

June 10, 1930.

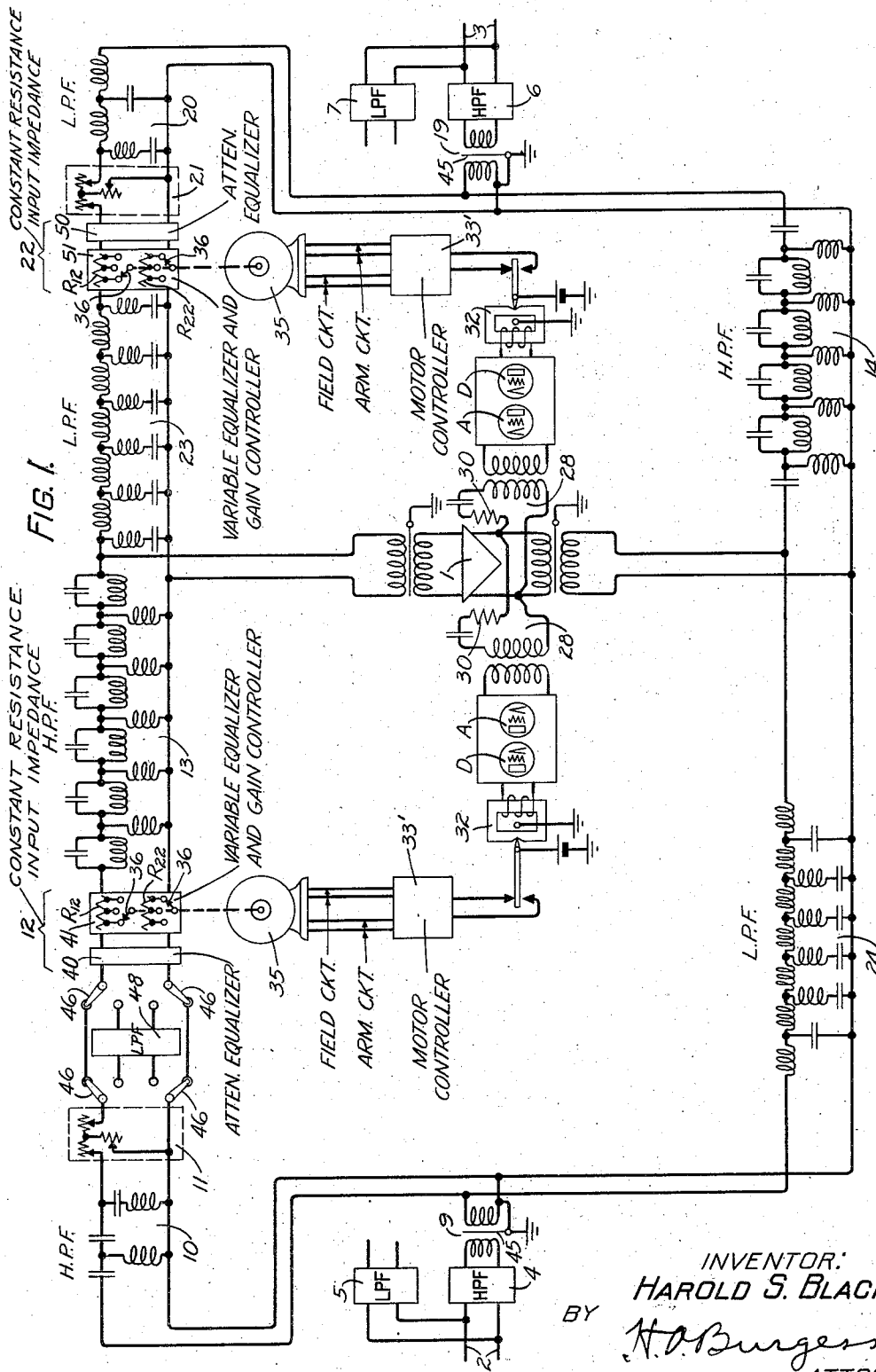
H. S. BLACK

1,762,953

SIGNALING SYSTEM

Filed June 26, 1928

2 Sheets-Sheet 1



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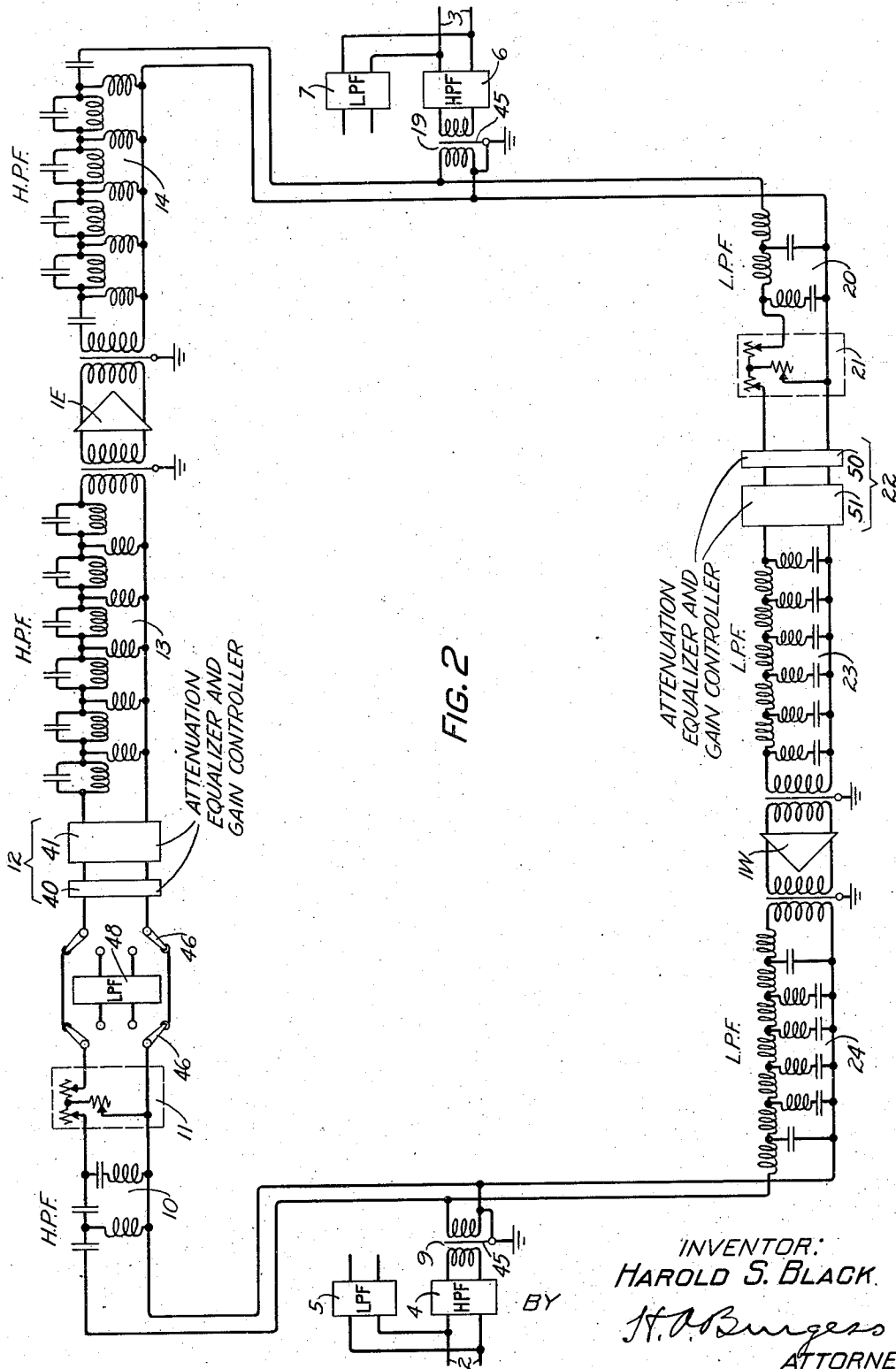
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

HAROLD S. BLACK, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

SIGNALING SYSTEM

Application filed June 26, 1928. Serial No. 288,355.

This invention relates to wave transmission systems, and especially to two-way transmission systems involving one-way amplifying devices.

5 An object of the invention is to facilitate reduction of wave reflections in such systems.

10 An example of applications of the invention is found in reducing crosstalk that, as explained in H. S. Black Patent 1,676,627, July 10, 1928, arises in a carrier wave signaling system because a repeater or a terminal circuit in the system reflects crosstalk currents created in the system by a neighboring system, and the reduction of crosstalk that, as explained in the copending application just mentioned, is created in the neighboring system because the repeater or the terminal circuit reflects signal currents that it should pass.

20 For instance, a carrier telephone repeater system of a general type disclosed in U. S. Patent to K. S. Johnson and M. B. Long, 1,606,795, November 16, 1926 or in U. S. Patent to C. W. Green, 1,739,668, December 17, 1929, may be considered. In such a system the signaling waves from one of the carrier line sections connected by the repeater line in one frequency range. They pass through an input high pass grouping or direction filter (or high frequency transmission band filter), thence through an attenuation equalizer which equalizes the attenuation of the one line (and certain apparatus associated with it) over the one frequency range, thence through a unidirectionally transmitting amplifier and thence through an output high pass direction filter to the second line section. The signaling waves from the latter line section lie in a second frequency range, below the first range. They pass through an input low pass direction filter (or low frequency transmission band filter), thence through an attenuation equalizer which equalizes the attenuation of the second line section (and certain apparatus associated with it) over the second frequency range, thence through a unidirectionally transmitting amplifier, and thence through an output low pass direction filter to the first

line section. The four filters serve to separate the oppositely directed signals in the repeater. Thus waves from the output circuit of a repeater amplifier are prevented from reaching the input circuit of the amplifier. In one specific aspect the present invention is a system of this general type but with the equalizers disposed between portions of the input filters, a major portion of each input filter being connected between an equalizer and an amplifier. An attenuating network, which compensates for lower attenuation of the second line section over the low frequency range than over the high frequency range, is also connected between the two portions of the low pass input filter. Each equalizer is of a type which has its characteristic impedance a constant resistance for the range of frequencies over which the equalizer is to equalize attenuation. Such equalizers are disclosed in U. S. Patent to O. J. Zobel, 1,603,305, October 19, 1926.

