

Feb. 10, 1942.

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2,272,613

TRANSMISSION WITH LEVEL EQUALIZING

Filed May 22, 1940

2 Sheets-Sheet 1

FIG. 1

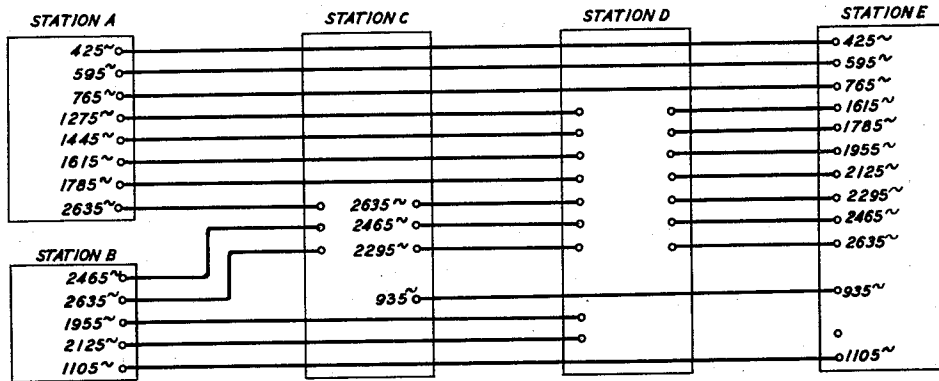
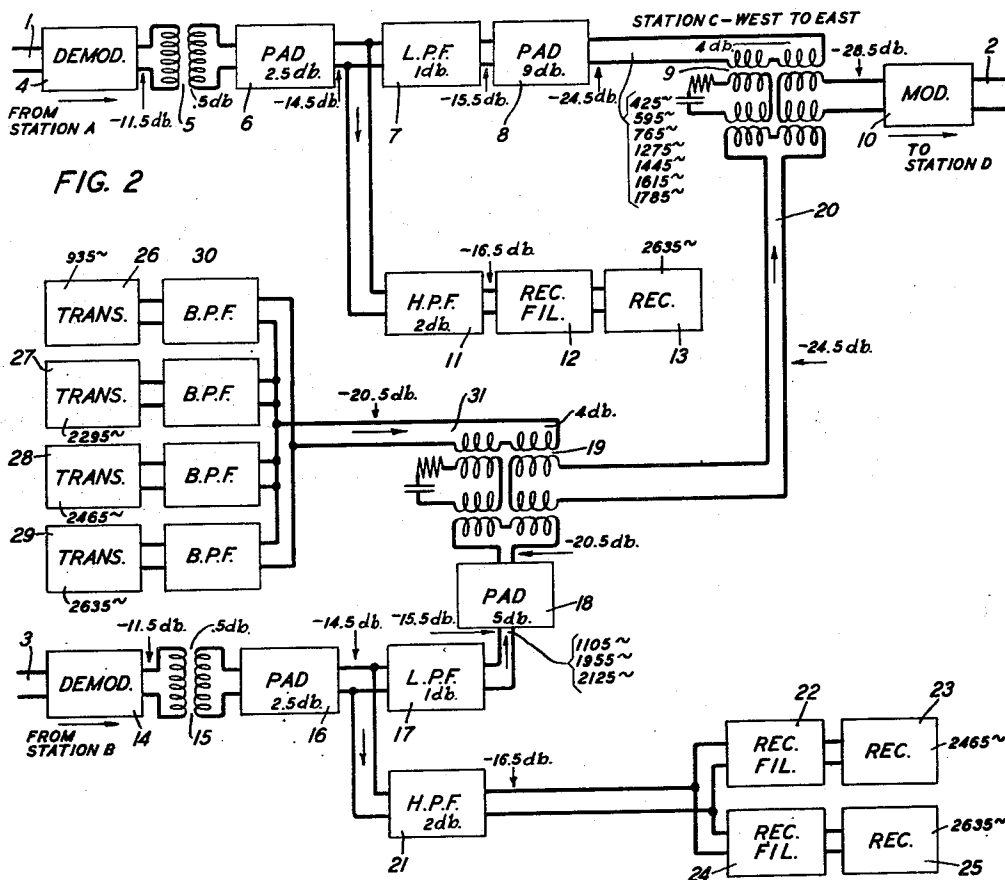


