

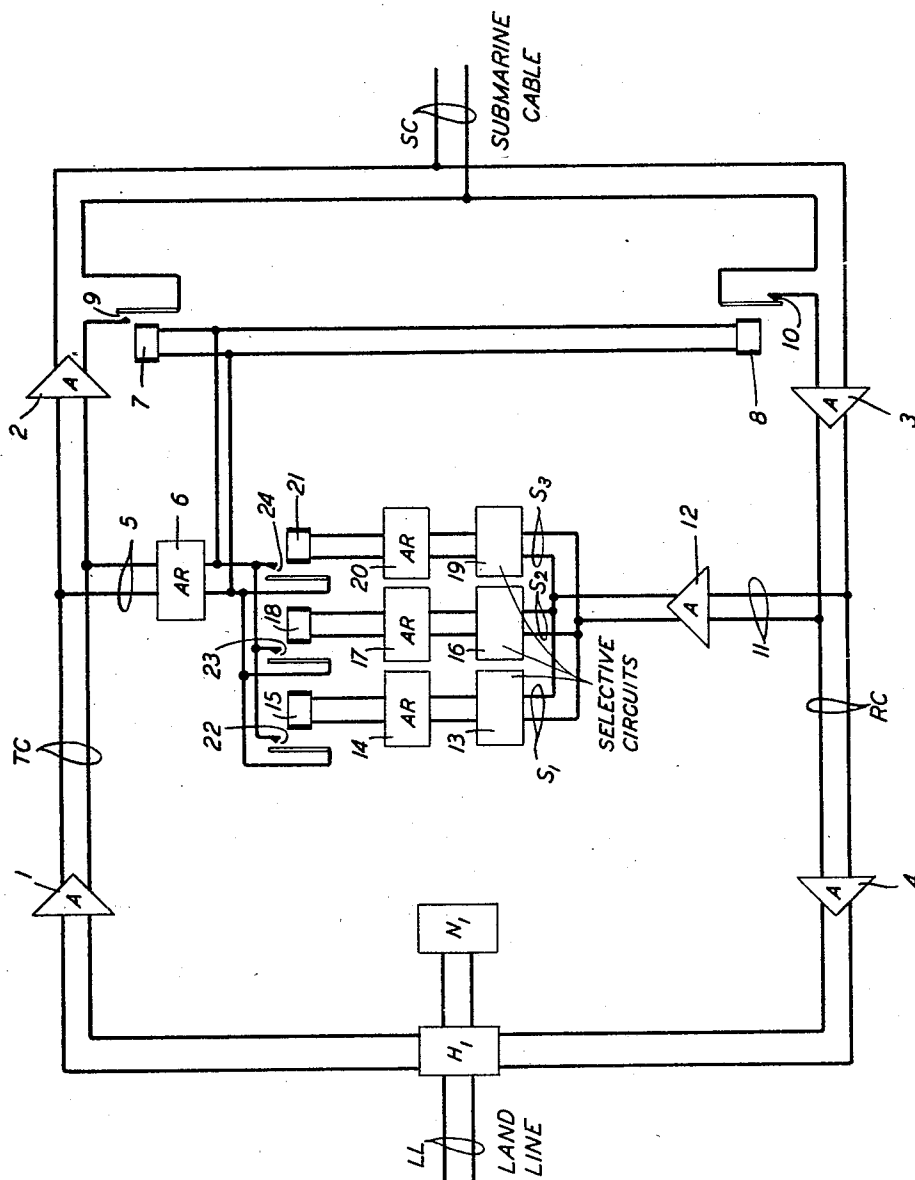
Jan. 19, 1932.

H. W. DUDLEY

1,841,405

TRANSMISSION CONTROL CIRCUITS

Filed Dec. 4, 1930



INVENTOR
H. W. DUDLEY
BY
H. A. Bengers
ATTORNEY

UNITED STATES PATENT OFFICE

HOMER W. DUDLEY, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

TRANSMISSION CONTROL CIRCUITS

Application filed December 4, 1930. Serial No. 499,880.

This invention relates to circuits for controlling transmission in signaling systems and particularly to circuits for reducing the effects of interfering waves on the operation of such transmission control circuits.

An object of the invention is to discriminate between electrical waves of different characteristics, for example, between useful signals and interfering noise waves.

Another object is to improve the operation of signal-controlled devices for suppressing echoes and preventing singing in two-way signaling systems subject to interfering waves, for example, resistance noise waves.