35 An important advantage arises from thus locating the equalizer that is in the high frequency path through the repeater at a position ahead of the major portion of the input filter in that path, and locating the equalizer and the attenuating network which are in the low frequency path through the repeater at a position ahead of the major portion of the input filter in that path; for, as explained hereinafter, there results, in the case of each input filter, a material easing of the filter design requirements that are necessary to insure that current reflections in the repeater, which produce crosstalk as indicated above, will not be too great. As a consequence, the design of the filter is made much easier and individual elements of the filter can be made more cheaply.

40 Preferably the unidirectionally transmitting amplifier that amplifies the signals transmitted in one direction over the line also amplifies the signals transmitted in the other direction, in the general manner disclosed in United States Patent to J. S. Jammer, 1,527,651, February 24, 1925 or United States Patent to J. S. Jammer and C. W. Green, No. 1,658,338, February 7, 1928. A feature

of this form of the invention is that attenuating means, one positioned ahead of a major portion of the input high pass filter (or high frequency transmission band filter) and one ahead of a major portion of the input low pass filter (or low frequency transmission band filter), control the transmission equivalents of the system for the oppositely directed signals independently for the two directions. For example, the attenuation equalizer in the high pass input filter equalizes transmission of the signal currents transmitted in one direction over the line without affecting signal currents transmitted in the other direction; and the equalizer in the low pass filter equalizes transmission of the signal currents in the other direction without affecting signals transmitted in the first direction. Further, the equalizer may be adjustable for varying the gain of the amplifier circuit by different amounts at different frequencies, independently for the two directions of transmission over the line. The adjustments of the attenuation equalizing and gain adjusting means may be made by automatic gain controllers, respectively responsive to pilot waves of different frequencies transmitted to the repeater from the different directions and selected by filters after passing through the repeater amplifier.

Other objects and features of the invention will be apparent from the following description and claims.

Figs. 1 and 2 are circuit diagrams of carrier telephone systems embodying two different forms of the invention, respectively.

In Fig. 1 a unidirectionally transmitting amplifier 1 transmits carrier signaling waves in both directions between sections 1 and 2 of a carrier transmission line which transmits voice frequency waves also. The carrier signaling waves from line section 2 and the voice frequency waves from that line section are separated by a high pass filter 4 and a low pass filter 5 of a high frequency composite set. Similarly the carrier signaling waves from line section 3 and the voice frequency waves from that line section are separated by a high pass filter 6 and a low pass filter 7 of a high frequency composite set.

The carrier signaling waves may be carrier waves modulated by speech or other modulating waves. The carrier signaling waves from line section 2 lie in one carrier frequency range. They pass through a transformer 9, a small portion 10 of an input high pass filter (or high frequency transmission band filter), thence preferably through a resistance pad or attenuating network 11, thence through an attenuation equalizer 12 which equalizes the attenuation of line section 2 (and the filter 4 and the input high pass filter) over the one frequency range, thence through the major portion 13 of the

input high pass filter, thence through the unidirectionally transmitting amplifier 1, and thence through an output high pass direction filter 14, to the line section 3. The carrier signaling waves from the latter line section lie in a second carrier frequency range, below the first carrier frequency range. They pass through a transformer 19, a small portion 20 of an input low pass filter (or low frequency transmission band filter), thence through a resistance pad or attenuating network 21, thence through an attenuation equalizer 22 which equalizes the attenuation of the line section 3 (and the filter 6 and the input low pass filter) over the second carrier frequency range, thence through the major portion 23 of the input low pass filter, thence through the unidirectionally transmitting amplifier 1, and thence through an output low pass direction filter 24 to the line section 2. The input high pass filter, the input low pass filter, the output high pass filter and the output low pass filter prevent waves from the output circuit of the repeater amplifier from reaching the input circuit of the amplifier. The equalizers 12 and 22 are disposed between portions of the input high pass filter and the input low pass filter respectively, a major portion 13 of the high pass input filter being connected between equalizer 12 and the input side of amplifier 1, and a major portion 23 of the low pass input filter being connected between equalizer 22 and the input side of amplifier 1.