FIG. 2



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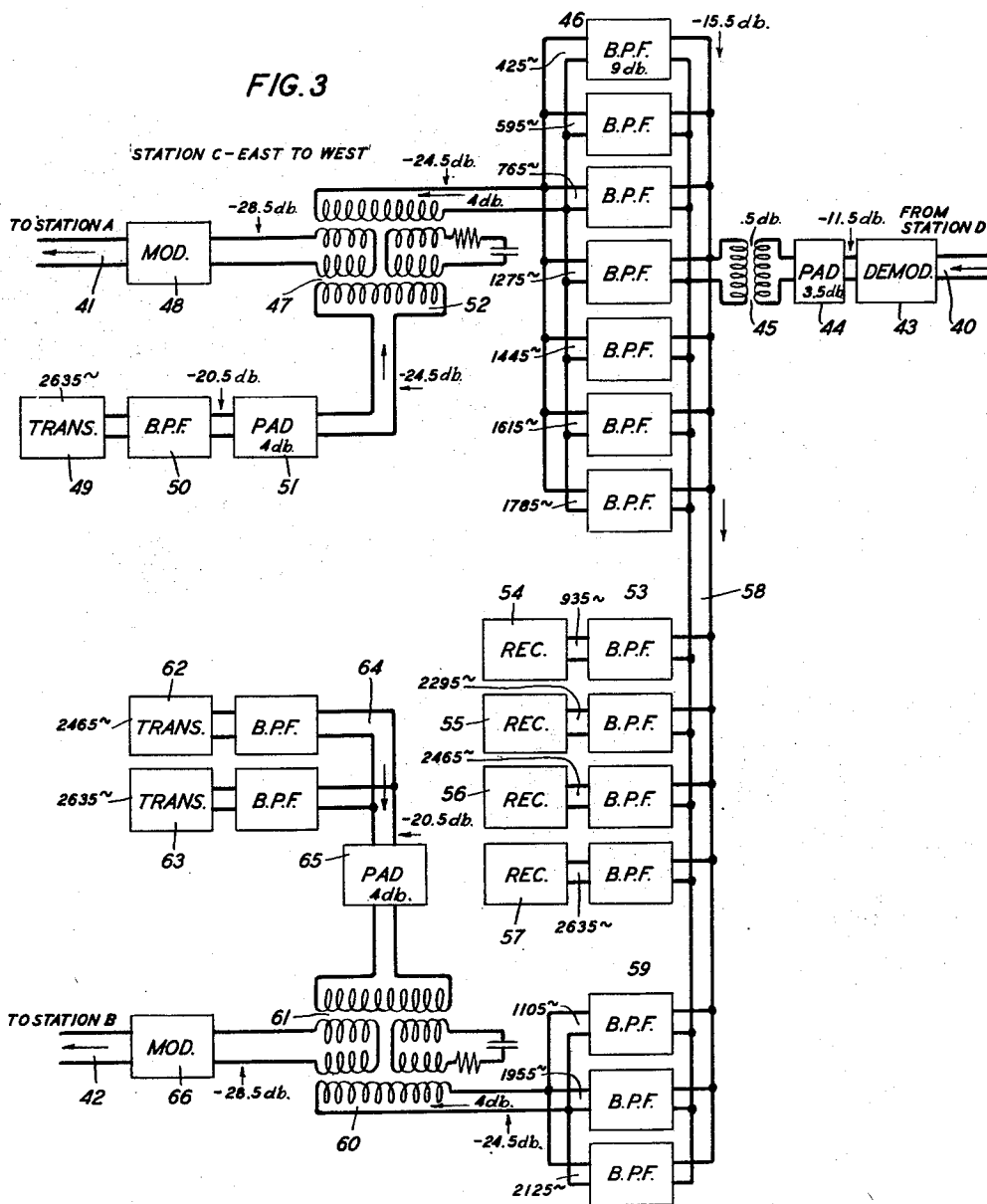
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2 Sheets-Sheet 2



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TRANSMISSION WITH LEVEL EQUALIZING

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1 Claim. (Cl. 179—15)

The present invention relates to multiplex transmission systems and more particularly to interconnections between channels of different systems with the introduction of new channels or the dropping off of channels at an intermediate station.