The invention in a broad aspect is a system for discriminating between waves on the basis of differences in their energy characteristics. More specifically stated it is a system for discriminating between waves having an energy spectrum which may be considered as discrete, for example, speech waves, and waves having a substantially continuous energy spectrum over a definite frequency range, for example, waves due to thermal agitation in electric conductors, so-called resistance noise waves.

Resistance noise has an infinitesimal amount of power at any frequency so that if the frequency band of the waves transmitted over a signaling line is subdivided into a number of sufficiently narrow sub-bands, the amount of power due to resistance noise in each sub-band may be reduced to a desired small value. On the other hand, in the case of a vowel in speech (and in a lesser degree in the case of speech in general) a frequency range however small will contain finite power provided that one of the discrete frequencies of the vowel (or speech) is present therein. Therefore, by selecting from the combined speech and noise waves transmitted over a signaling system, a sufficient number of small frequency bands to insure the presence of at least one of the discrete frequencies of the speech, in an ideal case any desired amount of discrimination between the speech power and the resistance noise power may be obtained.

The circuit of the invention based on the above mentioned characteristics, comprises

wave-controlled apparatus connected across the transmission path carrying the signals and the interfering noise waves, through one or more selective circuits each selecting from the combined waves a different frequency band of such small width that the magnitude of the energy therein due to noise waves is too small to operate the associated device, which, however, will be operated by the energy of the signal waves in the band if a discrete frequency is present therein. A sufficient number of these circuits may be provided so that when the transmission path is transmitting the signals at least one of the selected bands will contain a discrete signal frequency which has sufficient power to operate the wave-controlled device.

The circuit of the invention may be applied to advantage in a long two-way signaling system, such as a two-way telephone or submarine telephone cable system, employing signal-controlled devices for determining the direction of transmission, to prevent false operation of such devices by the noise waves while maintaining them at maximum sensitivity as regards operation by useful signals.

The objects and advantages of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawing, the single figure of which shows one terminal of a long two-way signaling system, such as a submarine telephone cable system, employing transmission control circuits embodying the invention.

The terminal circuits shown in the drawing comprise a transmitting circuit TC including the one-way amplifying devices 1 and 2 for transmitting in amplified form signal waves received over the land line LL into the submarine cable SC, and a receiving circuit RC including the one-way amplifying devices 3 and 4 for transmitting in amplified form signal waves received over the submarine cable circuit SC into the land telephone line LL. The input of the transmitting circuit TC and the output of the receiving circuit RC are associated in conjugate relation with each other and in energy transmitting relation with the land telephone

line LL by means of the hybrid coil H_1 and associated balancing network N_1 in the manner well known in the art. The output of the transmitting circuit TC and the input of the receiving circuit RC are directly connected to the west end of the submarine cable SC.

Connected across the transmitting circuit TC between the output of the amplifying device 1 and the input of the amplifying device 2 therein is the input of a control circuit 5 comprising the wave-controlled, relay-controlling device 6, and the windings of the mechanical relays 7 and 8 connected in parallel to the output of the device 6.

In the transmitting circuit TC between the output of the amplifying device 2 therein and the submarine cable circuit SC are the normally open contacts of a switch 9 arranged to be closed by operation of the relay 7. In the receiving circuit RA between the submarine cable circuit SC and the input of the amplifying device 3 are the normally closed contacts 10 of a switch arranged to be opened by operation of the relay 8.

Connected across the receiving circuit RC between the output of the amplifying device 3 and the input of the amplifying device 4 therein is a control circuit 11 comprising the one-way amplifying device 12 and a plurality of auxiliary circuits S_1 , S_2 and S_3 connected in parallel across the output of the device 12. The amplifier device 12 is not necessary if the waves diverted into control circuit are sufficiently amplified by the amplifier 3 in the circuit RC. If the device 12 is not used the selective circuits S_1 , S_2 and S_3 are connected in parallel directly across the receiving circuit RC. The auxiliary circuit S_1 comprises the selective circuit 13 connected to the output of the amplifying device 12, the wave-controlled, relay-controlling device 14 connected to the output of the selective circuit 13, and the windings of a mechanical relay 15 connected to the output of the device 14. The auxiliary circuit S_2 comprises the selective circuit 16 connected to the output of the amplifying device 12, the wave-controlled, relay-controlling device 17 connected to the output of the selective circuit 16, and the windings of a mechanical relay 18 connected to the output of the device 17. Similarly, the auxiliary circuit S_3 comprises the selective circuit 19 connected to the output of the amplifying device 12, the wave-controlled, relay-controlling device 20 connected to the output of the selective circuit 19, and the windings of a relay 21 connected to the output of the device 20.

