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INTERCONNECTION OF TRANSMISSION LINES

Filed June 9, 1934

FIG. 1

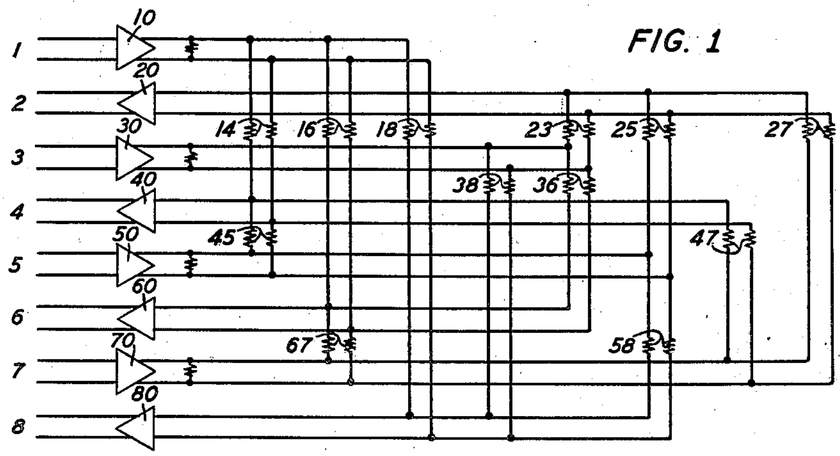


FIG. 2

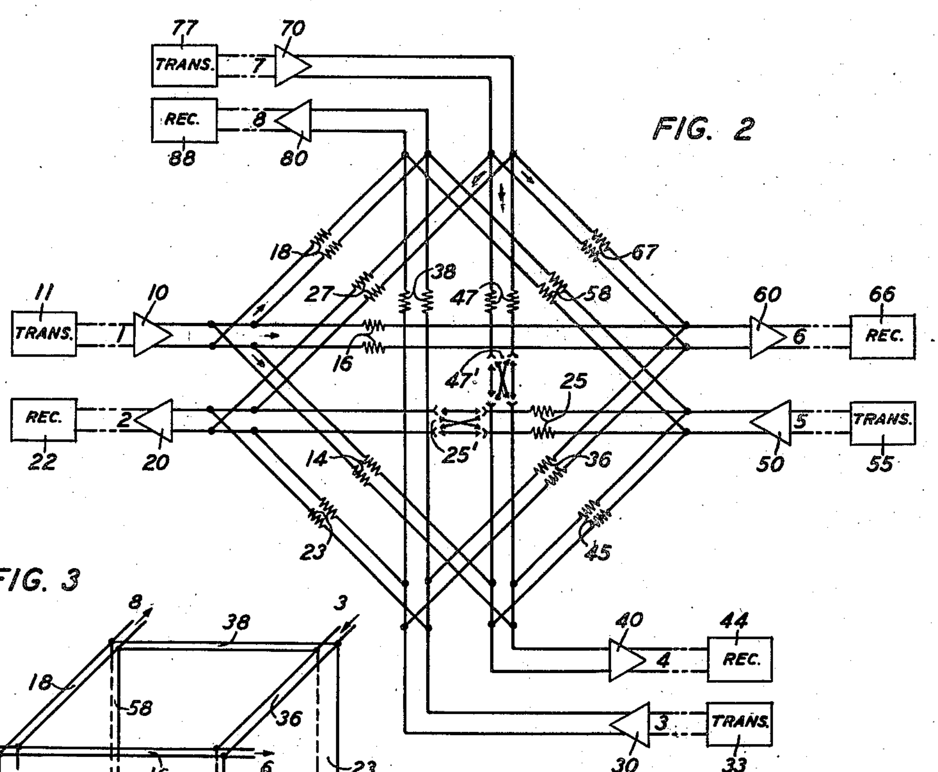
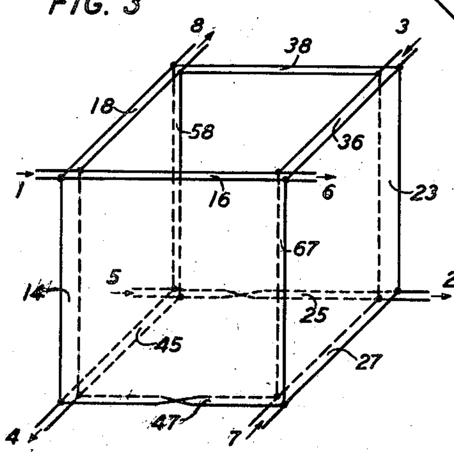


FIG. 3



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INTERCONNECTION OF TRANSMISSION LINES

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3 Claims. (Cl. 178—44)

The present invention relates to the interconnection of a plurality of pairs of transmission circuits so that each pair is enabled to transmit to and receive from each other pair of circuits.

