

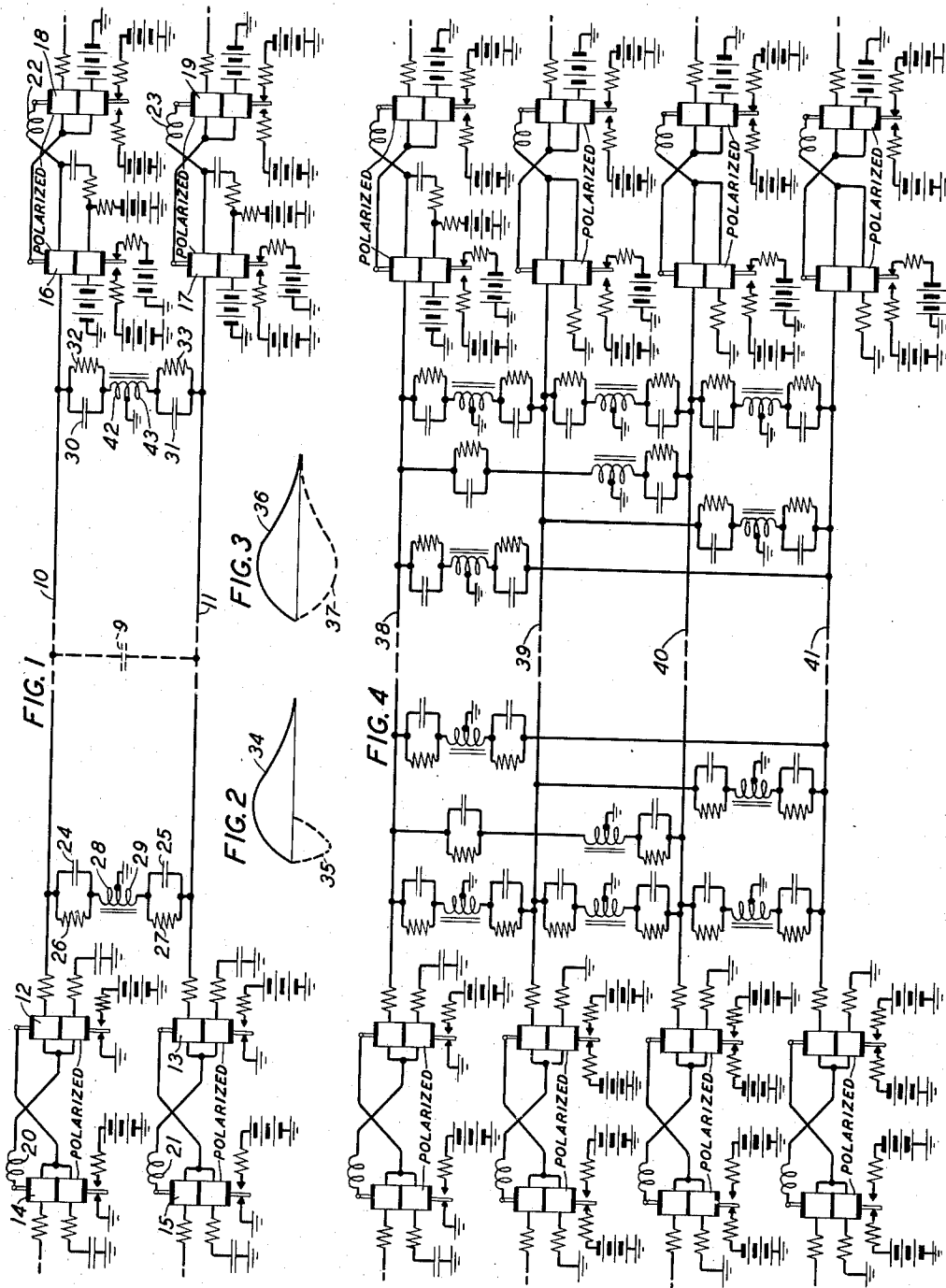
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NEUTRALIZING ARRANGEMENT FOR TELEGRAPH CIRCUITS

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NEUTRALIZING ARRANGEMENT FOR
TELEGRAPH CIRCUITS

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This invention relates to electrical communication systems and more particularly to means for reducing interference in telegraph circuits. It is an object of this invention to provide an improved circuit arrangement for reducing interference, usually called cross-fire, encountered between adjacent telegraph circuits.