Each of the networks 11 and 21 is adjustable for varying its attenuation while maintaining the impedance which it presents at its input terminals and at its output terminals a constant resistance impedance. The network 11 in conjunction with a variable equalizer 41 described below, adjusts the transmission equivalents of the channels of the high frequency range, to take account of different attenuation characteristics for different lines in which the repeater may be used. The maximum attenuation of networks 11 and 21 may be, for instance, 2 TU and 12 TU, respectively. The attenuation of network 21 is the larger because that network not only serves, in conjunction with a variable equalizer 51 described below, the same purpose with respect to the channels of the low frequency range that has been described for network 11 and equalizer 31 with respect to the channels of the high frequency range, but also compensates for the lower attenuation of line section 3 over the frequency range of the carrier signaling waves transmitted to the repeater from line section 3 than over the frequency range of the carrier signaling waves transmitted from the repeater to line section 3. The networks 11 and 21 are connected between the portions of the input filters between which the equalizers 12 and 22, respectively are connected. As

will be made apparent hereinafter, it is especially advantageous to have the 12 TU network 21 positioned between the major portion of filter 23 and the line section 3.

5 The equalizer 12 has its impedance facing network 11 a constant resistance impedance. This equalizer comprises a basic or fixed attenuation equalizer 40 and a variable equalizer 41 connected in tandem. The fixed equalizer 40 may be for example of the type of the
10 equalizer shown in Fig. 16 of Zobel Patent 1,603,305, October 19, 1926. The attenuation of the fixed equalizer 40 may be constant for any frequency but may decrease as the frequency increases, or in other words have an
15 attenuation frequency characteristic of negative slope. The variable equalizer 41 may be for example a network such as the adjustable artificial line of Fig. 4 of Zobel Patent 1,591,073, July 6, 1926. The attenuation of the variable equalizer 41 is adjustable, and increases with frequency, or in other words has a characteristic of positive slope. By
20 varying or adjusting the equalizer 41, the gain of the repeater from line section 2 to line section 3 can be varied at will independently of the gain for transmission in the opposite direction, and by such different amounts for different frequencies as to compensate, over the range of frequencies transmitted through the high pass input filter, for
25 variations of attenuation of the line section 2, which of course are different for different frequencies. The variations of attenuation of the line section 3, over this frequency range or for transmission in the direction from line section 2 to line section 3, are taken care of by an equalizing gain control means (not shown) at that end of section 3 remote from the repeater shown. Thus, in
30 conjunction with that means, the equalizer 41 maintains a constant overall transmission equivalent of the line for transmission in the direction from line section 2 to line section 3, regardless of changes such for example as weather changes.

The attenuation equalizer 22 comprises a basic or fixed equalizer 50 and a variable equalizer 51. The equalizers 22, 50 and 51 are like equalizers 12, 40 and 41 respectively, except that they are designed to equalize
50 transmission through line section 3, filter 6 and the low pass input filter instead of through line section 2, filter 4 and the high pass input filter. Consequently, by varying or adjusting the equalizer 51 the gain of the repeater from line section 3 to line section 2 can be varied at will, independently of the gain for transmission from line section 2 to
60 line section 3, and by such different amounts for different frequencies as to compensate for variations of attenuation of the line section 3, over the range of frequencies transmitted through the low pass input filter. The variations of attenuation of the line section 2,

for this frequency range or for transmission in the direction from line section 3 to line section 2, are taken care of by an equalizing gain control means (not shown) at that end of section 2 remote from the repeater shown. Thus, in conjunction with that means, the equalizer 51 maintains a substantially constant overall transmission equivalent of the line for transmission in the direction from section 3 to section 2, regardless of changes such for example as changes in temperature and humidity in the weather.

It will be apparent that although the repeater amplifier is common to the paths for transmission in opposite directions over the circuit not only the gain control but also the attenuation equalization is independently adjustable for the two directions of transmission. The equalizing and gain control means are of a type not adversely affected by the high power level of the output waves from amplifier 1 in spite of the fact that the equalizing and gain control means get little protection (by filters 10 and 20) from those high power levels.

As indicated above, undue current or wave reflections from the repeater, and consequent crosstalk between adjacent parallel carrier circuits (of which only one circuit is shown), are avoided by the positioning of the equalizer 12 ahead of the major portion 13 of the input high pass filter as regards energy flow through that filter, and by the positioning of the equalizer 22 and the 12 TU attenuating pad 21 ahead of the major portion 23 of the input low pass filter, as regards energy flow through that filter. Near end crosstalk can be prevented by having the frequency range of the carrier signaling currents the same for the two adjacent circuits, for each direction of transmission. For example, consider line section 2 and the corresponding section of the adjacent parallel circuit which may be regarded as repeated at the same point as the circuit shown. Even if a signal modulated carrier wave of high power level from the output of the amplifier (not shown) in the adjacent circuit, corresponding to amplifier 1, induces a wave in section 2 the induced wave is of such low frequency that it will not pass through the portion 13 of the input high pass filter shown. This frequency allocation likewise prevents objectionable near end crosstalk from line section 2 into the adjacent circuit. Similarly it prevents near end crosstalk between line section 3 and the corresponding section of the adjacent parallel circuit.

