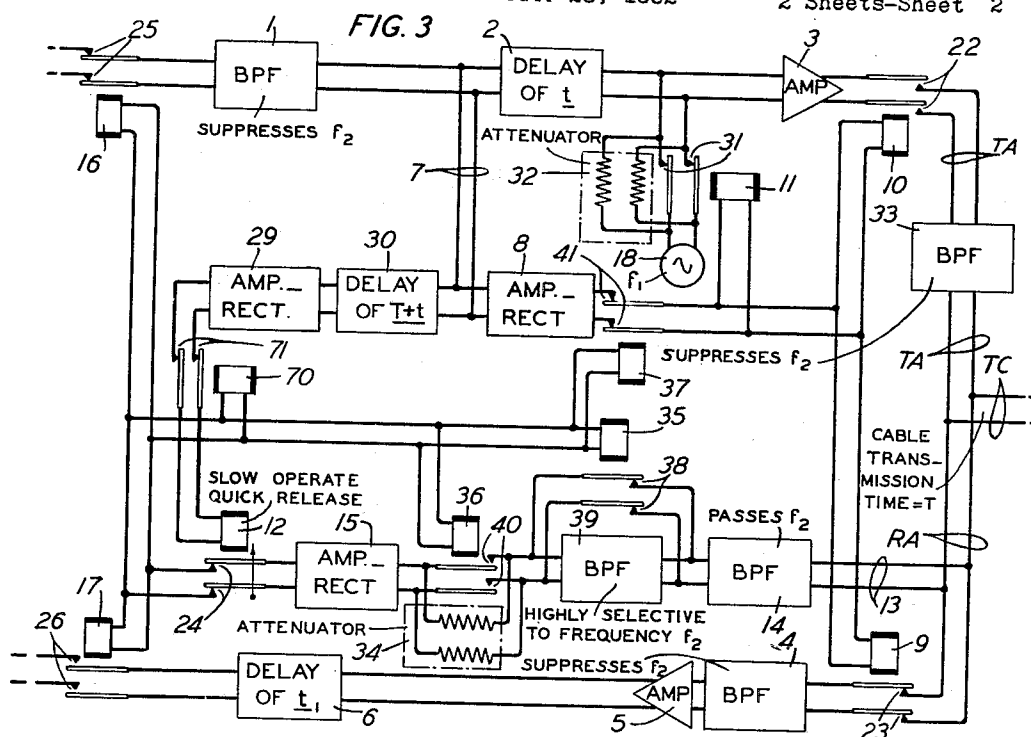
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TRANSMISSION CONTROL IN TWO-WAY SIGNALING SYSTEMS

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2 Sheets-Sheet 2



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TRANSMISSION CONTROL IN TWO-WAY
SIGNALING SYSTEMS

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Application October 28, 1932. Serial No. 640,035

8 Claims. (Cl. 179-170)

The invention relates to two-way signaling systems and particularly to the control of signal transmission in such systems.

The invention is particularly directed to a two-way communication system including one or more long two-way transmission links of appreciable transmission time, for example, a two-way cable telephone system in which the telephonic signals for both directions are transmitted between distant points over the same two-wire line or cable, such as a transoceanic submarine cable telephone system. The relatively long time (as compared to radio circuits, for example) required for transmitting the telephonic signals over the line or cable in such a system greatly increases the chance that two telephone subscribers at the ends of the system may both start talking within a time interval equal to the overall transmission time of the two-way line or cable, resulting in each subscriber seizing control of the voice operated switching apparatus at his own terminal and locking out the transmission of the other. Circuits have heretofore been designed to avoid the above mentioned difficulty by giving complete control of the switching apparatus at both ends of the system to the subscriber who first starts talking. Certain circuits of this kind, commonly known as "courier" systems, utilize one or more auxiliary control currents transmitted ahead of, or along with, the telephonic signals and under the control thereof, to partially or completely control the switching apparatus at the terminals of the system.

An object of the invention is to improve the operation of two-way signaling systems employing auxiliary control waves or couriers for controlling the directional switching apparatus.

In accordance with the invention, improved operation of the directional switching apparatus in systems of the above described type is attained by properly shaping the control waves as to amplitude at the transmitting end of the system. In one embodiment a single control wave is employed which control wave is so shaped that a portion sent over the system in advance of the signals to initiate operation of the switching relays has a comparatively high amplitude, and the remaining portion transmitted continuously over the system along with the signals has a lower amplitude. This results in faster switching while simplifying filter requirements.

In another embodiment of the invention in which operation of the directional switching relays is initiated by a control wave pulse sent over

the system in advance of the signals, and is maintained by the following speech waves, the receiving control is made more sensitive than the transmitting control to obviate clipping and the control pulse is shaped as to amplitude at the transmitting end of the system to obviate audible transients.

The invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawings:

Figs. 1, 3 and 4 of which show diagrammatically a portion of a terminal circuit for a two-way telephone cable system embodying different modifications of the system;

Figs. 2 and 5 of which show schematically control wave shaping devices adapted respectively for use in the modifications of the invention shown in Figs. 1 and 4; and

Fig. 6 shows a set of curves illustrating alternative methods of operation of the control wave shaping devices in the system of Fig. 4.

Since the terminal stations at each end of the cable in the systems to be described may be substantially identical in construction except for changes in the design of the control wave generators and the filters necessitated by the fact that the values of the frequencies of the control waves transmitted from the two terminals are different, it has been deemed sufficient to illustrate only one terminal of each cable system.

Fig. 1 illustrates a portion of the west terminal station for a two-way telephone cable TC having a transmission time T between stations. The station comprises a transmitting-amplifying path TA having its output adapted to be connected directly to the west end of the telephone cable TC, and a receiving-amplifying path RA having its input connected directly to the west end of the telephone cable TC. The input of the transmitting path TA and the output of receiving path RA may be connected by means of a three-winding transformer or hybrid coil, or other suitable means, in substantially conjugate relation with each other, and in energy transmitting relation with a west circuit (not shown), such as a toll telephone circuit.