The present invention relates to an improvement in the cross-fire reducing arrangement disclosed in U. S. Patent 1,580,191, J. M. Fell, April 13, 1926, which is capable of substantially neutralizing the cross-fire encountered between the individual wires of cable pairs without interfering with the transmission over the wires.

The coupling between the individual wires of cable pairs, due to the electrostatic capacity between the wires, is much greater than the coupling between adjacent open wire telegraph lines or circuits. While the arrangement described in the above-identified patent is satisfactory for neutralizing cross-fire current between adjacent open wire telegraph lines, it is not satisfactory for compensating or neutralizing cross-fire between the individual wires of a cable pair.

It is the object of the present invention to provide an improved cross-fire neutralizing arrangement which is satisfactory for neutralizing the cross-fire currents encountered between the individual conductors of cable pairs.

Another object of this invention is to provide cross-fire neutralizing means suitable for use between the individual wires of a cable quad.

Briefly, in accordance with this invention, a network is connected between each of the wires and ground or between each end of each of the wires and ground. The network is designed to pass substantially the same proportion of all of the telegraph frequencies as transmitted by the line. The networks connected to the two conductors of the pair at each end are coupled together so that an opposing potential is induced in either one during transmission over the other conductor. The induced potential or current is in such a direction as to counteract, balance, or neutralize the cross-fire currents received through the capacity between the conductors.

The foregoing objects and other objects and features of this invention, novel features of which are specifically set forth in the claims appended hereto, may be fully understood from the following description when read with reference to the attached drawing in which:

Fig. 1 shows a typical telegraph system to which a neutralizing arrangement in accordance

with a preferred embodiment of this invention is applied;

Fig. 2 illustrates the type and degree of compensation obtained with the networks of the prior art;

Fig. 3 shows the compensation with the networks designed in accordance with this invention; and

Fig. 4 shows the manner in which the compensating networks in accordance with this invention may be applied to the individual wires of a cable quad.

Fig. 1 shows a typical telegraph system in which two separate and independent telegraph circuits, or channels, are operated over adjacent wires. Due to the fact that the wires are adjacent, they have considerable distributed capacity between them. This capacity is represented in Fig. 1 by the dotted condenser 9. Condenser 9 is intended to represent not only distributed capacity but any other capacitive coupling between the line wires. When telegraph impulses are transmitted over either of the lines, a certain amount of the current leaks off or is transmitted through the capacity 9.

In the system shown in Fig. 1, the transmission over lines 10 and 11 is of the type disclosed in U. S. Patent 2,131,870, W. W. Cramer, October 4, 1938. It is to be understood, however, that any other suitable type of telegraph transmission may be employed, such as the usual duplex telegraph systems. Furthermore, these other types of systems may be employed upon either or both of the conductors 10 and 11. It is not essential that the same type of transmission be provided over both circuits which operate over the adjacent wires.

As long as wires 10 and 11 are open wire lines, the distributed capacity 9 is relatively small so that the cross-fire currents are likewise small. In addition, telegraph signaling currents of appreciable magnitude are transmitted over the open wire lines. Consequently, the cross-fire currents are quite small compared to the received signaling impulses and do not, therefore, seriously interfere with the telegraph transmission except under unusual circumstances. The arrangement shown in U. S. Patent 1,580,191 is suitable for further reducing the small effect of the cross-fire current in open wire lines. However, when it is attempted to operate two telegraph channels over the individual wires of a cable pair, the cross-fire currents are much greater in proportion with the signaling currents, first, because a distributed capacity and conductance illustrated

by condenser 9 between the individual wires of the cable pair are much greater and, consequently, produce a much greater effect upon the receiving signaling impulses. In addition, the magnitude of signaling current which may be transmitted over the individual conductors of a cable is much less than may be transmitted over an open wire line. Consequently, the effects of the cross-fire currents are much greater.