Relay 15 is adapted to operate in response to the energization of its windings by operation of the device 14 to close its contacts 22 so as to short-circuit the control circuit 5 at a point therein between the device 6 and the

windings of relays 7 and 8. Relay 18 is adapted to operate in response to the energization of its windings by operation of the device 17 to close its contacts 23 so as to independently short-circuit the control circuit 5 at a point therein between the output of the device 6 and the windings of relays 7 and 8. Similarly, relay 21 is adapted to operate in response to the energization of its windings by operation of the device 20 so as to independently short-circuit the control circuit 5 at a point therein between the output of the device 6 and the windings of relays 7 and 8.

It is apparent that the terminal circuit which has just been described is of the type known in the art as semi-biased, that is, the circuit is normally operative to transmit in one direction (in this case from the submarine cable SC into the land line LL over the receiving circuit RC) and transmission in the opposite direction (in this case from the land line LL into the submarine cable SC over the transmitting circuit TC) is dependent upon a switching operation.

The wave-controlled, relay-controlling devices 6, 14, 17 and 20 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 impressed upon their inputs to control the operation of mechanical relays connected to their outputs.

The selective circuits 13, 16 and 19 may be resonant circuits of the type well known in the art, each tuned to a selected different frequency within the frequency range of the waves impressed upon their input from the output of the amplifying device 12, so as to transmit to the windings of relays 15, 18 and 21 respectively with little attenuation the resonant and neighboring frequencies in the impressed waves, while producing appreciable attenuation in other frequencies of the impressed waves. Alternatively, the selective circuits 13, 16 and 19 may be band-pass filters of well known type, for example, such as disclosed in U. S. patents to Campbell 1,227,113 and 1,227,114, issued May 22, 1917, in which case the filters are designed to transmit respectively to the windings of relays 15, 18 and 21 with little attenuation a different sub-band of frequencies within the frequency range of the waves impressed upon their inputs while producing appreciable attenuation in the impressed frequencies outside the range of the selected sidebands.

The fundamental frequency of the voice varies from 125 to 200 cycles per second. Due to modulation in carbon transmitters, all of the higher harmonics of the fundamental are normally present in commercial telephone speech in appreciable amounts up to 2500 cycles or more. Selection of a band of frequencies from the waves impressed on the

input of the control circuit 11 from the receiving circuit RC, extending from a frequency of say 1200 cycles to a frequency of 1400 cycles per second would, of course, contain several discrete speech frequencies. If, therefore, the selective circuits 13, 16 and 19 are utilized to respectively select a different frequency sub-band within this frequency range, at least one of the selected bands would contain a discrete speech frequency which would contain appreciable power. The sub-bands, however, are of such narrow width that the power due to resistance noise waves contained in any one of them would not be appreciable. If the amplifier-rectifier devices 14, 17 and 20 therefore are normally adjusted so as to be normally inoperative by the amount of power due to resistance noise contained in any one of the selected sub-bands but to be operated by the amount of power contained in a discrete speech frequency, it is apparent that at least one of the relays 15, 18 and 21 connected in the output of the devices 14, 17 and 20 respectively will operate in response to the speech waves from the output of the amplifier 12 to close its contacts and thus short-circuit the control circuit 5. The resistance noise waves, however, which will get through to the inputs of the relays 15, 18 and 21 will not have sufficient power to operate any one of these relays. The control circuit 11 connected to the receiving circuit RC, therefore, effectively discriminates between the speech waves impressed upon its input and interfering noise waves, so that false operation of the receiving switching circuits by noise is effectively prevented.

It is of course evident that if a greater number of selective circuits are used, the chance of a frequency sub-band selected by one of the selective circuits containing at least one discrete speech frequency of sufficient power to operate the associated short-circuiting relay is greatly increased, and, of course, if the selected band in the output of the amplifier 12 is subdivided into a greater number of small sub-bands, the amount of power in any one band due to the resistance noise will be greatly decreased. Thus any desired amount of protection against noise may be obtained by suitable choice of the proper number of the selective circuits and associated apparatus.

The operation of the system illustrated as a whole will now be described. Speech waves together with the accompanying noise waves received over the land line LL will be impressed by the hybrid coil H_1 upon the transmitting circuit TC and amplified by the amplifying device 1 therein. The amplified speech waves and noise waves in the output of the amplifier A_1 will be divided between the input of the amplifier 2 in the transmitting circuit TC and the input of the control circuit 5.

