

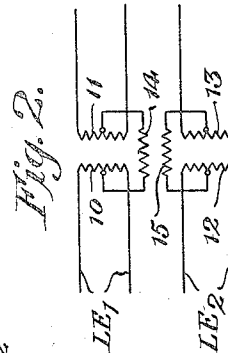
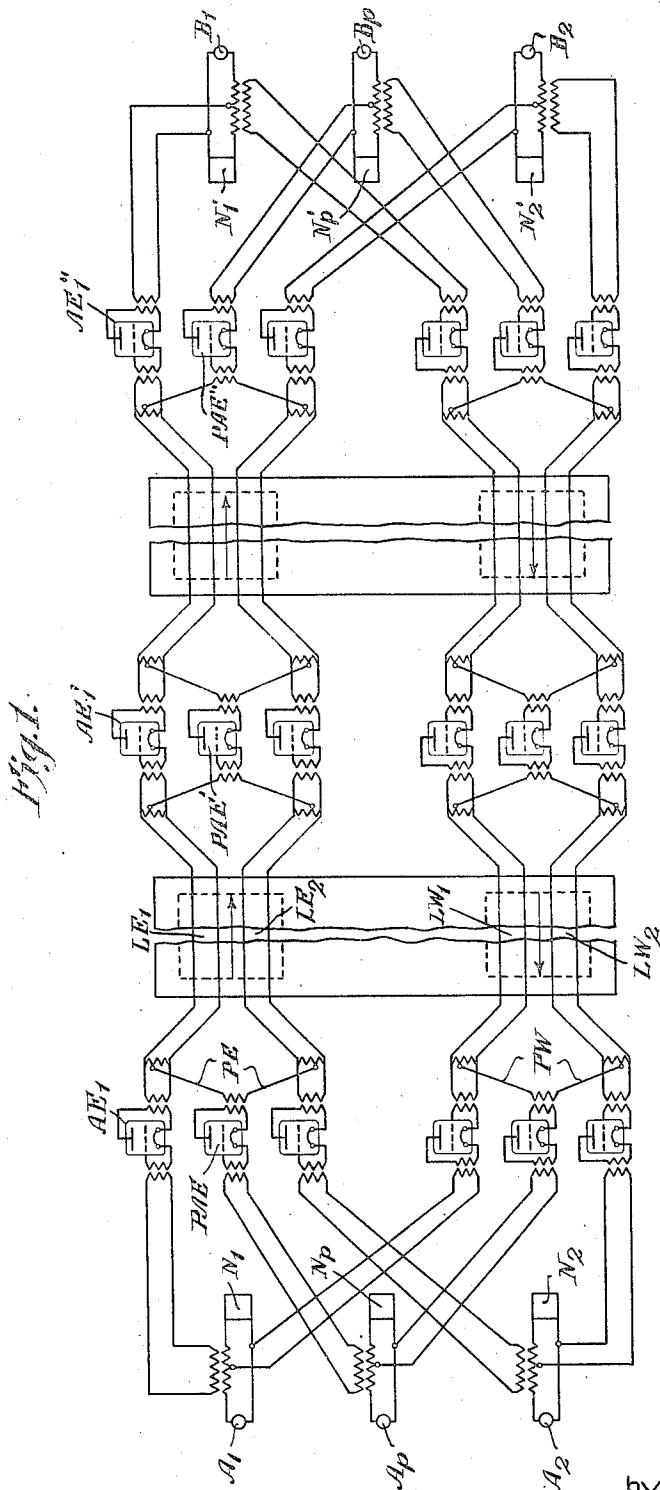
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DECREASING CROSS TALK IN PHANTOM CIRCUITS

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DECREASING CROSS-TALK IN PHANTOM CIRCUITS.

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To all whom it may concern:

Be it known that I, KUNO FISCHER, a citizen of the German Realm, residing at Charlottenburg, Germany, have invented certain new and useful Improvements in Decreasing Cross-Talk in Phantom Circuits, of which the following is a specification.