However, if a signal modulated carrier wave of high power level from the output of the amplifier (not shown) in the adjacent circuit, corresponding to amplifier 1, induced a wave in section 2 and the induced wave encountered a considerable change in impedance upon its arrival at the input high pass

filter of the repeater shown, then a considerable portion of the energy of the induced wave would be reflected from the input high pass filter and in the absence of preventive means, this reflected energy would be transmitted from the repeater over line section 2 and at the distant terminal of the carrier line would pass through a filter (not shown) in a carrier wave receiving channel, corresponding to filter 24 and be heard as crosstalk. Likewise, if a considerable impedance irregularity existed at the input high pass filter (not shown) of the repeater in the adjacent circuit, corresponding to repeater 1, that impedance irregularity might occasion objectionable crosstalk in the absence of preventive means. Similarly, any pronounced impedance mismatching at the input low pass filter shown or at the corresponding input low pass filter of the adjacent repeater of the adjacent circuit, might result in objectionable crosstalk between the carrier circuit shown and the adjacent carrier circuit, in the absence of preventive means.

Ordinarily it is very difficult and expensive to prevent objectionable reflection in the input filters of a carrier repeater, since even slight departures from the theoretically correct impedances of the elements of the filter are sufficient to cause a considerable reflection. However, when an equalizer of the constant resistance impedance type, referred to above, follows a filter in a circuit, such for example as filter 10, the equalizer largely determines the terminating impedance of the filter, so that the design requirements for the network following the equalizer, such for example as of the network 13 are considerably eased as to its impedance as part of the terminating impedance of the filter. Thus, for the major portions 13 and 23 of the input filters of the repeater shown, the design requirements necessary to avoid objectionable current reflections from the repeater and consequent crosstalk between parallel carrier circuits, are considerably eased by placing the equalizer 12 and 22 ahead of those portions, respectively. The resistance networks 11 and 21, if present, also tend to render the impedance requirements for the filters 13 and 23, respectively less severe. Preferably the number of filter sections positioned ahead of each of the equalizers 12 and 22, i. e., the number of filter sections in the portions 10 and 20 of the input high pass filter and the input low pass filter, respectively, is only sufficient to substantially match the impedances of the repeater and those of the transformers 9 and 19 for the high and low frequency groups of carrier frequency signaling waves. For the frequency range of the waves transmitted from filter 24 to line 2, the impedance seen looking into filter 10 should be high enough to prevent unduly shunting these waves away from the line; and for the frequency range of

the waves transmitted from filter 14 to line 3, the impedance seen looking into filter 20 should be high enough to avoid unduly shunting these waves away from the line. By way of example each of the filters 10 and 20 is shown as consisting of one and one half sections. As regards the input high pass filter and the input low pass filter, reliance is placed principally on the filter portions 13 and 23 for separation of the messages transmitted in opposite directions over the circuit, these filter portions preferably containing enough filter sections to produce substantially all of the attenuation required in the input filters for separating the different frequency groups of carrier signaling waves.

If the filter portion 13 following the equalizer 12 has its impedance within its frequency range of free transmission and down to within about 2,000 cycles of its cut-off frequency, of the proper value to avoid production of objectionable reflections, then very little attention need be given to the impedance of the filter portion outside of its transmission band, since the equalizer loss becomes higher and higher at the lower frequencies, and any waves reflected from this filter portion toward the line 2 must pass through the equalizer 12 and suffer attenuation in that equalizer before reaching the line 2. As a result, the design of the input high pass filter is made much easier and the individual elements of the filter can be made more cheaply.

In the neighborhood of the cut-off frequency of the low pass filter 23, which neighborhood is a frequency range in which the impedance of this filter is poor as regards matching the equalizer impedance that faces it, the attenuation of equalizer 22 is lower than at lower frequencies. However, the 12 TU pad 21 supplements the action of equalizer 22 in attenuating reflections from the filter 23.

The high pass line filter 6 produces reflections which are cumulative with reflections produced in the low pass filter 23. However, the equalizer 22, as well as the 12 TU pad, has high attenuation for the latter reflections at frequencies in the neighborhood of or lower than the cut-off frequency of the filter 6, which are frequencies at which the impedance of the filter 6 is a poor match for the line impedance that it faces.

The transformers 9 and 19 preferably have electrostatic shields 45, of copper for example, between the primary and secondary windings. The shielded transformers increase the attenuation of the circuit for longitudinal currents, and render it feasible to have the filters 10, 13, 23, 20, 24 and 14 of the unbalanced type, as shown. All of these filters, and the filters 4, 5, 6, and 7, and also a filter 48 to be referred to presently may be constructed in accordance with the principles

disclosed in Campbell Patent 1,227,113, May 22, 1917, and 1,493,600, May 13, 1924, and Zobel Patent 1,538,964, May 26, 1925.