The transmitting-amplifying path TA includes in order reading from west to east, a band-pass filter 1, a delay circuit 2 and the one-way wave amplifying device 3. The receiving-amplifying path RA includes in order reading from east to west, the band-pass filter 4, the one-

way wave amplifying device 5 and the delay circuit 6.

Connected across the transmitting-amplifying path TA between the band-pass filter 1 and the delay circuit 2 is the input of a control circuit 7 comprising the wave-controlled, relay-controlling device 8, and the operating windings of mechanical relays 9 to 12 and 60 connected in parallel across the output of the device 8. Connected across the input of the receiving-amplifying path RA is the input of a control circuit 13 comprising the band-pass filter 14, the wave-controlled, relay-controlling device 15, and the operating windings of mechanical relays 16 and 17 connected in parallel across the output of the device 15.

The source 18 of alternating control waves of frequency f_1 is adapted to be connected to the transmitting-amplifying path TA in the output of the delay circuit 2 through the wave-shaping device 19 and the band-pass filter 20 by the closing of the normally open switch contacts 21 in response to operation of the relay 11 when its operating winding is energized.

The normally open switch contacts 22 in the output of the transmitting-amplifying path TA are adapted to be closed in response to operation of the relay 10 when its operating winding is energized, to connect the output of the transmitting-amplifying device 3 to the cable TC.

In the receiving-amplifying path RA between the point of connection of the control circuit 13 thereto and the band-pass filter 4 are the normally closed switch contacts 23 adapted to be opened in response to operation of the relay 9 when its operating winding is energized, to disconnect the receiving-amplifying device 5 from the cable TC. The normally closed switch contacts 24 in the output circuit of the control device 15 are adapted to be opened in response to operation of the relay 12 when its winding is energized, to prevent subsequent energization of the windings of the relays 16 and 17 by operation of the control device 15.

The normally closed switch contacts 25 in the input of the transmitting-amplifying path TA are adapted to be opened in response to operation of the relay 16 when its winding is energized, to prevent the speech currents of the west subscriber connected to the input of the path TA from being transmitted to the cable TC or to the input of the control circuit 7.

The normally open switch contacts 26 in the output of the receiving-amplifying path RA are adapted to be closed by operation of the relay 17 when its winding is energized to render the path RA operative to transmit the east subscriber's speech currents from the output of the receiving-amplifying device 5 to the receiving circuit of the west telephone subscriber.

In addition to the operating winding, each of the mechanical relays 9, 10 and 11 has a hangover winding which when energized operates to control the relay contacts in the same manner as the operating winding. These windings are arranged to be supplied in series with energizing current from a battery 61 over the circuit 62 when the normally open switch contacts 63 therein are closed by operation of the relay 60 when its winding is energized. A condenser 64 in series with a resistance 65 is connected across the switch contacts 63 so that the condenser 64 is discharged while the switch contacts 63 are maintained closed by the relay 60. When relay 60 releases with cessation in the supply of ener-

gizing current to its winding the switch contacts 63 will open to break the energizing circuit for the hangover windings of the relays 9, 10 and 11 from battery 61, but these windings are maintained energized for an additional hangover interval while the condenser 64 charges from battery 61 through the resistance 65 and the relay windings. Thus the relays 9, 10 and 11 will be maintained operated for a slight interval of time after their operating windings are deenergized with release of the control device 8. By proper choice of the battery 61, the condenser 64 and the resistance 65, the hangover of the transmitting relays 9, 10 and 11 may be made such as to prevent premature opening or closing of the relay contacts which might result in clipping of the speech in the transmission path or improper operation of the control wave supply.

Operation of the receiving relay 16 under control of the receiving control device 15, besides causing the opening of the switch contacts 25 in the path TA, also opens the normally closed switch contacts 66 in the energizing circuit 62 for the hangover windings in relays 9, 10 and 11, and closes the short-circuiting connection 67 around condenser 64. Thus, operation of relay 16 under control of the receiving device 15 not only disables the input to all relays 9 to 12 and kills the hangover of relays 9 to 11, but also prevents subsequent false operation of these relays by energy stored in the band pass filter 1 and the control device 8 at the time relay 16 operates.

The wave-controlled, relay-controlling devices 8 and 15, and the corresponding devices at the east cable terminal station (not shown), may be vacuum tube, amplifier-rectifier devices of the type well-known in the art, or any other devices which will respond to alternating current waves impressed on their inputs to control the operation of circuit-control devices, such as mechanical relays, vacuum tube or gas filled tube relays, in their outputs.

The band-pass filters 1, 4, 14 and 20, and the corresponding filters at the east cable terminal station, may be of the band-pass type disclosed in the United States patents to Campbell, No. 1,227,113 and No. 1,227,114, issued May 22, 1917. The band-pass filters 1 and 4 are designed to suppress waves of the frequency f_2 corresponding to those of the control waves generated by the control wave generator at the east cable terminal station corresponding to the control wave generator 18 at the west cable terminal station, and to transmit waves of other frequencies. The band-pass filter 14 is designed to select the control wave frequency f_2 transmitted from the east cable terminal station, and to suppress waves of speech frequency and waves of the frequency f_1 corresponding to the control wave frequency generated by the control wave generator 18 at the west cable terminal station. The control wave frequencies f_1 and f_2 are different frequencies which may be inside or outside the voice frequency range. The band-pass filter 20 is designed to confine the control waves originally of the frequency f_1 received from the control wave source 18 supplied to the transmitting-amplifying path TA to a narrow band. Similarly, the band-pass filter at the east cable terminal station corresponding to band-pass filter 20 at the west cable terminal station is designed to confine the control waves originally of frequency f_2 when supplied to the transmitting-amplifying path at the former station to a narrow frequency band.

The delay circuits 2 and 6 may be networks of any type suitable for producing a delay of the required amount, which will be specified below, in the transmission thereof of alternating current impressed upon their inputs; for example, they may be low-pass electrical filters such as disclosed in the United States patent to Campbell referred to above, acoustic filters, or networks for a similar purpose such as disclosed in Arnold Patent No. 1,565,302, issued December 15, 1925.