In multiplex carrier current transmission systems it is necessary to hold the energy levels in the different channels on the same line to approximately the same value in order to avoid overloading or excessive cross-talk or improper operation of certain of the channels. Such systems are generally designed to operate at predetermined normal energy levels and the level, of course, varies from point to point along the line depending on the losses and gains introduced by the line, the repeaters and the other apparatus in the system. Usually the level at a transmitter has a different normal value from that at a receiver, for example.

Traffic conditions require at times that a certain number of channels be provided over a line from or to a certain point and that a different number be provided on the same line or system from that point on; or that certain channels be dropped off or terminated at some intermediate point and other channels be picked up at such point. Sometimes two multiplex systems converge at a point or diverge from a point with the dropping off or picking up of channels. In all such cases it is important for satisfactory operation of the system to bring the energy levels in the various channels to the normal values specified for the particular points in the system, whether terminal or intermediate.

While it would in general be a relatively simple matter to bring the energy levels in all channels to the desired values by use of variable gain amplifiers and pads, the use of amplifiers is to be avoided wherever possible because of their maintenance costs. A difficulty in the use of pads alone is that the losses required in the pads are generally small, and the circuits involved are low impedance circuits so that, as a result, the pads in the different circuit branches affect transmission in neighboring branches by changing the impedances of the branches.

A general object of the present invention is to interconnect circuits or channels carrying signals at different energy levels and to bring the levels to the same value at a branching point, without use of apparatus such as amplifiers requiring maintenance.

This object is accomplished in accordance with this invention by the use of conjugate connec-

tions which permit the introduction of loss in one branch without affecting the impedance of an interconnected branch or channel.

The nature and objects of the invention will be more clearly understood from the following detailed description when read in connection with the accompanying drawings, in which:

Fig. 1 is a schematic diagram of an over-all system embodying a number of stations and showing how certain of the channels extend through the various stations and certain other channels are dropped off or picked up at intermediate points;

Fig. 2 is a block schematic diagram of the apparatus required at station C of Fig. 1 for west to east transmission; and

Fig. 3 is a similar block schematic diagram of the apparatus required at station C for east to west transmission.

Referring first to Fig. 1, boxes are shown representing stations A, B, C, D and E with lines interconnecting the boxes, each line indicating a single channel of a multiplex voice frequency carrier telegraph system. The frequency of the corresponding channel is indicated adjacent to a small circle representing the terminating point of the respective channel. By way of example, station A may be at Los Angeles, station B at Galveston, station C at Amarillo, station D at Topeka and station E at Chicago. While any suitable type of transmission medium may be used between these stations, the present description will assume that the voice frequency carrier telegraph channels are all transmitted as a group through a single channel of a carrier telephone system. It will be noted that the maximum number of telegraph channels in use occurs between stations C and D, the number being fourteen. The lowest frequency is 425 cycles, while the highest frequency is 2635 cycles. This number of channels and this frequency range are accommodated on one voice channel of a standard multiplex carrier telephone system.

It will be noted in Fig. 1 that three channels extend all the way from station A to station E through stations C and D and that one channel extends all the way from station B to station E through stations C and D. Other channels extend only part way as is indicated by the small circles representing channel terminals. The manner in which the channels are extended through intermediate points or are dropped off or picked up will be made clear from the diagrams of Figs. 2 and 3.

Considering now Fig. 2, the circuit 1 repre-

sents one channel of a carrier telephone system incoming from station A and reference to Fig. 1 shows that this channel is carrying eight carrier telegraph channels of which one is to be dropped off at station C while the other seven are to continue through on outgoing line 2 shown at the right. Circuit 3 represents a single channel of another carrier telephone system incoming from station B, this channel carrying five carrier telegraph channels of which two are to be dropped off at station C and the other three are to continue through on outgoing line 2 toward station D.

The apparatus shown in the form of rectangles is standard apparatus of the type at present in wide usage in carrier telephone and carrier telegraph systems and is of a type well known to those versed in the art. This apparatus may, of course, be of any one of several types, the only requirement being that it perform the functions required of transmitting, detecting, modulating, etc., necessary for accomplishing carrier telephone and carrier telegraph transmission. The present description will assume that the carrier telegraph terminal equipment represented in the drawings is of the type disclosed in detail in an article entitled "Voice-frequency carrier telegraph system for cables" by B. P. Hamilton, H. Nyquist, M. B. Long and W. A. Phelps, published in the Journal of the American Institute of Electrical Engineers, March 1925, and that the carrier telephone modulators and demodulators indicated, as well as the rest of the carrier telephone system not indicated but required for actual transmission, are of the types disclosed in an article entitled "Carrier systems on long distance telephone lines" by H. A. Affel, C. S. Demarest and C. W. Green, published in the Bell System Technical Journal, July 1928.