This invention relates to telephone transmission circuits, and more particularly to an arrangement of circuits whereby the so-called cross-talk effect may be reduced.

In telephone cables at the present time, the conductors are arranged in so-called "quads," consisting of four conductors of which one pair forms one two-way transmission circuit and the other pair forms another two-way transmission circuit, these two circuits being usually denominated "side circuits." By the use of phantom resistances or choke coils, a third effective circuit may be obtained from the two side circuits. This is accomplished by arranging the circuits so that the two conductors forming one side circuit act in parallel to form one conductor of the third, or so-called "phantom" circuit, while the other pair of conductors constituting the other side circuit act in parallel to form the return path for the phantom. The phantom, like the side circuits, is operated as a two-way transmission path, that is, transmission may take place over the circuit in both directions.

It has been the practice to twist the conductors forming each side circuit together to reduce cross-talk in the side circuit and also to twist the pair of conductors together to reduce cross-talk in the phantom. A similar thing is done in overhead lines by transposing pairs of conductors. While this method serves to reduce the cross-talk to some extent, it has not been entirely satisfactory. In accordance with the present invention, therefore, it is proposed to so arrange matters that outgoing and incoming conversations will take place over pairs of conductors belonging to different quads, at the same time taking care that both side circuits of a given quad are used for transmission in the same direction. This involves operation upon a four-wire basis as distinguished from two-wire operation, since four conductors are necessary for a complete two-way transmission channel, one pair being used for transmission in one direction and

the other pair being used for transmission in another direction.

With respect to the phantom circuit, the invention contemplates operating in such a manner that the phantom made up from the conductors forming two side circuits of a quad will act as one side of a four-wire circuit, a similar phantom of another quad constituting the other side of the four-wire circuit, so that one phantom will be used for transmission in one direction and another phantom for transmission in the reverse direction. The phantom of a particular quad should be so arranged as to transmit in the same direction as the two side circuits of the quad.

If, with matters thus arranged, the various quads which are used for transmission in the same direction are electrically isolated from quads transmitting in the opposite direction, the amount of cross-talk will be very greatly reduced. In order to understand why the cross-talk is reduced, let us consider two adjacent lines, one of which is transmitting in one direction and the other of which is transmitting in the opposite direction. In both cases the currents impressed upon the line at one end are greatly attenuated upon reaching the other end. Consequently the cross-talk induced in the receiving end of one line from the currents of considerable amplitude which are impressed upon the adjacent transmitting end of the other line, may have values comparable with and even greater than the attenuated currents which are being received from the transmitting end of the same line. Upon the other hand, if the two adjacent lines are operated so that transmission takes place in the same direction, the cross-talk effect must necessarily be much smaller than the currents actually transmitted over the line, for with respect to a given line the current normally flowing therein will be comparable in magnitude to the current in the adjacent line which induces the cross-talk, and this holds true at any point along the line. Consequently it follows that by grouping circuits so that both the side circuits and the phantoms of one group transmit in one direction while the side circuits and the phantoms of the other group transmit in the other direction, the cross-talk produced in any circuit of a group due to induction from an-

other circuit in the group will be of much less consequence than the cross-talk induced by a circuit transmitting in the other direction.

- 5 Cross-talk of the latter variety, which is known as "near end" cross-talk, may be practically eliminated or at any rate greatly reduced by the segregation of the two groups of circuits. The method by which the electrical segregation of the groups is obtained is well known in the art. For example, in a cable the conductors of one group may be "shielded" from those in the other group in any one of a number of ways. In the case of open-wire circuits, the two groups may be arranged upon opposite ends of the cross-arms so that they are physically separated from each other.

- 20 The invention may now be more fully understood by reference to the following description when read in connection with the accompanying drawing, Fig. 1 of which is a simplified circuit diagram illustrating the principles of the invention, and Fig. 2 of which is a detail showing how loading may be applied to the side and phantom circuits of Fig. 1.