The wave-shaping device 19 through which the control waves of frequency f_1 from the control wave source 18 at the west cable terminal station is transmitted, and the corresponding wave-shaping device through which the control wave of frequency f_2 is transmitted at the east cable terminal station is designed to so shape the wave front of the control current that its amplitude initially is high and is reduced a short time later to a lower value which is maintained constant during the continuous transmission of the control wave. This device is so designed that the initial amplitude of the control wave is as high as is permitted by the overload characteristics of the transmitting amplifier and the cable structure or by cross-talk requirements. The device is so designed that the final value of amplitude of the control wave reached in a given short time t after the control waves start to flow, is low enough to cause only a small additional load on the transmitting amplifier 3 and the cable TC over that caused by speech alone but still sufficiently high to maintain the receiving relay at the distant terminal station, in the operated condition initiated by the initial high amplitude value of the control current, in the manner which will be explained in connection with the description below of the operation of the system of Fig. 1.

The wave-shaping device 19, and the corresponding device at the east cable terminal station, may, for example, be a wave-shaping vacuum tube amplifier such as is shown diagrammatically in Fig. 2. Referring to Fig. 2, it will be noted that the wave-shaping amplifier shown comprises the two vacuum tube amplifying devices 27 and 28 connected in push-pull relation and comprising several resistance elements and variable condensers in the tube input and output circuits. By properly choosing or adjusting the values of the resistances and condensers in the input and output circuits of the amplifying tubes to obtain the desired gain characteristic and time constants, the amplitude of the control waves impressed upon the input of the amplifier may be made to have in the output circuit of the amplifier the desired high value initially and falling off to the desired lower constant value in a definite time.

The operation of the system as a whole will now be described, referring to the west cable terminal station only. When no speech waves are being transmitted over the system in either direction, the switch contacts in the transmission paths and control circuits at both stations are in the positions indicated at the west station shown in the drawings. With the switch contacts in the positions shown, the transmitting-amplifying path TA at each terminal is normally disabled in its output while the receiving-amplifying path RA at each terminal is operative in its input but disabled in its output.

It will be assumed that the west subscriber associated with the west cable terminal station shown

in Fig. 1 starts to speak before the east subscriber associated with the east cable terminal station, not shown. The west subscriber's speech waves will be transmitted first through the band-pass filter 1 which operates to suppress effectively therefrom the waves of frequency f_2 corresponding to the frequencies assigned to the control waves transmitted from the east cable terminal. The speech waves in the output of the band-pass filter 1 will be divided between the delay circuit 2 in the transmitting path TA and the input of the control circuit 7 connected to that path. The portion diverted into the control circuit 7 causes the operation of the control device 8 therein to energize the windings of the mechanical relays 9 to 12 and 60 connected to its output.

Relay 9 is designed so that it will operate in response to the energization of its winding simultaneously with or slightly before the operation of relays 10 and 11, to open the normally closed switch contacts 23 in the input of the path RA causing the receiving-amplifying device 5 and its associated apparatus to be disconnected from the cable TC. Relay 10 operates simultaneously with, or preferably, slightly before relay 11, to close normally open switch contacts 22 in the path TA to connect the transmitting amplifier 3 to the cable TC, and relay 11 operates to close the normally open switch contacts 21 to connect the control wave source 18 of frequency f_1 to the wave-shaping device 19.

Relay 60 is designed to operate at about the same time as relays 9 to 11, to close the switch contacts 63 causing the hangover windings of the relays 9 to 11 to be energized and the condenser 64 in the hangover circuit to be charged in the manner previously described.

The control waves of frequency f_1 from the control wave source 18 are transmitted through the wave-shaping device 19 and the band-pass filter 20 to the transmitting path TA and after amplification in the transmitting amplifier 3 are transmitted out over the cable TC to the east cable terminal station. As stated above, the wave-shaping device 19 is designed to shape the wave front of the control wave of frequency f_1 so that its initial amplitude exceeds its final amplitude by a factor depending on the overload characteristics of the transmitting amplifier and the cable structure, and the cross-talk requirements of the system. Preferably, the wave-shaping device 19 is so designed that the amplitude of the control current is reduced to its final value in approximately the same time that the speech currents take to traverse delay circuit 2. The west subscriber's speech currents, which meanwhile have been delayed in transmission through delay circuit 2 for the time t which is substantially equal to the time taken for the amplitude of the control wave to be reduced from its initial high value to its final lower value, reach the input of the transmitting-amplifying device 3 substantially at the same time as the reduced amplitude portion of the control wave arrives thereat. These speech waves are amplified in the amplifying device 3 along with the low amplitude control waves and are transmitted out over the cable TC along with the control waves.

Relay 12 by any suitable means is designed so that it will operate in response to energization of its winding a time slightly more than T after relays 9 to 11 have operated (where T = the transmission time over the cable TC between the west and east cable terminal stations), to open the normally closed switch contacts 24 in the output

of control circuit 13 thereby rendering that circuit inoperative to energize relays 16 and 17 substantially at the same time as the arrival of the control waves of frequency f_1 at the east cable terminal station.

The manner in which control of the transmitting and receiving paths and associated control circuits at the east cable terminal station is obtained for the first talker associated with the west station will now be described, and will be clear by reference to the similar apparatus at the west station shown in the drawings. That the apparatus to be referred to is that of the east station will be indicated by using the same characters to designate it as the corresponding apparatus at the west station, but followed by a prime (') mark.

The high amplitude wave front of the control wave of frequency f_1 on arrival at the east cable terminal station will be impressed upon the receiving circuit RA' and, the band-pass filter 4' in that path being designed to suppress the frequency f_1 , it will be diverted into the control circuit 13' and will be passed by the band-pass filter 14' therein to the control device 15 causing the operation of the latter to energize the windings of mechanical relays 16' and 17' connected to its output. Operation of control device 8' in control circuit 7' by the speech currents of the east subscriber if he starts to talk after the west subscriber but before relay 16' has been operated in response to the speech currents of the latter will not be effective to prevent the operation of relays 16' and 17' by the west subscriber's speech currents because of the lag in operation of relay 12' with respect to operation of relays 9' to 11' (which is slightly more than T seconds). Relay 16' will operate to open the normally closed switch contacts 25' in the input of the transmitting-amplifying path TA' thereby rendering that path thereafter inoperative to transmit the east subscriber's subsequently initiated speech currents to the cable TC, or to the control circuit 7'. The operation of relay 16' will also open the normally closed switch contacts 66' in the energizing circuit 62' for the hangover windings of relays 9' to 11', and close the short-circuiting connection 67' across the hangover condenser 64', thus immediately killing the hangover of the relays 9' to 11' as well as disabling their operating windings.