Reverting to Fig. 2, the carrier telephone channel 1 is connected to demodulator 4, the output currents of which pass through coil 5 and pad 6 and divide into two branches, one of which passes through low-pass filter 7, pad 8, hybrid coil 9 and into the input side of modulator 10 in outgoing line 2. Seven telegraph channels, having frequencies as indicated, extending from 425 cycles to 1785 cycles resulting from demodulation at 4, are transmitted over this circuit into modulator 10 in outgoing line 2. These are separated as a group from the channel to be dropped off by the low-pass filter 7 and the high-pass filter 11, the latter of which passes waves of the frequency of 2635 cycles into the carrier telegraph receiving channel comprising filter 12 and receiving apparatus 13.

The hybrid coil 9 may be of well-known or standard construction and its particular function will be described at a later point.

The carrier telephone channel 3 incoming from station B is connected to demodulator 14, the output of which passes through coil 15 and pad 16 where the circuit divides into two branches leading respectively to low-pass filter 17 and high-pass filter 21. Filter 17 is in a branch leading through a pad 18 to hybrid coil 19 whose outgoing branch 20 leads through hybrid coil 9 to the input of modulator 10. In this way the carrier telegraph channels, whose frequencies are respectively 1105 cycles, 1955 cycles and 2125 cycles (see Fig. 1), resulting from demodulation at 14, are transmitted through to the modulator 10 in outgoing line 2. The two channels to be dropped off pass through filter 21 to the individual channel apparatus comprising filter 22 and receiver

23 in one case and filter 24 and receiver 25 in the other case.

The four channels to be picked up comprise the four voice frequency carrier telegraph transmitters 26, 27, 28 and 29 operating on frequencies of 935 cycles, 2295 cycles, 2465 cycles and 2635 cycles, respectively. These are transmitted through the individual channel filters 30 into the common outgoing branch 31 which is connected to hybrid coil 19 leading to branch 20, hybrid coil 9 and modulator 10.

In a channel interconnecting system as illustrated in Fig. 2 it is necessary to adjust the transmission levels to the proper values as has previously been indicated. The levels existing at various points in the system are shown in decibels and the losses in certain individual pieces of apparatus are also shown in decibels. A known type of multiplex carrier telephone system is automatically maintained to operate at a level of minus 11.5 decibels at the output of its demodulators, such as 4 or 14 in the figure, and to operate at a level of minus 28.5 decibels at the input to the modulator, such as 10. These and the other level magnitudes represent energy levels below an arbitrary reference level of zero the exact value of which has no particular significance in the present discussion, the main interest being in the difference in the level existing from point to point in the system.

In order that the channels emerging from the demodulator 4 at a level of minus 11.5 decibels shall enter modulator 10 at a level of minus 28.5 decibels certain losses are introduced between these points as follows: The coil 5 introduces 0.5 decibel, pad 6 introduces 2.5 decibels, filter 7 introduces 1 decibel, pad 8 introduces 9 decibels and there is a 4 decibel loss in the hybrid coil 9. The required level at the input of receiving filter 12 is minus 16.5 decibels. This level is reached by the use of pad 6 in combination with filter 11 which has a 2 decibel loss.

The losses on the output side of demodulator 14 are seen by reference to the figure to be similar to those just described except that in this case pad 18 introduces a 5 decibel loss and hybrid coil 19 introduces a 4 decibel loss in place of the 9 decibel loss introduced by pad 8 in the former case.

The transmitters 26 to 29 operate at a level of minus 20.5 decibels in their output 31. The 4 decibel loss in the hybrid coil 19 brings these to the same level as the currents received from the demodulator 14, namely, minus 24.5 decibels in circuit 20.