The portion diverted into the control circuit 5 will operate the wave-controlled, relay-controlling device 6 therein causing the windings of relays 7 and 8 to be energized. Relay 8 will operate to open the normally closed switch contacts 10 in the input of the receiving circuit RC, thereby making that circuit thereafter inoperative to transmit received waves from the submarine cable circuit SC to the land line LL. Relay 7 will immediately thereafter operate to close the normally open switch contacts 9 in the output of the transmitting circuit TC, thereby making that circuit operative to transmit speech waves from the output of the amplifier 2 into the submarine cable SC.

The portion of the speech waves in the input of amplifier 2 in the transmitting circuit TC will be amplified by that amplifier and, the switch contacts 9 being now closed, will be transmitted directly into the submarine cable circuit SC and transmitted thereover to the receiving station at the other end thereof. It is of course necessary that the contacts 9 in the output of the transmitting circuit TC be closed before the speech waves arrive at that point in the circuit. It may be desirable therefore to insert a delay circuit of any of the well known types in the transmitting circuit TC between the point of connection of the control circuit 5 thereto and the switch 9 in order to insure that the contacts 9 are in the closed condition when the speech waves arrive thereat.

The device 6 or the relays 7 and 8 connected to the output thereof should be designed so as to have a given amount of hangover in action in order that, after the transmission of speech waves from the path TC into the control circuit 5 ceases, the transmitting circuit TC will remain operated and the receiving circuit RC inoperative for a sufficient additional length of time to prevent clipping of the speech waves or false operation of the control circuit 11.

Speech waves and accompanying noise waves received over the submarine cable SC upon arrival at the terminal circuit will be transmitted into the input of the receiving circuit RC, the transmitting circuit TC being disabled in its output by the open switch contacts 9. The waves in the receiving circuit RC will be amplified by the amplifying device 3 and the amplified waves in the output of the device 3 will be divided between the input of the amplifying device 4 and the input of the control circuit 11. The main portion of the speech waves in the output of the amplifier 3 will be amplified by the amplifier 4 in the receiving circuit RC and transmitted thereover to the hybrid coil H_1 and impressed thereby on the land line LL over which it will be transmitted to the listening subscriber.

The portion of the waves in the output of

the amplifier 3 including the speech waves and the interfering noise waves diverted into the control circuit 11 will be amplified by the amplifying device 12 therein, and the amplified waves will be divided between the parallel auxiliary circuits S_1 , S_2 and S_3 .

Each of the selective circuits 13, 16 and 19 will select a different frequency sub-band of the impressed waves, within a given frequency range, for example, within the frequency range extending from 1200 to 1400 cycles per second. As the selected bands have such small width, the energy due to resistance noise in any one of them is not sufficient to operate the control devices 14, 17 or 20 connected to the output of the selective circuits.

Because of the small width of the selected sub-bands, the energy due to the speech waves therein will also be of insufficient magnitude to operate any of the devices 14, 17 and 20 unless there should happen to be one or more discrete speech frequencies of appreciable energy content in one or more of the selected bands. Let it be assumed that there is such a discrete frequency in the band selected by the selective device 13. The control device 14 will be operated by this discrete frequency and the windings of relay 15 in its output energized so as to close the contacts 22 to short-circuit the control circuit 5 between the output of the device 6 and the input of the relays 7 and 8. If there should be additional discrete speech frequencies in the bands selected by selective circuits 16 or 19, the corresponding relays 18 or 21 will operate in consequence of the operation of control devices 17 or 20 by the additional discrete frequencies to close their contacts 23 and 24, and thus to close additional short-circuits across the control circuit 5 between the output of device 6 and the windings of relays 7 and 8. Only one short-circuit across path 5, of course, is necessary to prevent operation of the device 6 therein by waves or noise energy from the transmitting circuit TC from causing false operation of relays 7 and 8 to respectively close the transmitting circuit TC and open the receiving circuit RC by closing the contacts 9 and opening the contacts 10 in the respective circuits.

The control devices 14, 17 and 20 or the relays 15, 18 and 21 should be designed to have sufficient hang-over in their action so as to maintain the short-circuiting contacts 22, 23 and 24 closed for the proper interval of time after the input of the speech waves to the amplifier 12 in control circuit 11 ceases, so as to prevent false operation of the relays 7 and 8.