Relay 17' will simultaneously operate to close the normally open switch contacts 26' in the output of the receiving-amplifying path RA' thereby rendering that path operative thereafter to transmit to the east subscriber.

Substantially a time t after the high amplitude wave front of the control wave f_1 has caused initial operation of the control device 15', where t is preferably just sufficiently long to insure completion of operation of the device 15' to energize the windings of relays 16' and 17', the reduced amplitude portion of the control wave f_1 will arrive at the east cable terminal station along with the west subscriber's speech currents and will be diverted into the receiving path RA' thereat. The reduced amplitude portion of the control wave f_1 is passed by the band-pass filter 14' in control circuit 13' and is impressed upon the input of the control device 15' maintaining that device continuously in the operated condition initiated by the high amplitude wave front of the control wave, during the transmission of the west subscriber's speech currents.

The west subscriber's speech currents are trans-

mitted by the band-pass filter 4' in the receiving path RA' and are amplified by the receiving amplifying device 5' therein. The amplified speech waves in the output of amplifying device 5' after transmission through the delay circuit 6', which operates to delay their transmission for a small interval of time t_1 just sufficiently long enough to enable completion previously of the operation of the relay 17' under control of the control wave f_1 to render the output of the path RA' operative by closing switch contacts 26' before the speech waves arrive at that point in the path RA'. The west subscriber's speech waves are then transmitted out over the output of the path RA' to the receiving apparatus of the east telephone subscriber.

The mechanical relay 12 at the transmitting station which, as is stated above, is designed to be slow-operating as compared to the other transmitting relays, is also designed by any suitable means, such as by its mechanical construction, to be quick-releasing so as to release substantially instantaneously with any interruption in the continuous transmission of the west subscriber's speech currents sufficient to allow the control device 8 to release at least momentarily. At any pause, therefore, in the continuous transmission of the west subscriber's speech currents sufficiently long to allow release of the receiving relays 16' and 17' at the east cable terminal station due to the falling off of the supply of the control wave f_1 to the input of the control device 15' and by virtue of the slow operate and quick release characteristics of relay 12, the east subscriber can, if he wishes, break in during the pause and seize exclusive control of the switching circuits of the system in the following manner.

The east subscriber's speech currents after transmission through the band-pass filter 1', which suppresses therefrom the frequency f_1 corresponding to that of the control wave transmitted from the west cable terminal station, will be divided between the input of the control device 8' in control circuit 7' and the delay circuit 2' in the main transmission path TA' at the east cable terminal station. The portion impressed upon the control device 8' will cause its operation to energize the windings of the mechanical relays 9' to 12' connected to its output, which operate in a manner similar to that described above in connection with the corresponding transmitting relays at the west cable terminal station to seize control of the switching circuits of the east cable terminal station for the east telephone subscriber's speech currents, and to transmit the control wave of frequency f_2 having an initial high amplitude and a subsequently reduced amplitude to the west cable terminal station. The control wave f_2 initiates and maintains control of the receiving relays at the west terminal station in a manner similar to that described in connection with the receiving relays at the east cable terminal station.

The pre-shaping of the control waves at the transmitting terminal in the system, one station of which is shown in Fig. 1, results in a more rapid build-up of the envelope of the control wave spurt at the output of the band-pass filter in the receiving control circuit at the receiving terminal than would be the case if the control waves were not so pre-shaped, and the receiving relays 16, 17 or 16', 17' operated from this envelope through operation of the control device 15, 15' will consequently operate earlier than would otherwise be the case, thus permitting the

use of less delay in the voice channels than would otherwise be necessary. It is not unlikely that this method of operation would in many cases obviate the necessity of storing the voice currents in a delay circuit, and that, therefore, delay circuits 6, 6' in the voice receiving path at each terminal may be eliminated. The initial high amplitude of the control waves also allows an effective reduction in false operation of the receiving control device 15, 15' by energy in transmitted speech or that reflected by the cable since it is possible either to reduce the sensitivity of control device 15, 15' or increase the selectivity of band-pass filter 14, 15' from the values required on control waves without the initial high amplitude of the control waves.

In Fig. 3 is shown a modification of the system of Fig. 1 in which ordinary attenuators instead of wave-shaping amplifiers as shown in Fig. 2 are utilized to give the desired shaping of the control waves to speed up the operation of the receiving relays.

The system of Fig. 3 differs essentially from the system of Fig. 1 only in the following particulars.

In the system of Fig. 3 the operation of mechanical relay 12 is controlled by an additional amplifier-rectifier device 29 connected in parallel with the device 8 to the transmitting path TA, instead of by the device 8 itself, and the delay in operation of the relay 12 in response to the speech currents in the path TA is attained by employing an electrical delay circuit 30 in the input of the device 29 to delay the transmission of energizing current to the latter for the time interval of $T+t$ instead of by design of the mechanical relay 12 to make it slow-operating to the required degree as in the case of the system of Fig. 1.

In the system of Fig. 3, an additional relay 70 is connected to the output of the receiving control device 15 in parallel with the relays 16 and 17, and is responsive to operation of the device 15 to open the normally closed switch contacts 71 in the circuit connecting relay 12 to the output of control device 29, thus preventing false operation of relay 12 by energy stored in band-pass filter 1, delay circuit 30 or control device 29 at the time relay 16 operates.