By switches 46 a low pass filter 48 may be connected in circuit between pad 11 and equalizer 12, if desired. The cut-off frequency of this filter is preferably just above the upper limit of the frequency range of the signals transmitted over the circuit. Thus since the filters 4 and 6 preferably have a cut-off frequency just below the lower limit of the carrier signals transmitted over the circuit, the repeater amplifies only waves of frequency within the frequency range of the carrier signaling waves transmitted over the circuit. The filter 48 prevents overloading of the repeater by interference from power line carrier waves. The carrier waves in power line carrier signaling systems ordinarily are of high power relative to the power of carrier signaling waves in carrier telephone transmission lines and lie in a frequency range somewhat above the frequency range of the latter waves. For example, the upper limit of the carrier signaling frequencies transmitted by the repeater may be 30 kilocycles whereas the power line carrier signaling waves may lie in the frequency range between 30 kilocycles and 40 kilocycles. If desired, instead of including the low pass high cut-off filter 48 in circuit, the purpose served by the inclusion of that filter may be accomplished by making the filter 4 or the filter 13 a band pass filter with its upper cut-off frequency equal to that which the filter 48 would have if the latter filter were used.

If desired the adjustment of the variable equalizers 41 and 51 respectively can be made automatically, by two motors 35 respectively, under the control of two pilot frequency waves of two different frequencies sent to the repeater over lines 2 and 3 respectively and selected by two tuned circuits or frequency selective means 28 respectively after amplification in amplifier 1.

The pilot frequencies may lie in the frequency range between that of the group of signal side band components transmitted to the repeater over line 2 and that of the group of signal side band components transmitted to the repeater over line 3. The filters 10, 13 and 14 may be made to include in their pass ranges the frequency of the pilot wave transmitted over line 2 but not the other pilot frequency; and the filters 20, 23 and 24 may be made to include in their pass ranges the frequency of the pilot wave transmitted to the repeater over line 3 but not the other pilot frequency.

The motors 35 may be controlled by the pilot frequency waves, respectively, in the manner, for example, in which the motor 35 of Fig. 10 of Affel Patent 1,511,013, October 7, 1924, is controlled by a pilot frequency

wave. The reference characters 28, 30, 31, 32, 35 and 36 designate respectively the same elements as in the Affel patent. The reference character 33' designates the motor reversing switches and power supply (not shown) which are designated 33, 34 and 38 in the Affel patent. Resistance 30 prevents all of the energy of the pilot frequency to which the tuned circuit 28 is selective from being absorbed at the first repeater or automatic gain control means encountered. The pilot frequency from the tuned circuit 28 is fed to a circuit comprising an amplifier A and a detector D which has a contact milliammeter 32 in its output circuit. The milliammeter controls the motor controller 33' for the motor 35.

A plurality of switches 36 are driven by the motor 35, as the switch 36 of Affel is driven by motor 35 of Affel. Each of these switches is individual to one of the attenuation adjusting resistances such as R_{12} and R_{22} of the variable equalizer (which correspond to resistances R_{12} and R_{22} of Fig. 3 of the above mentioned Zobel Patent 1,591,073).

With the transmission line in normal condition, the pilot frequency wave transmitted over the line will be of sufficient amplitude to maintain the contact of milliammeter 32 in the neutral position. When the amplitude becomes greater or less, operation of the milliammeter in one direction or the other results in the motor controller 33' causing motor 35 to operate clockwise or counter-clockwise respectively. Consequently, switches 36 are driven to adjust the resistances R_{12} and R_{22} to again bring the amplitude of the pilot frequency wave in the input circuit of amplifier A to the normal value. The number of pairs of switches driven by the motor 35 is the same as the number of sections and half sections of the variable equalizer that are to be varied in their attenuation setting. If each of the resistances in the equalizer is so varied, then, as explained in Zobel 1,591,073, mentioned above, the attenuation of the equalizer can be varied considerably without producing undue departure from the ideal attenuation-frequency characteristic for the variable equalizer.

If greater variation of the attenuation is desired, then instead of having the gain controlling motor 35 vary the settings of the resistances of the individual sections of the variable equalizer, means (not shown) can be provided whereby the motor 35 operates switches that connect any desired number of half sections of the variable equalizer in circuit as shown in Fig. 4 of the above mentioned Zobel Patent 1,591,073.

Fig. 2 shows a system which is like that of Fig. 1 except that no automatic gain controller is shown and instead of having a common amplifier for the two directions of transmission separate amplifiers 1E and 1W are

used for the two directions in the general manner disclosed in the above mentioned patent to K. S. Johnson and M. B. Long. The operation of this system will be apparent from the description of Fig. 1 given above.

What is claimed is:

1. A wave transmission system comprising a device for controlling the transmission equivalent of the system for waves to be transmitted through the system, said device having an input path and an output path, means for applying waves of two different frequencies to said input path, the intensity of the waves of one frequency having a lower order of magnitude than the intensity of the waves of the other frequency, and frequency selective means connected to said output path of said device, for passing said one frequency to the exclusion of the other, said device transmitting both of said frequencies with attenuation low compared to the attenuation of said frequency selective means for said other frequency.