It is to be understood that the invention is not limited to the particular circuit or the details of the terminal station illustrated and described since numerous modifications may be made therein by persons skilled in the art without departing from the spirit and scope

of the invention. Although the terminal circuit illustrated and described comprises a normally operative receiving circuit, a normally disabled transmitting circuit and switching means responsive to energy to be transmitted over the cable to make operative the transmitting circuit and to disable the receiving circuit, and switching means responsive to energy received over the cable SC for disabling the first mentioned normally operative switching circuit, the invention is not limited to these details. For example, the invention is applicable as well to such circuits modified so as to comprise a normally disabled receiving circuit, a normally operative transmitting circuit, switching means responsive to energy received over the cable for disabling the transmitting circuit and rendering operative the receiving circuit, and switching means responsive to energy to be transmitted out over the cable for disabling the first mentioned normally operative switching means.

In the particular embodiment of the invention illustrated and described, current-controlled mechanical relays are employed for producing an open circuit in, or a short-circuit across a transmission path to disable it or closing an open circuit or opening a short-circuit to make it operative, it is to be understood that the invention is not limited to conditioning means of this type. For example, within the scope of the invention the transmission path may be conditioned by utilizing current-controlled relays to disable the transmission paths by inserting losses in these paths, and to make the paths operative by removing a loss inserted therein, or by any other suitable means. Instead of utilizing mechanical relays and movable contacts for performing the switching operation, stationary means may be used, such as vacuum tube relays as disclosed, for example, in an article by C. A. Beer and E. G. Evans in the Journal of the Institute of Electrical Engineers (London), vol. 20, pages 65 to 72 inclusive, published in April, 1927, or in the U. S. patent to Crisson 1,647,212, issued November 1, 1927.

What is claimed is:

1. A signal receiver subject to combined alternating current waves including useful signal waves having a discrete frequency spectrum and interfering waves which over a definite frequency range have a substantially continuous energy spectrum, comprising selective means for selecting from the frequency band of said combined waves one or more narrow sub-bands within said definite frequency range, one or more wave rectifying devices, means for impressing each of the selected sub-bands on a different one of said rectifying devices, each of said devices being adjusted to be inoperative for impressed energy of an amount corresponding to that due to said interfering waves con-

tained in the selected sub-band impressed thereon but to operate in response to the greater amount of energy which would be contained in a discrete signal frequency of the selected signal waves, and signal receiving means responsive to the rectified energy produced by operation of any one of said rectifying devices.

2. A signal receiver according to claim 1 and in which said selective means comprises one or more electrical wave band-pass filters.

3. A terminal for a two-way telephone transmission line comprising transmitting and receiving circuits connected to said line, means responsive to telephonic waves to be transmitted over said line for varying the transmission efficiency of at least one of said circuits, a plurality of wave-controlled devices responsive to received wave energy of a given amount to independently control said transmission efficiency varying means, means for selecting and supplying to each of said wave-controlled devices, a different band of frequencies of the combined telephonic and speech waves received over said line, each band having insufficient energy due to said noise waves to operate the associated wave-controlled device, but at least one of said bands having one or more discrete speech frequencies of the received telephonic waves containing sufficient energy to operate the associated wave-controlled device.

4. The terminal of claim 3 and in which the transmitting circuit is normally disabled and the receiving circuit normally operative, said transmission efficiency varying means comprises means for effectively disabling said receiving circuit, and for rendering said transmitting circuit operative, and said wave-control devices are responsive to received wave energy of said given amount to effectively disable said transmission efficiency varying means.

5. A terminal for a two-way telephone transmission cable subject to interfering noise waves which over a definite frequency range have a substantially continuous energy spectrum, comprising transmitting and receiving circuits connected to said line, means responsive to telephonic waves to be transmitted over said cable for varying the transmission efficiency of one of said circuits, a plurality of transmission devices responsive to rectified wave energy impressed thereon to independently control said transmission-efficiency varying means, a plurality of selective means connected in parallel to the receiving circuit and each adapted to select a different narrow frequency sub-band of the alternating current waves received over said cable, a plurality of wave rectifying devices each controlling one of said transmission devices, and means for impressing one of the selected sub-bands on one of said rectifying devices, each rectifying device being adjusted so as to be

unresponsive to an amount of impressed wave energy corresponding to that due to the interfering waves in the frequency sub-band impressed thereon but to operate in response to a greater amount of energy which would be contained in a discrete frequency of speech if present in the impressed sub-band.

In witness whereof, I hereunto subscribe my name this 2nd day of December, 1930.

HOMER W. DUDLEY.

70

80

85

90

95

100

105

110

115

120

125

130