In the system of Fig. 3, the control wave source 18 is normally connected directly to amplifier 3 so as initially to apply a high amplitude control wave to path TA when relay 10 operates, and relay 11 operates by opening the normally closed switch contacts 31 to break the direct connection of the source 18 to amplifier 3 and to connect it thereto through the attenuator 32 so as to reduce the amplitude of the control wave transmitted to the cable TC to the desired low value just before the west subscriber's speech currents, which are delayed in the delay circuit 2 for the time interval of t , are transmitted to the cable. A band-pass filter 33 may or may not be necessary in the output of the path TA to suppress waves of the frequency f_2 corresponding to the control wave transmitted from the other terminal, while transmitting the control wave frequency f_1 and the speech waves to the cable.

In the system of Fig. 3 an attenuator 34 identical with the attenuator 32 is normally connected in the receiving control circuit 13 between the band-pass filter 14 and the input of the control device 15. Three additional mechanical relays 35, 36 and 37 are connected to the output of the control device 15 in the receiving control circuit 13 in parallel with the relays 16 and 17 so as to

operate in response to operation of the device 15. Operation of the relay 35 opens normally closed switch contacts 38 effectively connecting a band-pass filter 39 highly selective to the control wave frequency f_2 transmitted from the east cable terminal station to the output of the band-pass filter 14. Relay 36 simultaneously operates to close normally open switch contacts 40 effectively short-circuiting the attenuator 34, thus connecting the output of band-pass filter 14 to the input of control device 15 through band-pass filter 39 only.

Relays 37 and 70 operate substantially simultaneously with relays 16, 17 and preferably slightly before relays 35 and 36 in response to operation of the control device 15 respectively to open the normally closed switch contacts 41 in the output of control device 8 to disable the energizing circuits for the transmitting relays 9 to 11, relay 10 being preferably arranged to release first, and to open normally closed contacts 71 to disable relay 12.

The apparatus at the east cable terminal station (not shown) is identical with that of the west cable terminal station shown in Fig. 3 except for the change in the design of the filters at the former station necessitated by the fact that the control wave frequency transmitted from the former station from the source corresponding to the source 18 at the west cable terminal station is of frequency f_2 instead of f_1 . The band-pass filters at the east cable terminal station corresponding to the filters 1 and 4 at the west cable terminal station, therefore, would suppress the frequency f_1 instead of the frequency f_2 ; the band-pass filter at the east station corresponding to the band-pass filter 14 at the west station would pass the frequency f_1 instead of the frequency f_2 , and the band-pass filter at the east station corresponding to the band-pass filter 39 at the west station would be highly selective to the frequency f_1 instead of to the frequency f_2 .

The operation of the modified system of Fig. 3 is quite similar to that of the system of Fig. 1 described above and, therefore, need not be described in detail. Assuming that the west subscriber starts to talk before the east subscriber, the former's speech currents control the operation of control device 8 to energize the windings of relays 9, 10 and 11 connected to its output, and control the operation of control device 29 after a delay of a time interval of $T+t$ due to the operation of delay circuit 30, to energize the winding of relay 12. Relays 9 and 10 operate, respectively, to disable the input of the receiving path RA and to render operative the output of the transmitting path TA. Relay 11 operates just before the west subscriber's speech current gets through the delay circuit 2 in the path TA, to insert in the path of the control waves of frequency f_1 supplied from the source 18 the attenuator 32 operating to reduce the amplitude of the control waves f_1 transmitted to the cable from its initial high amplitude to a lower amplitude, as in the case of the wave-shaping device 19 in the system of Fig. 1. Thus, a portion of the control waves of frequency f_1 of comparatively high amplitude is transmitted to the cable TC in advance of the west subscriber's speech waves and the following portion reduced in amplitude due to the action of attenuator 32 a short time later is transmitted out over the cable along with the west subscriber's speech waves.

Relay 12 at the west cable terminal station, due to the action of delay circuit 30 in the input of the

control device 29, is delayed in operating until substantially the time of arrival of the control wave of frequency f_1 at the east cable terminal control 15'. The relay 12 then operates to open the normally closed switch contacts 24 in the output of the receiving control circuit 13 to disable the energizing circuit for the receiving relays 16, 17, 35 to 37 and 70, thereby preventing their subsequent operation in response to operation of the control device 15.

The high amplitude wave front of control wave f_1 on arrival at the east cable terminal station is diverted into the receiving control circuit 13' thereat and is transmitted by the band-pass filter 14'. The high amplitude portion of the control wave f_1 is then transmitted through the attenuator 34' to the input of control device 15' causing its operation to initially energize the windings of relays 16', 17', 35' to 37' and 70' connected to its output. Relay 16' operates to open the normally closed switch contacts 25' in the input of the transmitting path TA' at the east station thus preventing the east subscriber's speech currents subsequently received from being transmitted to the cable TC, or to the transmitting control devices 8' and 29'.

Relay 17' operates substantially simultaneously with relay 16' to close the normally open switch contacts 26' in the output of the receiving path RA' rendering that path operative thereafter to transmit the west subscriber's speech currents to the receiving circuit of the east subscriber. Relays 70' and 37' will operate substantially simultaneously with relays 16' and 17' and somewhat before relays 35' and 36' to disable relays 9' to 12'. Relay 35' will open the normally closed switch contacts 38' thus effectively inserting the band-pass filter 39', which is highly selective to the frequency f_1 , in the control circuit 13', and the relay 36' will operate to close the normally open switch contacts 40' to short circuit the attenuator 32', thus effectively compensating for the drop in amplitude of the control wave of frequency f_1 in transmission from the west cable station. The portion of the control wave f_1 which is reduced in amplitude, on arrival at the east cable terminal station slightly after the high amplitude portion, will be diverted into control circuit 13', passed by the band-pass filter 14' and selected by the highly selective band-pass filter 39' therein. The low amplitude portion of the wave f_1 in the output of the band-pass filter 39' will be impressed directly on the input of the control device 15' to maintain it in the operated position initiated by the preceding high amplitude portion of the control wave, continuously during transmission of the west subscriber's speech currents.