An object of the invention is to interconnect a number of pairs of circuits or lines in mutually communicative relation while maintaining a high loss between a given transmitting circuit and the receiving circuit with which it is paired.

The lines so interconnected may carry any type of currents or waves such as speech, music or visual image currents. The invention has particular application to situations in which it is desired to associate several four-wire circuits so that each transmitting line may transmit into all the other receiving lines except its own receiving line, and as to that it is practically conjugate. The invention provides a simple and direct method of accomplishing this result by use of simple attenuators which may be directly connected to the several lines as will be described.

The drawing comprising Figs. 1, 2 and 3 shows three ways of representing the same interconnecting scheme for four four-wire lines (except for minor differences to be noted hereinafter), different representations being used to enable the invention to be more readily understood.

In order not to complicate the description and drawing, it is assumed that but four four-wire lines are to be interconnected, but as will be pointed out, the invention is not limited to any particular number of lines.

The lines to be interconnected are numbered 1 to 8 in the drawing, lines 1, 3, 5 and 7 being transmitting lines, while 2, 4, 6 and 8 are receiving lines. Lines 1 and 2 constitute the two sides of the same four-wire circuit and for convenience will be referred to as one pair of lines. Other four-wire circuits comprise the pair 3, 4, the pair 5, 6, and the pair 7, 8. Transmitters 11, 33, 55 and 77 are shown (Fig. 2) connected to lines 1, 3, 5 and 7 respectively; and receivers 22, 44, 66 and 88 are connected to receiving lines 2, 4, 6 and 8.

As stated above, waves originating in a given transmitter, as 11, after pasing over line 1, are to be sent into receiving circuits 4, 6, and 8 with preferably equal facility, but are to be eliminated from line 2, which means practically that they are to be as effectively suppressed in line 2 as is consistent with the cross-talk restrictions that may be imposed on the system. Amplifiers 10, 20, 30, etc. are shown connected in respective lines 1, 2, 3, etc. The waves in line 1 after amplification (if desired) at 10 are directly impressed on lines 4, 6 and 8 through respective attenuators 14, 16 and 18. The line 1 may have a suitable resistance bridged across it as shown at the output of amplifier 10.

Considering further the transmission from line 1, it will be observed that paths exist from line 1 to line 2 as follows, taking the attenuators in order: 18, 58, 25; 18, 38, 23; 16, 67, 27; 16, 36, 23; 14, 47, 27; 14, 45, 25 comprising six paths, each of which includes three attenuators in tandem. Each of the paths so traced includes two line junctions besides the junction at line 1 and that at line 2. Other paths exist from line 1 to line 2 comprising more than three attenuators in series, e. g. such a path as 18, 58, 45, 47, 27, but these paths contribute so little to the transmission from line 1 to line 2 that they may be neglected in comparison with the three-pad paths above traced.

If the losses in the attenuators are high, the total transmission from line 1 to line 2 may be made negligibly small.

In one example used by applicants, each attenuator comprised 30,000 ohms divided between the two sides of the circuit, and the lines 1, 2, 3, etc. were adjusted (using shunts when necessary) to 600 ohms as seen looking into the line at a junction point. Under these circumstances, the attenuator loss was 40 decibels in direct transmission from line 1 to line 4 or line 6 or line 8. The six principal parallel paths from line 1 to line 2, as given above, each had a loss of 120 decibels, or in combination, a resultant loss of 104 decibels. If amplifier 80 has a gain of 40 decibels, the waves impressed on line 8 after having traversed attenuator 18 and amplifier 80 have the same amplitude as they had at the output terminals of line 1. But the cross-talk into line 2 from the shunt paths was, as given above, 104 decibels down, minus the 40 decibels gain of amplifier 20, or 64 decibels down from the level of outgoing transmission in line 1.

Since the circuit configuration is entirely symmetrical, the transmission between other lines is entirely similar to that described above with respect to line 1 as transmitting line.