- Referring to Fig. 1, two sets of quads are shown. Two conductors of one quad constitute a line LE_1 arranged for transmission from west to east between stations A_1 and B_1 . Two conductors of the other quad constitute a line LW_1 arranged to transmit from east to west between stations B_1 and A_1 . In a similar manner the other two conductors of the first quad constitute a line LE_2 for transmitting from west to east between stations A_2 and B_2 , while the remaining pair of conductors of the other quad constitute a line LW_2 for transmitting from east to west between the stations B_2 and A_2 . It will thus be seen that we have two complete four-wire circuits so arranged that the conductors of each quad all transmit in the same direction.

- As is usual in four-wire circuits, one-way amplifiers are included in the lines transmitting in a given direction. For example, amplifiers AE_1 , AE_1' and AE_1'' are schematically illustrated in connection with the line LE_1 , and similar amplifiers are illustrated in connection with the other lines. The lines LE_1 and LW_1 , constituting one four-wire circuit, are connected through the usual hybrid coil at each terminal to the terminal line leading to the stations A_1 and B_1 respectively. The terminal lines are balanced by artificial lines or networks N_1 and N_1' at the two terminal stations, so that the lines LE_1 and LW_1 are substantially conjugate with respect to each other. In a similar manner, the conductors LE_2 and LW_2 are connected to the terminal lines leading to the stations A_2 and B_2 .

A phantom circuit PE is obtained from the four conductors constituting the lines LE_1 and LE_2 of the one quad by means of drops taken from the midpoints of choke coils or resistances bridged across the side circuits as indicated. Similar phantom connections are made at each repeating point, so that a one-way phantom circuit may be obtained in which amplifiers PAF, PAF' and PAF'' are inserted as indicated. This phantom circuit operates to transmit from station A_p to station B_p in a direction from west to east. A similar phantom circuit PW may be obtained from the conductors of the other quad and may be provided with one-way amplifiers for transmitting in a direction from east to west between terminal stations B_p and A_p . The two phantom lines are connected through hybrid coils to the terminal lines in a manner similar to that described in connection with the side circuits and are rendered substantially conjugate by balancing the terminal lines with suitable networks N_p and N_p' . As will be noted, the phantom circuits are arranged to transmit in the same direction as the side circuits from which they are formed, and one complete four-wire phantom conducting system involves eight individual conductors. Assuming that the quads are electrically segregated, it will be apparent that the cross-talk in line LE_1 , for example, will be that induced from a line such as LE_2 transmitting in the same direction and will consequently be much smaller in magnitude than the normal currents transmitted over the line LE_1 . The cross-talk induced by a line transmitting in the opposite direction, such, for example, as the line LW_2 , may be made negligible by the electrical segregation of the circuits. The same holds true with respect to the phantom. For example, the only cross-talk with which we need be concerned in the case of the phantom PE is cross-talk induced by other phantoms transmitting in the same direction, it being assumed that all phantom circuits transmitting in the opposite direction are electrically segregated from those transmitting in the same direction as the phantom PE. By this method of operation the cross-talk problem is reduced to "far end" cross-talk only, the "near end" cross-talk being reduced by the grouping of the circuits. Owing to its relatively small magnitude, the far end cross-talk will be fully taken care of by the twisting of the conductors in the usual manner. At first thought it might seem that the system herein disclosed involves a prodigious waste of conductors in order to obtain a reduction in the cross-talk, since it involves four conductors for each fundamental circuit and eight conductors for each phantom. Upon closer analysis, however, it

will be seen that the arrangement is quite economical as compared with the ordinary system in which transmission takes place in two directions over the same circuit. In the first place, two-wire operation involves the use of the 22 type of repeater, so that the lines must be balanced at each repeater point, and, furthermore, since it is not possible to effect a perfect balance of the lines, the gain which may be obtained from each repeater is limited by the tendency of the repeater to sing as soon as the amplification is increased beyond a certain point. Practically, it has also been found that a limited number of intermediate amplifiers (usually not more than 5) can be inserted in tandem in the same circuit. Two-wire operation also involves a duplication of the band filters used in connection with repeaters at each repeater point.