The west subscriber's speech currents on arrival at the east cable terminal station along with the low amplitude portion of the control wave f_1 will be passed by the band-pass filter 4' in the receiving path RA' and amplified by the receiving-amplifying device 5'. The amplified speech waves in the output of amplifying device 5' will be delayed in transmission through the delay circuit 6' for a time interval of t_1 . The interval t_1 should be sufficiently long to enable completion previously of the operation of the receiving relay 17' in response to operation of control device 15' to render the output of the receiving path RA operative by closing switch contacts 26'. The amplified waves will then be transmitted over the output of the path RA' to the east subscriber's receiving circuit.

Although not shown, the transmitting relays 9, 10 and 11 should be designed to have the proper hangover to prevent clipping of speech or false operation, for example, by the use of hangover windings and a condenser-resistance circuit controlled by an additional relay connected to the output of control device 8 as shown in Fig. 1. An arrangement similar to that shown in the circuit of Fig. 1 may then be used to kill the hangover in these relays when the receiving relays are operated under control of the receiving control device 15.

Although, in the systems of Fig. 1 and Fig. 3 the receiving-amplifying path in each terminal has been shown and described as normally disabled, and as being rendered operative by operation of a receiving relay 17, 17' connected to the output of the receiving control device 15, 15', in response to the speech currents of the distant subscriber, in many cases it may not be necessary to have the receiving path normally disabled, in which case, the receiving relays 17, 17' and the delay circuits 6, 6' may be dispensed with.

In the system of Fig. 1, the sources of control waves f_1 and f_2 have been illustrated or described as normally disconnected from the wave-shaping devices 19, 19' and adapted to be connected to the devices 19, 19' and thus to the cable TC, by operation of the transmitting relays 11, 11'. In some cases it may be desirable to have the sources of control waves normally connected to the wave-shaping devices and to have the transmitting relays 11, 11' in response to the control devices 8, 8' control directly the operation of the wave-shaping devices. For example, where the wave-shaping devices are vacuum tube amplifiers, the relays 11, 11' by operation may be made to remove blocking potentials on the grids of the tubes to render them operative and thus to start the wave-shaping process.

Fig. 4 shows diagrammatically a modified form of the invention in which control of the directional switching apparatus is initiated by a "courier" pulse and maintained by the voice currents themselves.

The system of Fig. 4 differs essentially from the system illustrated in Fig. 1 in the following particulars: The wave-shaping device 19 of the system of Fig. 1 is replaced by the device 42, designated in Fig. 5 as a pulse shaper, which operates to shape the control wave pulses transmitted therethrough according to any one of the curves in the family of curves illustrated in Fig. 6 which will be referred to later. In the system of Fig. 4, an additional relay 43, which is slow-operating, is connected to the output of the control device 8 in parallel with the relays 9 to 12, and is designed to operate in response to operation of the control device 8 after the relay 11 has operated to connect the control wave source 18 of frequency f_1 to the input of the pulse shaper 40 and thus to the path TA, to open the normally closed switch contacts 42 causing the control wave source 18 to be disconnected again from the pulse shaper 40. The momentary connection of the control wave source 18 to the path TA through the pulse shaper 40 and the band-pass filter 20 causes a pulse, or short train of waves, of the control wave frequency f_1 to be transmitted to the path TA in advance of the voice signals which are delayed in transmission for the interval t in passing through the delay circuit 2. The system of Fig. 4 also differs from the system of Fig. 1 in that in the former the receiving-control relay 16 is controlled over two paths instead of one.

One of these paths is the receiving-control circuit 13 including the band-pass filter 14 and the amplifier-rectifier device 15, also shown in the system of Fig. 1. The energization of control relay 16 is also controlled by another control circuit 45 having its input connected to the output of the receiving amplifier 5 in the receiving path RA and including the amplifier-rectifier control device 46.

The operation of the system of Fig. 4 is as follows: Let it be assumed that the west telephone subscriber starts to talk before the east telephone subscriber associated with the east cable terminal, not shown. The west subscriber's speech currents will be transmitted through the band-pass filter 1 in the input of the transmitting path TA which will suppress effectively therefrom waves of the frequency f_2 corresponding to that of the control wave source at the east cable terminal. The west subscriber's speech currents in the output of the band-pass filter 1 will be divided between the input of the transmitting control circuit 7 and the delay circuit 2 in the path TA. The portion diverted into the control circuit 7 will cause the operation of the amplifier-rectifier device 8 therein to energize the windings of the mechanical relays 9 to 12 and 43 connected to its output. Relay 9 will operate to disable the input of the repeating path RA by opening the normally closed switch contacts 23 therein, and the relay 10 will simultaneously operate to connect the output of the transmitting amplifier 3 to the cable TC by closing the normally open switch contacts 22 in the output of the path TA.

Relay 11 will operate to close the normally open switch contacts 21 to connect the source 18 of control waves of frequency f_1 to the transmitting path TA through the pulse shaper 40 and the band-pass filter 20. An instant later the slow operating relay 43 will operate to open the normally closed switch contacts 44 in the input of the pulse shaper 42 thus disconnecting the source 18 of control waves from the pulse shaper 42 and thus from the transmitting path TA.

The momentary connection of the source 18 to the path TA will result in a pulse or short train of control waves of frequency f_1 , shaped in a manner which will be described below by the pulse shaper 42, being transmitted to the path TA in advance of the west subscriber's speech waves which have been meanwhile delayed in the delay circuit 2 for the small interval of time t . This control wave pulse will be amplified in the transmitting-amplifier 3, and, relay 10 having previously operated to close the switch contacts 22, will be transmitted out over the cable TC in advance of the amplified speech waves by the small interval of time t .

The slow-operate relay 12 will operate in response to operation of the control device 8 by the west subscriber's speech currents substantially a time T after the relays 9 to 11 have operated, where T is the transmission time over the cable TC between terminal stations, to open the normally closed switch contacts 24 in the output of the receiving control circuit 13 to disable the energizing circuit for the relay 16. Thus, the west subscriber's speech waves will obtain complete control of the switching apparatus at the west cable terminal station substantially at the time the control wave pulse f_1 arrives at the east cable terminal station and seizes control of the switching apparatus thereat in the manner which will be described below.