When it was attempted to neutralize these currents by means of the network shown in Fig. 1 of the above-identified Fell patent, it was found that if the constants of a network were so adjusted as to substantially neutralize or even to materially reduce these cross-fire currents, the network disturbed the transmission to such an extent that it was impossible to satisfactorily transmit telegraph impulses over the lines. Curve 34 of Fig. 2 shows the wave form of typical cross-fire currents usually encountered in telegraph systems. Curve 35 represents a typical wave form of the neutralizing potential applied to the opposite line to counterbalance the cross-fire currents in the system disclosed in the above-identified patent to Fell when it is adjusted to permit reasonably satisfactory transmission over the respective telegraph lines or systems. As may be readily seen, curve 35, which represents the neutralizing potential, is in no way comparable to the wave form of the cross-fire currents and, hence, is incapable of satisfactorily neutralizing these currents.

Thus, the system disclosed in the Fell patent does not satisfactorily meet the following two conditions simultaneously when the cross-fire currents approach the magnitude encountered between the individual wires or conductors of cable pairs. These conditions are: (1) that the network should not materially interfere with the transmission of the telegraph signaling impulses over one wire and (2) that, at the same time, it should substantially neutralize the cross-fire currents induced in the other wire of the pair or in the other wires of the quad.

In accordance with the present invention a network comprising a resistance 26 in parallel with the condenser 24 is connected between each of the wires 10 and 11 and ground. In accordance with this invention this network may be provided any place along the wire. In the preferred embodiment of this invention a network of this type is connected between each end of each of the wires of a pair and ground. This network is designed to have an impedance characteristic similar to the impedance characteristic of the line to which it is connected so that it will pass or transmit substantially the same percentage of each of the component currents or frequencies as transmitted by the line to which it is connected. The impedance of this network need not be substantially equal to the impedance of the line and in a preferred embodiment of this invention will not be equal to the impedance of the line but will probably have a higher impedance than the impedance of the line. However, the network is designed so that it does have the same impedance characteristic as the line, that is, the ratio of its impedance to the impedance of the line will be substantially the same for all of the component frequencies transmitted over the line. Thus, by connecting this network between the line and ground, the wave form or shape of the telegraph impulses transmitted over the line will not be materially altered by the network other than perhaps a slight reduction in

magnitude. This network will not, therefore, add any appreciable distortion to the signals transmitted over the main line.

It should be noted that this network provides a direct current path between the line and ground. It has been previously thought that this would shunt or drain off too much of the direct current flowing over the line and, thus, materially interfere with the transmission of the telegraph signaling impulses. It has been discovered, however, that this direct current path is essential to the proper operation of this invention and that in draining off a small amount of the direct current, it does not materially reduce the length of line over which the signals may be transmitted. Instead, it has been discovered that this direct current path is essential in order for the network to pass substantially the same percentage of each of the component currents as pointed out above. Since direct current is one of the component currents transmitted over the main line or channel, the network should be arranged to transmit or pass the proper percentage of the direct current.

By suitably coupling the two networks connected from each of the wires of a cable pair it has been discovered it is possible to substantially neutralize the cross-fire currents encountered between the individual wires or conductors of cable pairs and thus materially improve the transmission characteristics of these individual wires. Inasmuch as the same percentage of each of the component currents pass through the network as passes over the line, the same neutralizing currents or potentials may be applied to the other wire of the pair as flows through the mutual coupling due to the capacity between the wires. Thus, it is possible to substantially neutralize each of the components of the cross-fire currents induced in the other wire of the pair.

It is to be understood that this invention is not limited to the specific network shown and described herein, but includes such additional networks as will fulfill the two requirements pointed out above, namely, that it has the same frequency characteristic to ground as the main line so that it will pass substantially the same percentage of each of the component currents as passes over the main line and that it will apply neutralizing or balancing potentials to the other wire of the pair for each of the component currents or frequencies of the cross-fire currents so as to substantially neutralize all of the cross-fire currents.

When a network in accordance with this invention is employed to neutralize cross-fire currents, the neutralizing potential has a wave form similar to that illustrated in curve 37 of Fig. 3. As may be readily seen from Fig. 3, this induced potential is substantially equal in magnitude to the cross-fire currents but in opposition thereto so that it will substantially neutralize these cross-fire currents.