2. A wave transmission system comprising a device for controlling the transmission equivalent of the system for waves to be transmitted through the system, said device having an input path and an output path, means for applying waves of different frequencies to said input path of said device, the intensity of the waves of one frequency having a higher order of magnitude than the intensity of the waves of another frequency and said device transmitting both of said frequencies, an electric space discharge device having an input path, and frequency selective means, connecting said output path of said first device to said input path of said discharge device, for passing said other frequency but preventing the waves of said one frequency received from said first means from reaching said input path of said discharge device.

3. A wave transmission system comprising a line, means for equalizing the attenuation of said line at different frequencies, said means having an input path and an output path, an electric space discharge device having an input path, frequency selective means connecting said output path of said means to said input path of said device, and means, including said first means and a portion of said line, for applying to said frequency selective circuit waves of one frequency which have intensity of one order of magnitude and waves of another frequency which have intensity of a higher order of magnitude, said frequency selective means passing said waves of said one frequency to the exclusion of said waves of said other frequency.

4. A wave transmission system comprising a line; means for equalizing the attenuation of said line at different frequencies, said means having an input path and an output path and having its input impedance a con-

stant resistance for said frequencies, a circuit connecting said line to said input path, an electric space discharge device having an input path, and a wave filter connecting said output path of said means to said input path of said device.

5. The combination with a line of a two-way repeater therefor, said repeater comprising means for equalizing the attenuation of said line at different frequencies and an amplifying device having an input circuit, said means having an input path and an output path and having its input impedance a constant resistance for said frequencies, a circuit connecting said line to said input path, and a wave filter connecting said output path of said means to said input path of said device.

6. The combination of a transmission line, means for equalizing the attenuation of said line at different frequencies, said means having an input circuit and an output circuit, an amplifier having an input circuit and an output circuit, means including said output circuit of said amplifier and a portion of said line for applying waves of different frequencies to said input circuit of said equalizing means, the intensity of said waves of one frequency having a different order of magnitude than the intensity of said waves of another frequency; and a frequency selective circuit, connecting said output circuit of said equalizing means to said input circuit of said amplifier, for passing said waves of said one frequency but preventing said waves of said other frequency received from said means from reaching said input circuit of said amplifier.

7. In combination, a line, a circuit for transmitting waves to said line, a circuit for transmitting waves from said line, a one-way path connecting said circuits, and an attenuation equalizer in one of said circuits for equalizing the attenuation of said line over a range of frequencies.

8. The combination with two lines, of two channels interconnecting said lines, said two channels comprising a common unidirectionally transmitting portion, a portion individual to one of said channels for transmitting waves from one of said lines to said common portion, a portion individual to said other channel for transmitting waves from said other line to said common portion, means in said first individual portion for equalizing the attenuation of said one line over a range of frequencies, and means in said other individual portion for equalizing the attenuation of said other line over another range of frequencies.

9. In a signaling system, the combination with two lines for transmitting currents, of two channels for transmitting currents of different frequencies in opposite directions between said lines, said two channels comprising a common unidirectionally transmitting

portion, a passive impedance network connecting one of said lines to said common portion, a passive impedance network connecting said other line to said common portion, means in one of said networks for equalizing the attenuation of one of said lines over a range of frequencies, and means in said other network for equalizing the attenuation of said other line over another range of frequencies.

10. Two lines, an amplifier for said lines, a path for transmitting waves from the first said line through the amplifier in a given direction, to the other line, another path for transmitting waves from said other line through said amplifier in said direction to said first line, means individual to one of said paths for equalizing attenuation of one of said lines over a range of frequencies, and means individual to said other path for equalizing attenuation of said other line over a range of frequencies.

11. A wave transmission system comprising two lines, a one-way amplifier for repeating from one of said lines to the other and from said other line to said one line, output frequency grouping direction filters connecting the output side of said amplifier to said lines respectively, frequency selective paths respectively connecting said lines to the input side of said amplifier, frequency grouping direction filters included in said paths respectively, and line attenuation equalizers for said lines respectively, connected between portions of said filters respectively and between major portions of said filters and said lines respectively, each of said equalizers having its input impedance a constant resistance for the frequencies to be transmitted therethrough.

12. A wave transmission system comprising a wave attenuating device adjustable for varying its attenuation by different amounts at different frequencies to be transmitted through the system, said device having an input path and an output path, means for applying waves of two different frequencies to said input path, the intensity of the waves of one frequency having a lower order of magnitude than the intensity of the waves of the other frequency, and frequency selective means connected to said output path of said device, for passing said one frequency to the exclusion of the other, said device transmitting both of said frequencies with attenuation low compared to the attenuation of said frequency selective means for said other frequency.