The control wave pulse f_1 on arrival at the east

cable terminal station is impressed on the receiving-amplifying path RA' thereat and, the band-pass filter 4' in that path being designed to reject effectively the frequency f_1 , will be diverted into the control circuit 13' and passed by the band-pass filter 14' therein to the input of the control device 15'. The consequent operation of control device 15' will cause the winding of the receiving relay 16' to be initially energized, this relay then operating to open the normally closed switch contacts 25' in the input of the transmitting-amplifying path TA rendering that path inoperative thereafter to transmit subsequently received speech currents from the east subscriber to the cable TC and to the input of the control circuit 7'.

The west subscriber's speech waves on arrival at the east cable terminal station lagging behind the preceding control pulse f_1 by the small interval of time t , will also be impressed upon the receiving-amplifying path RA' and will be passed by the band-pass filter 4' therein to the input of the receiving-amplifying device 5'. The amplified speech waves in the output of the amplifying device 5' will be divided between the outgoing portion of the receiving path RA' and the input of the control circuit 45'. The main portion of the west subscriber's speech waves will be transmitted out over the outgoing portion of the path RA' to the receiving circuit of the east subscriber.

A small portion of the amplified speech waves in the output of the amplifying device 5' will be diverted into the control circuit 45' and cause the operation of the control device 46' which will cause energizing current to be supplied to the receiving relay 16' supplementing that previously supplied thereto by operation of the control device 15' in the receiving control circuit 13'. Thus, when the control device 15' releases at the end of the pulse f_1 , the relay 16' will be maintained energized by the control device 46' during the substantially continuous supply of the west subscriber's speech waves to the input thereof.

Although not shown, the transmitting relays in the system of Fig. 4 should be arranged by any of the well known methods to have the required hangover in their operation, and preferably means should be provided to enable operation of the receiving relays to kill that hangover, for example, means similar to that disclosed in Fig. 1 for a similar purpose.

In the system of Fig. 4, the receiving control circuits 45, 45' are preferably made more sensitive than the opposite end transmitting control circuits 7, 7', for example, by proper mechanical design of the transmitting and receiving control relays or the amplifier-rectifier apparatus controlling them, so that all speech which causes operation of the transmitting control in one end of the system will also cause operation of the opposite end receiving control. Because of this difference in sensitivity of the transmitting and receiving controls, the receiving terminal will remain operated on slightly weaker transmitted speech which will cause the transmitting control (far end) to release. The release of the far end transmitting control would operate to send another control wave pulse out over the cable in advance of the succeeding speech syllable. Ordinarily, this additional control pulse would operate to produce transient disturbances in the receiving band-pass filter 4, 4' in the receiving speech path at the receiving terminal which would be transmitted to the listener and be very disturb-

ing. This is obviated by the pulse shaper 42, 42' at the transmitting terminal, which is designed to operate to shape the control wave pulses so as to cause an immediate reduction in the amplitude of the control pulse after the receiving relays at the receiving terminal have been initially operated. Thus, a minimum transient is produced in the band-pass filter 4 or 4' in the receiving voice path at each terminal, which filter is utilized to keep the control waves out of the speech channels, but which is inherently unable to suppress the transients which would be caused by application of a so-called "square wave" pulse such as would be produced by ordinary relay operation.

The pulse shaper should be designed so that the initial amplitude of the control wave pulse, that is, its wave front, is sufficient to assure fast operation of the receiving relays. The exact shape of the pulse will be determined by the filter characteristics, the overload point of the transmitting amplifier and the cable structure as well as the speed requirements of the relays.

The "square wave" type of control impulse which would ordinarily be transmitted by the operation of the transmitting control relay 11 in the system of Fig. 4, is illustrated by the dot-dash curve 47 in Fig. 6 showing the control pulse amplitude as ordinates and time as abscissae. The solid curves 48, 49 and 50 in Fig. 6 illustrate alternative shapes which might be given to the control wave pulse by proper design of the pulse shaper, the particular one favored being determined by the above mentioned characteristics of the cable and terminal apparatus in a given system. The pulse shaper 42 may be a vacuum tube amplifier, for example, in which the circuit constants are adjusted to give the required gain characteristics in a manner which is well known in the art.

Instead of having the control wave source 18 normally disconnected from the pulse shaper 42 and connected thereto in response to operation of the control device 8 by speech waves, it may in some cases be desirable to have the source 18 normally connected to the pulse shaper 42 and the relay 11 control the operation characteristics of the latter to give the required shaping of the control wave pulse. The circuit of one type of variable vacuum tube amplifier which might be employed to give the proper shaping of the control wave by the latter method is illustrated in Fig. 5. It comprises a three-electrode vacuum tube amplifying device 51 having its input connected to the control wave source, for example, the source 18 by the input transformer 52 and its output connected to the band-pass filter 20 by the output transformer 53. Connected in series between the filament and grid of the tube 47 is the battery 54, the condenser 55 shunted by the resistance 56, and the secondary winding of the input transformer 52. Connected in shunt with the series circuit comprising the battery 54 in series with the condenser 55 shunted by the resistance 56, is a circuit comprising in series the battery 57, the normally closed switch contacts 21 of the relay 11 and the resistance 58. Normally, a high negative biasing voltage is produced on the grid of tube 51 by the battery 57 through resistance 58, so that the amplifier 51 is normally blocked and control waves from the source 18 are not supplied to the band-pass filter 20. When relay 11 operates in response to energization of its winding by operation of control device 8 by the west subscriber's speech currents,

the switch contacts 21 are opened breaking the connection from battery 57 to the grid of tube 47. Then, the grid of tube 51 is supplied with biasing voltage from the battery 54 through resistance 55 and the secondary winding of the input transformer 52, the value of the battery, its poling and the values of the constants of the input circuit of the amplifying device being chosen so that the tube 51 becomes operative to amplify the control waves from the source 18 impressed on the input transformer, the amplified waves being supplied through the band-pass filter 20 to the transmitting path TA of the west cable terminal station. The shape of the control wave pulse transmitted through the band-pass filter 20 depends on the values of the condenser 55, the resistance 56 and the resistance 58. Then, by properly choosing relative values of these elements, the desired type of wave shaping will be obtained.

