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SYSTEM FOR TRANSPOSITION OF CONDUCTOR SETS IN CABLES

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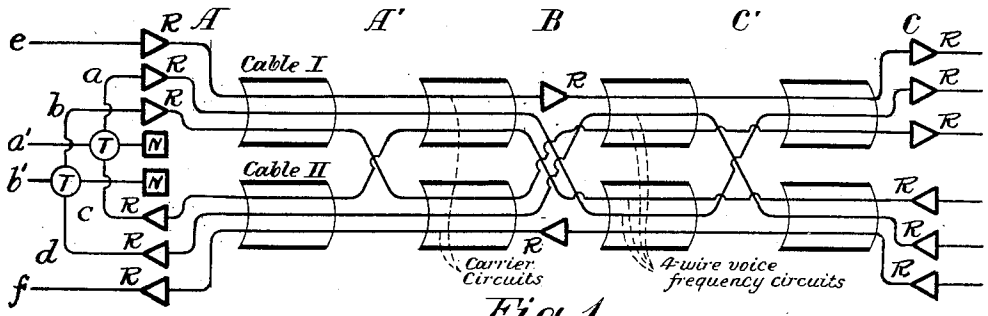

Fig. 1

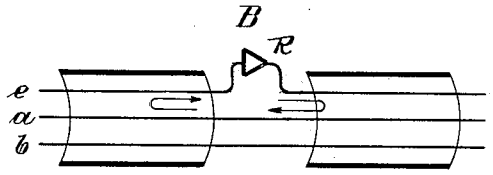

Fig. 2

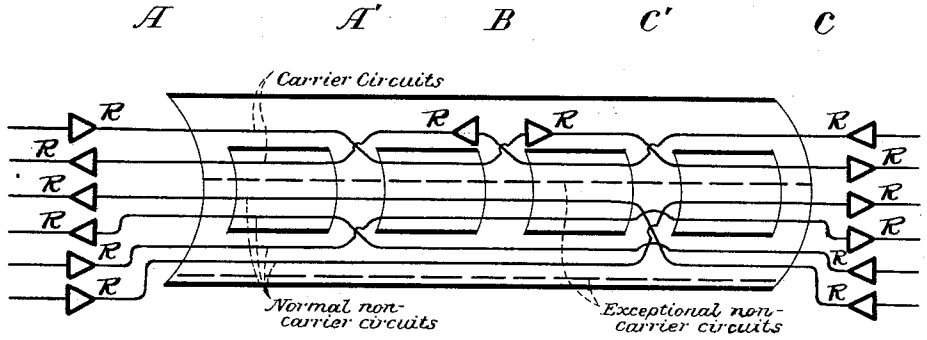

Fig. 3

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SYSTEM FOR TRANSPOSITION OF CONDUCTOR SETS IN CABLES

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9 Claims. (Cl. 179—78)

It is among the objects of my invention to provide a new and improved system of transposition of conductors in a cable system. Another object of my invention is to provide for the operation of twin cables, one of them for transmission one way at its ends and the other for transmission the opposite way at its ends with transpositions of the conductor pairs systematically disposed at certain points between the ends. Another object of my invention is to arrange a corresponding system of transpositions in a single cable with a shield. All these objects and other objects and advantages of my invention will become apparent on consideration of a limited number of examples of practice according to the invention which I have chosen for disclosure in this specification. It will be understood that the following disclosure relates principally to these particular examples of the invention and that its scope will be indicated in the appended claims.

Referring to the drawing, Figure 1 is a diagrammatic representation of an embodiment of my invention in twin cables; Fig. 2 is a detail to which reference will be made in explaining the principles involved in Fig. 1; and Fig. 3 is a diagram showing my invention embodied in a single cable with a shield within it.

Referring to Fig. 1, this represents two cables extending between stations C and A respectively east and west. Each line represents a conductor pair. The pairs *a* and *c* are combined in a four-wire system with terminal *a'* at the left, and similarly, the pairs *b* and *d* are combined in a four-wire system with its terminal *b'* at the left. The triangular symbols R in Fig. 1 represent repeaters with their points directed toward the output ends. The circle symbols T are usual three-winding transformers, and the square symbols N are usual balancing networks. It will be seen that all the pairs have repeaters at station A at the left and that those pairs which enter cable I at this place have repeaters with their outputs entering the cable, but the pairs in cable II at the left have repeaters with their input ends toward the cable II. It will also be seen that at the opposite end at the station C there are similar repeaters similarly directed. But at intermediate stations certain of the conductor pairs are transposed.