It should be noted that when one of the lines is transmitting, assume, for example, the left-hand station connected to line 10 is transmitting impulses to the right-hand station connected to line 10, certain cross-fire current will be received by the receiving relay 13 connected to the left-hand end of line 11 and also by relay 17 connected to the right-hand end of line 11. The cross-fire currents received by relay 13 at this time are usually called near-end cross-fire currents while the cross-fire currents received by re-

lay 17 are usually called far-end cross-fire currents. It has been discovered that to neutralize the near-end cross-fire currents requires a network having slightly different constants than the network required to substantially neutralize all of the near-end cross-fire currents. However, the difference is not great and a compromise value for the constants of these networks may be easily obtained which provides substantially complete neutralization of the cross-fire currents between the individual wires of a cable pair.

Due to the fact that the pairs are twisted and interchanged at quite frequent intervals so that the wires of the different pairs are not adjacent to each other for any considerable distance within the cable, the distributed capacity and conductance between the individual wires of different pairs are quite small so that the effects of cross-fire currents between these circuits may usually be neglected.

There is an exception, however, in the case of quads wherein two pairs are twisted about each other and remain adjacent to each other for substantially the entire length of the cable. In this case, the distributed capacity or conductance between each of the individual conductors of the quad, as well as the conductance between the individual conductors of each pair of quads, is appreciable and causes a considerable amount of cross-fire interference between the various individual wires of the quad. It is, therefore, necessary to provide additional neutralizing networks between each of the wires of the quad in addition to the neutralizing networks required between the individual wires of each pair of wires of the quad. This arrangement is shown in detail in Fig. 4 of the drawing wherein a pair of networks is connected between each of the wires of each pair of the quad and additional pairs of networks are connected between each of the other wires of the quad, that is, between each wire of one pair and both wires of the other pair.

As pointed out above, the transmission over each of the wires need not necessarily be of the same type. Thus, the transmission over one wire, for example, wire 38 of Fig. 4, may be in accordance with the transmission system described in the above-identified patent to Cramer. The transmission over the wires 39 and 40 may be of the usual differential duplex type of transmission and transmission over wire 41 may be of the so-called upset duplex type of transmission in which the potentials at one end of the line are reversed from that usually employed in the differential duplex transmission systems. While two differential duplex transmitting systems have been shown operating over wires 39 and 40, these wires may or may not be wires of one of the pairs of the quad. Wire 39 may be a wire of one pair of the quad and wire 40 one wire of the other pair of the quad. Irrespective of the par-

ticular type of telegraph transmission system which operates over any of these wires, the operation of the network in balancing out or reducing the effects of the cross-fire currents is substantially the same as described above.

It is to be understood that the invention is not limited to the specific embodiment shown in the drawing but is applicable generally to the telegraph systems generally employed for the transmission of telegraph signaling impulses.

What is claimed is:

1. In a grounded telegraph system, the combination of two grounded telegraph circuits operating over adjacent telegraph lines, leak circuits individual to and connected between each of said telegraph lines and ground, means for mutually coupling said leak circuits together, and a network connected in said leak circuit having substantially the same impedance characteristics as the line to which it is connected and providing a direct current path through said leak circuit.

2. In a grounded telegraph system operating over the conductors of a cable quad, means for reducing the interference between the circuits operating over the individual conductors of the quad which comprises a pair of networks connected between each set of two wires of the quad, each set comprising any two conductors of the quad, and means for mutually coupling each of said networks to the other network of the respective pair to balance out the interference induced in the other conductors due to the transmission of signals over any conductor of the quad and a direct current path included in each of said networks between ground and the conductor to which said network is connected.

3. In a grounded telegraph system, the combination of two grounded telegraph circuits each connected to one of the wires of a cable pair, a network individual to and connected between each of said wires and ground including a direct current path, and means for inductively coupling said networks together.

4. In combination, a pair of cable conductors, a first telegraph system connected to one of the conductors of said pair, a second telegraph system connected to the other conductor of said pair, a leak circuit individual to each of said conductors and connected between its respective conductor and ground, a network connected in said leak circuits having substantially the same impedance characteristics as the conductor to which it is connected including a direct current path through the leak circuit from the conductor to ground, and means for so inductively coupling said leak circuits together that interfering currents caused to flow in one of said conductors, due to the operation of the telegraph system connected to the other of said conductors, are substantially neutralized.

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