Although in the particular embodiments of the invention which have been described, mechanical relays have been shown for conditioning the transmission paths by operating movable switches to close or open-circuit these paths, the invention is not limited to the particular conditioning means shown. For example, within the scope of the invention the transmission path may be effectively disabled or made operative by the insertion or removal of short circuits or loss networks in the paths controlled by wave-controlled apparatus. Stationary devices having no movable elements may be employed in place of the mechanical relays shown, for example, vacuum tube relays, such as disclosed in Crisson Patent 1,647,212, issued November 1, 1927, or in an article by C. A. Beer and G. C. Evans in the Institute of P. O. Electrical Engineers (London), vol. 20, pp. 65 to 72 inclusive, published in 1920.

It is to be understood that the invention is not limited to the exact details of the circuits and the terminal stations illustrated and described as numerous modifications thereof may be made by persons skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a signal transmission system, a wave transmission path connecting stations, wave-controlled, circuit-control apparatus at one of said stations adapted when operated to condition said one station for receiving signals from said path, means at the other of said stations responsive to the initiation of signals thereat, for sending over said path to operate and maintain operated the circuit-control apparatus at said one station, a control wave having a varying amplitude-time characteristic, its initial amplitude exceeding its final amplitude by a factor dependent on the overload characteristics of the transmission system.

2. In a system for transmitting telephone signals in opposite directions between stations over a two-way transmission path, wave-controlled, circuit-control apparatus at said stations for directionally controlling transmission, means at one station responsive to initiation of telephonic signals thereat for sending over said path to operate the circuit-control apparatus at the other station, a control wave having a portion preceding the signals of high amplitude, and a succeeding portion transmitted over said path along with the signals of reduced amplitude but sufficient to maintain said apparatus in the operated condition.

3. In a signal transmission system, a wave transmission path connecting stations, wave-con-

trolled, circuit-control apparatus at one of said stations adapted when operated to condition said one station for receiving signals from said path, means at the other of said stations responsive to the initiation of signals thereat for transmitting a control wave of a frequency outside the signal frequency range over said path to operate the circuit-apparatus at said one station, one portion of said control wave being transmitted over said path in advance of signals and a succeeding portion continuously with said signals, and means at said other station for shaping said control wave so that said one portion thereof has as large an amplitude as is consistent with the overload characteristic of said system and said succeeding portion a varying lower amplitude just sufficiently large enough to maintain said circuit-control apparatus operated during transmission of said signals.

4. In a signal transmission system, a wave transmission path connecting stations, wave-controlled, circuit-control apparatus at one station adapted when operated to condition said one station for receiving said signals, means at the other of said stations responsive to initiation of signals thereat, for sending out over said path in advance of signals a short train of control waves to operate initially said circuit-control apparatus at said one station, means at said other station for shaping the transmitted control wave so that it initially has a high amplitude reducing quickly to a lower amplitude and means for utilizing the signals when they arrive at said one station for maintaining the circuit-control apparatus in the operated condition initiated by the preceding train of control waves.

5. A terminal circuit for a two-way signal transmission medium comprising a normally disabled transmitting circuit and a receiving circuit connected to said medium, control means connected to said transmitting circuit and responsive to signals initiated therein to disable the receiving circuit and render the transmitting circuit operative, and for causing to be transmitted to said medium a control wave having a portion transmitted in advance of the signals of high amplitude and a succeeding portion of lower amplitude transmitted continuously along with said signals, and a receiving control circuit connected to said receiving circuit and selectively responsive to waves of certain frequencies received thereby from said medium, only in the absence of signal transmission in said transmission circuit initiated a given time before the advent of said waves of said certain frequencies in said receiving circuit.

6. The terminal circuit of claim 5 and in which said given time determining the operation of the receiving control circuit is not greater than the transmission time over said medium between terminals.

7. A two-way telephone transmission system comprising a two-way transmission medium and a terminal circuit therefor comprising a normally disabled transmitting circuit, a normally opera-

tive receiving circuit, transmitting control means responsive to initiation of telephonic signals in said transmitting circuit to disable said receiving circuit, render operative said transmitting circuit and to send out to said medium in advance of said signals a short train of control waves, receiving control means connected to said medium and selectively responsive to control waves of certain frequencies received therefrom to disable said transmitting circuit and said transmitting control means, means responsive to telephonic signals received by said receiving circuit when operative from said medium to maintain the transmitting circuit and transmitting control means disabled, means also responsive to the telephonic signals initiated in said transmitting circuit and operative at a time after the preceding train of control waves has been transmitted to said medium substantially equal to the transmission time over said medium between terminals, to disable said receiving control means and said means responsive to received signals, and means for shaping the short train of control waves transmitted to said medium so that it has a varying amplitude time characteristic dependent on the transmission requirements of the system.

8. A two-way telephone transmission system comprising a two-way signal transmission medium connecting stations each comprising a normally disabled transmitting circuit, a normally operative receiving circuit, transmitting control means responsive to initiation of telephonic signals in said transmitting circuit to disable said receiving circuit, to render operative said transmitting circuit and to cause a short train of control waves of frequencies different for each station to be transmitted out over said medium to said other station in advance of the signals, receiving control means connected to said medium and selectively responsive to the control waves received thereover from the other station to initially disable said transmitting circuit and said transmitting control means, means connected to said receiving circuit and responsive to signals received thereby when operative to maintain said transmitting circuit and said transmitting control means in the disabled condition initiated by the preceding short train of control waves from said other station, said means responsive to received signals being more sensitive than said transmitting control means, means also responsive to said telephonic signals initiated in said transmitting circuit, and operative at a time after the preceding control waves have been transmitted to said medium substantially equal to the transmission time of said medium to disable said receiving control means and said means responsive to received signals, and means for so shaping the train of control waves transmitted to said medium that its amplitude is initially high and falls off quickly to a lower amplitude sufficient to maintain the receiving control means at said other station operated for a definite period of time.

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