Considering circuit 20 and pad 8 in the output of demodulator 4, if it were not for hybrid coil 9 the pad 8 would introduce a loss in circuit 20 where the loss is not desired. Likewise, if the branch 31 together with the branch containing pad 18 were connected to common branch 20 without hybrid coil 19, pad 18 would introduce a loss into the circuit 31. Employment of the hybrid coils at 9 and 19 enables the currents in the individual branches to be brought to the required levels independently of each other and then combined in a common output branch by means of the hybrid coil. For example, the circuit including pad 8 is conjugate with respect to the branch 20 so that the impedance of one does not affect the impedance of the other. While Wheatstone bridges or the like could be used in place of hybrid coils, the latter are preferred since their resistance losses need be only relatively small, thereby avoiding the use of ampli-

fiers to restore the currents to the desired level.

Referring to Fig. 3, a single channel of a multiplex carrier telephone system is shown at 40 incoming from station D and two outgoing channels of two separate carrier telephone systems are shown at 41 and 42, respectively. The output of demodulator 43 passes through a pad 44 and a coil 45 to the input side of a group of seven filters shown at 46, the outputs of which are connected in common to the hybrid coil 47 leading to modulator 48 in outgoing circuit 41. The seven filters shown at 46 could, of course, in some cases, be replaced by a single band-pass filter of proper band width but in the present case it is not convenient or feasible to keep consecutive frequencies within the same group. For example, a band filter passing the frequencies of group 46 would also pass 935 cycles of group 53 and 1105 cycles of group 59, which is not desirable. Consequently, it can be seen that the use of individual channel filters permits any desired grouping of frequencies required by the transmission conditions to be met, a matter of considerable convenience in a complicated system like the one described herein. To permit the parallel connection of the separating filters on both sides, as shown, it is of course necessary that they be specially designed for this purpose.

The single telegraph channel to be picked up at this station to extend toward station A is shown at 49, 50, 51 leading through branch 52 to hybrid coil 47. This channel utilizes a frequency of 2635 cycles.

The four channels to be dropped off at this station are selected by a group of individual channel filters 53 connected to receiving branch 58 and leading respectively to carrier telegraph receivers 54, 55, 56 and 57. These utilize the frequencies 935 cycles, 2295 cycles, 2465 cycles and 2635 cycles, respectively.

The three channels to be extended through this station to station B are connected by the filter group 59 of three channel filters connected in common on one side to branch 58 and connected in common on the other side to branch 60 leading to hybrid coil 61 and to the input of modulator 66.

The two channels to be picked up at this point for transmission to station B are shown at 62 and 63 connected through channel filters to branch 64 including pad 65 leading to hybrid coil 61.

Reference to the drawings will show the various energy levels and the means employed to bring the levels to the required values in the manner described in detail in connection with

Fig. 2. The hybrid coil 47 permits pad 51 to introduce a 4 decibel loss in the circuit 52, while keeping this loss out of the opposite branch connected to the filters 46. Similarly, hybrid coil 61 maintains branches 60 and 64 independent from an impedance standpoint so that the pad 65 has no effect on the impedance of circuit 60.

It will be noted that the invention achieves the required adjustment of levels with the use of only resistance pads and hybrid coils, which may be efficient from a transmission standpoint. No apparatus requiring maintenance is used. Moreover, the allocation of frequencies to the various channels is such as to enable the use of standard terminal apparatus thereby avoiding the design of special filters or other apparatus. The pads may be of ordinary resistance, either T-type, H-type or square configuration, depending on the type of circuit to which they are connected, and consist of fixed or adjustable resistances.

It will be understood that the specific values given are by way of illustration and are not to be considered as limiting. The configurations given are likewise by way of example and are not to be considered as limiting the invention, the scope of which is defined in the claim.

What is claimed is:

In a multiplex carrier transmission system, a multiplex line incoming to an intermediate station and a multiplex line outgoing from said station, incoming channels on said incoming line arriving in said station at relatively high level, outgoing channels on said outgoing line emerging from said station at low level, another channel at said station at higher level than said outgoing channels, and means to connect certain of said incoming channels on said incoming line to said outgoing line for through-transmission and simultaneously to connect said other channel to said outgoing line comprising a three-way transformer having two mutually conjugate pairs of terminals and a third pair of terminals, a first circuit branch connecting one of said mutually conjugate pairs of terminals to said certain of said incoming channels, a second circuit branch connecting the other pair of mutually conjugate pairs of terminals to said other channel, and a third circuit branch connecting said third pair of terminals to said outgoing line, and resistance means in said first and second circuit branches for independently reducing the level of the channels in said respective branches to the same level in said third circuit branch.

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