The four-wire circuit requires in contrast to the two-wire circuit balancing of the line at each terminal only. No balance is required at the intermediate repeater points for the reason that one-way amplifiers may be employed. The amplifiers may be adjusted to obtain their maximum gain, therefore, without producing singing at the repeater point. No singing can take place in the four-wire circuit so long as the total attenuation in the loop formed by the two sides in the four-wire circuit is equal to or greater than the total amplification in the loop. Consequently, with the same number of amplifiers it is possible to use conductors of smaller diameter, the amplifiers permitting (because of their greater gain) a greater attenuation between repeater points. It has been found in practice that, by the use of the four-wire principle, six wires of the total number of eight wires for the phantom may be obtained without using any more copper than would be necessary for the four wires used in the phantom when operated in the ordinary manner with 22 repeaters. The additional cost of the remaining two wires of the phantom is made up in the majority of cases by the elimination of a large number of balancing adjustments at the repeater points and by the elimination of the additional band filters, etc., required.

There remains to be considered the matter of loading the circuits. For four-wire operation, the side circuits may be loaded in the same manner as in the case of two-wire operation, and the usual methods may also be employed for loading the quad. For example, the phantom path transmitting in one direction and comprising the four conductors of a quad, may be arranged at the loading point as illustrated in Fig. 2 in which windings 10 and 11 may be taken as the windings of a ring transformer for coupling two adjacent loading sections of one

side circuit, and the windings 12 and 13 may be taken as the windings of a similar ring transformer for coupling the adjacent loading sections of another side circuit. Drops are taken off at the midpoints of the windings as indicated, and the windings 14 and 15 of another ring transformer may be included in the drops for the purpose of loading the phantom.

It will be obvious that the general principles herein disclosed may be employed in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. An arrangement for decreasing cross-talk in telephone lines comprising a quad of four conductors arranged to form two side circuits and a phantom circuit, and means whereby transmission takes place over each of the side circuits and over the phantom circuit in one and the same direction only.

2. An arrangement for decreasing cross-talk in telephone lines comprising a quad of four conductors arranged to form two side circuits and a phantom circuit, means for transmitting in one and the same direction only over each of the side circuits and over the phantom circuit, and a one-way return path for each side circuit and for the phantom circuit for transmission in the opposite direction, said return paths comprising conductors of quads other than said first mentioned quad.

3. An arrangement for decreasing the cross-talk in telephone lines comprising a quad of four conductors arranged to form two side circuits and a phantom, a second quad of four conductors also arranged to form two side circuits and a phantom, means whereby both side circuits and the phantom of said first mentioned quad will transmit in one and the same direction only, means whereby the two side circuits and the phantom of the second quad transmit in the opposite direction only, and means whereby each of the three transmission paths formed from one quad may be associated with a corresponding transmission path in the other quad to form a complete two-way transmission channel.

4. An arrangement for decreasing cross-talk in telephone lines comprising a plurality of quads of four conductors each, each quad being arranged to form two side circuits and a phantom circuit, means whereby the quads may be arranged in two groups electrically segregated from each other, means to permit transmission to take place over the side circuits and the phantom circuits of the quads in one group in one and the same direction only, means to permit transmission to take place over the side

circuits and phantoms of the quads in the other group in the opposite direction only, and means to associate each transmission path in the one group with a corresponding transmission path of the other group to form two-way transmission channels.

5. A telephone cable comprising a plurality of quads of four conductors each, said quads being arranged to form side circuits and phantom circuits, the various quads in the cable being arranged in two

groups, means to shield the quads in one group from the quads in the other group, means to permit transmission in one and the same direction only over the side circuits and the phantom circuits of one group, and means to permit transmission in the opposite direction only over the side circuits and phantom circuits of the other group.

In witness whereof, I have hereunto set my hand this 8th day of June, 1923.

KUNO FISCHER.