13. In combination, a line, a frequency selective circuit for transmitting waves of a given frequency range to said line, a frequency selective circuit for transmitting waves of another frequency range from said line, a one-way path connecting said circuits, and wave attenuating means in one of said circuits, adjustable for varying its attenu-

ation by different amounts at different frequencies transmitted by said one circuit.

14. In a signaling system, the combination with two lines for transmitting current, of two channels for transmitting currents of different frequencies in opposite directions between said lines, said two channels comprising a common unidirectionally transmitting portion, a passive impedance network connecting one of said lines to said common portion, a passive impedance network connecting said other line to said common portion, wave attenuating means in one of said networks, adjustable for varying its attenuation by different amounts at different frequencies over a range of frequencies transmitted by that network, and wave attenuating means in said other network, adjustable for varying its attenuation by different amounts at different frequencies over a range of frequencies transmitted by that network.

15. A two-way repeater, for a wave transmission system comprising two line sections for two-way transmission in which the frequencies transmitted in opposite directions are comprised in different frequency groups, said repeater having input and output branches for connection to each of said line sections, a common amplifier for all of said waves connected between said branches, two frequency grouping direction filters in said output branch, two frequency grouping input filters in said input branch, one at each side of the junction of said amplifier with said input branch, an attenuation network connected between two portions of one of the two latter filters, adjustable to vary its attenuation by different predetermined amounts for different frequencies in a frequency range passed by the filter in which it is connected, an attenuation network connected between two portions of the other of said input filters, adjustable to vary its attenuation by different predetermined amounts for different frequencies in a frequency range passed by said other filter, a major portion of each of said input filters being connected between said junction and said networks, and each of said networks presenting to the other portion of one of said filters an impedance which is substantially a constant resistance over the frequency range of the waves to be transmitted through the filter.

16. A wave transmission system comprising a line, means for equalizing the attenuation of said line over one group of frequencies, said means having an input path and an output path, an electric space discharge device having an input path, a circuit including frequency selective means for passing said one group of frequencies and preventing passage of a higher group of frequencies, said circuit connecting said output path of said means to said input path of said device, means, including said first means and

said line, for applying to said circuit waves of said one frequency group which have intensity of one order of magnitude and waves of said higher frequency group which have intensity of a higher order of magnitude, and a wave attenuating pad connected in said circuit between said equalizing means and said frequency selective means.

17. A wave transmission system comprising two lines, a one-way amplifier for repeating from one of said lines to the other and from said other line to said one line, one input path connecting said one line to the input side of said amplifier, another input path connecting said other line to the input side of said amplifier, one output path connecting the output side of said amplifier to said other line, another output path connecting the output side of said amplifier to said one line, one frequency grouping direction filter in said one output path, for passing one range of frequencies and suppressing a lower range, another output frequency grouping direction filter in said other output path, for passing said lower range and suppressing said one range, one input filter in said one input path, for passing said one range and suppressing said other range, another input filter in said other input path for passing said lower range and suppressing said one range, an attenuation equalizer connected between said one line and a major portion of said one input filter, another attenuation equalizer and a transmission equivalent adjusting network connected between said other line and a major portion of said other input filter, said one equalizer equalizing the attenuation of said one line over said one frequency range, said other equalizer equalizing the attenuation of said other line over said lower frequency range, said network compensating for lower attenuation of said other line for said lower frequency range than for said one frequency range, and each of said input paths transmitting both of said frequency ranges to the filter in the path, and line filters in said lines respectively, each of said line filters passing both of said frequency ranges and suppressing a frequency range lower than either.

18. A wave transmission system comprising two lines, a one-way amplifier for repeating from one of said lines to the other and from said other line to said one line, one input path connecting said one line to the input side of said amplifier, another input path connecting said other line to the input side of said amplifier, one output path connecting the output side of said amplifier to said other line, another output path connecting the output side of said amplifier to said one line, one frequency grouping direction filter in said one output path, for passing one range of frequencies and suppressing a lower range, another output frequency grouping direction filter in said other output path, for passing said lower range and suppressing said one range, one input filter in said one input path, for passing said one range and suppressing

said other range, another input filter in said other input path for passing said lower range and suppressing said one range, an attenuation equalizer connected between said one line and a major portion of said one input filter, another attenuation equalizer and a transmission equivalent adjusting network connected between said other line and a major portion of said other input filter, said one equalizer equalizing the attenuation of said one line over said one frequency range, said other equalizer equalizing the attenuation of said other line over said lower frequency range, said network compensating for lower attenuation of said other line for said lower frequency range than for said one frequency range, and each of said input paths transmitting both of said frequency ranges to the filter in the path, and line filters in said lines respectively, each of said line filters passing both of said frequency ranges and suppressing a frequency range lower than either.

19. A two-way repeater comprising a unidirectionally transmitting amplifier common to both directions of transmission and means responsive to amplified waves from said amplifier for controlling the transmission equivalent of said repeater independently for the two directions.

In witness whereof, I hereunto subscribe my name this 25th day of June, 1928.

HAROLD S. BLACK.