In some cases, for example, in the case of open-wire lines, it may be undesirable to use such high loss in the attenuators as in the example given above. In such cases, or in any case, it is advantageous, in order to keep the cross-talk volume at a suitably low value, to use transpositions at appropriate points in the interconnecing paths. Two such transpositions are indicated in Fig. 2 at 25′ and 47′ as alternative to the straight wire connections. If now the six paths from line 1 to line 2 be retraced, as above, it will be found that three of these paths include one of the transpositions 25′ or 47′ and the other three paths do not have a transposition in them. Thus, the resultant transmission through these sets of three paths tends toward zero.

Fig. 3 helps in perceiving the conjugacy that exists between any two lines of the same four-wire circuit, e. g., lines 1 and 2 which are at opposite "corners" of the cube diagram here represented. For simplicity the attenuators have been omitted from this figure. Transmission from line 1 to line 4, 6 or 8 is accomplished by passing alone one "edge" of the cube. Transmission from line 1 to line 2 through three edges in series is possible by the six paths that are traced above, e. g., 1—6—7—2; 1—8—3—2; 1—6—3—2; 1—8—5—2; 1—4—7—2; and 1—4—5—2. The first three paths contain no transposition, while the last three each contain one transposition.

The two transposition points, as shown, are not in exact symmetry but this is of no practical consequence except in cases where the attenuator losses become quite low. In those cases it is found that this slight dissymmetry can be compensated by increasing the losses in the attenuators of certain of the paths. With two transpositions located, as shown, and with attenuators of 800 ohms in each side of the path, and a line impedance of the order of 650 ohms, it was found that if each 800 ohm resistor in the paths 1—8, 3—6, 2—7 and 4—5 was increased to about 860 and 870 ohms, (the exact value was not critical) the loss could be made the same (about 14.7 decibels), for each direct transmission path of the system, that is from each transmitting line to the several receiving lines of other pairs of lines.

In another case, with the two transpositions, where the attenuators were all alike and comprises 5545 ohms in each side of each path with a shunt resistor of 850 ohms across each line junction with a line impedance of 700 ohms, the loss in transmission was about 30.2 decibels for all direct transmission paths through the interconnecting system.

While the invention has been disclosed as applied to a system of four four-wire lines, it is not limited to any particular number of lines, but may be applied to three, four or more than four such lines. The four-line system is not inconveniently complicated, however, and in some cases other considerations, such as traffic requirements, may dictate the use of two or more of the four-line networks, such as herein disclosed, connected to each other to accommodate a total of more than four four-wire lines, instead of an extension of the four-line scheme of connections to a five or more line basis. The manner of connection can be readily seen by imagining a second cube diagram alongside of Fig. 3, with the circuits 1 and 2 of Fig. 3 connected to diagonally opposite corners of the new cube, with amplifiers in these two connecting lines if desired. The other corners of the second cube would be connected to sending and receiving lines as in Fig. 3. In this case, circuits 1 and 2 would not connect to actual lines but would serve only to interconnect the two cubes, which together would then accommodate a total of six four-wire circuits.

While reference has been made throughout to four-wire lines, it is to be understood that any pair of lines, such as 1 and 2, may lead to a two-wire junction such as the usual hybrid coil connection commonly employed for such purpose, and the actual transmission to and from a distant point might, in that case, take place over the two-wire line for the most part.

What is claimed is:

1. In combination, a plurality of pairs of circuits each pair comprising a transmitting circuit and a receving circuit, means interconnecting said circuits to enable each transmitting circuit to transmit to all the receiving circuits of the other pairs, comprising an individual attenuating path connected from the transmitting circuit of each pair directly to the receiving circuit of each other pair, certain only of said paths containing a transposition, the loss in the attenuating paths being proportioned with respect to the circuit impedances such that the loss between transmitting and receiving circuits of the same pair is of a higher order of magnitude than that between transmitting and receiving circuits of different pairs.

2. An interconnecting circuit for more than two pairs of lines, each pair consisting of a transmitting line and a receiving line, comprising connections from the transmitting line of each pair to the receiving lines of other pairs, certain of said connections including a transposition such that resultant transmission between lines of the same pair through certain combinations of said connections that contain no transposition is opposed by resultant transmission between said pair of lines through combinations of the same connections that contain transpositions.

3. An interconnecting circuit for four pairs of lines, each pair consisting of a transmitting line and a receiving line, comprising connections from the transmitting line of each pair to receiving lines of the other three pairs, two of said connections being transposed such that of the six principal cross-talk paths between lines of any one pair, three are traceable through one of the transpositions while the other three contain no transposition.

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