The conductor pairs *a*, *c* and *b*, *d* that have just been identified, belonging to four-wire systems, are worked at voice frequencies. In addition there are conductor pairs in the same cable such as *e* and *f* that are worked at higher frequencies, that is, at carrier current frequencies. Such pairs require intermediate repeaters at the intermediate station B in addition to the repeaters at the end stations A and C, but the voice frequency pairs do not require such intermediate repeaters.

If the high-frequency pair such as *e* and the low-frequency pair such as *a* and *b* were disposed at station B, as indicated in Fig. 2, then on the output side of the repeater there would be energy at high level which would cause near-end cross-talk into a neighboring conductor or conductors of a pair such as *a*. This near-end cross-talk in the conductor or conductors of pair *a* would get around by another stage of near-end cross-talk to the input side of the repeater in pair *e* and so there would be circulation of energy with amplification at each cycle. To guard against this, the other pairs such as *a* are transposed from one cable to the other. Accordingly, although the first stage of cross-talk mentioned in connection with Fig. 2 may occur in Fig. 1, the second stage cannot occur because of such transposition.

Having transposed all the pairs such as *a* at station B, each such pair is transposed back again at a junction place where there are no repeaters, such as A' or C'. In this way the ends of the stretch, as shown in Fig. 1 at A and C, appear as distinct twin cables, all the inputs being into one cable at one end and all the outputs being from the same cable at the opposite end, and vice versa.

In an ordinary twin cable system, worked on the four-wire plan, if one cable is interrupted as by an accident, it renders the other cable entirely useless for two-way conversation purposes. But according to the system of transpositions here employed, if there is an interruption of one cable at any point between A' and C' along its length, half of the voice frequency four-wire circuits will remain uninterrupted, thus, for example, if the lower cable in Fig. 1 is interrupted between the points A' and B, nevertheless the four-wire system with terminal *a'* at the left, remains intact. Similarly, it can be seen that if a section of either cable in either stage A' to B or B to C' is interrupted, only one of the two four-wire systems with terminals *a'* and *b'* at the left, will be put out of service.

To make the probability of damage as small as possible, the four-wire voice circuits should be grouped as shown in Fig. 1 and at the same time the points A' and C' should be located as far apart as possible in the total stretch A to C. The minimum distance that will be permis-

sible between points A and A', and similarily between C and C', is determined by the near-end cross-talk and other near-end interference from voice circuits to carrier and vice versa, principally the former, with the power levels at the values of ordinary practice.

Referring to Fig. 3, this shows a single cable with an interior shield. It will be noticed that the repeaters at the ends A and C are directed so that all inputs from the repeaters are into the outer compartment and so that each repeater receives its input from an inner compartment. In this way, with the transpositions shown, the inner compartment is generally operated at a lower power level than the outer compartment. The low frequency or voice frequency lines have repeaters only at A and C, but the carrier current lines at high frequency have additional repeaters at the intermediate point B, and these are also disposed so that the high power level parts of the lines near the repeater outputs are in the outer compartment. Thus inductive interference acting on the cable will involve principally those parts of the lines that are at high power level and will therefore be relatively insignificant and, on the other hand, the parts of the lines at low power level will generally be within the inner compartment and will therefore be especially shielded from interference. The principle is followed throughout that wherever there is a one-way repeater, the low level circuit connected to the input of that repeater is in the low level compartment, that is the inner compartment, and the high level circuit connected to the output of that repeater is in the high level compartment, that is the outer compartment. This requires an odd number of transpositions between the main repeater offices such as A and C. These offices are fifty miles apart, and the carrier lines have additional repeaters at B, which will therefore be twenty-five miles apart, and additional transposition points must be provided at A' and C' so that transpositions can be made at twelve and one-half mile intervals.

In the case of two-wire circuits, of course there is no particular point which can be designated as a high level point in contrast to another point as a low level point and, consequently, there is no particular advantage in transposing these circuits between the inner and outer compartments. There would be no harm in transposing them as for the circuits involved in four-wire systems provided that the transposition is not made at a point where there are carrier repeaters only. Such circuits may be considered as exceptional non-carrier circuits and may be connected simply as shown by the dotted lines in Fig. 3. There is a particular reason for keeping a certain circuit in the same compartment for a considerable distance in the case where such circuit is connected to an open wire line which may bring in considerable interference, particularly longitudinal disturbances. When such a circuit is kept in the high level compartment from the point of entry in the cable to the first repeater office it will do a minimum amount of harm.

I claim:

1. A cable conductor system comprising two shielded compartments side by side, conductor pairs therein, and repeaters for certain of said pairs at a certain point along the length of said cable conductor system, the conductor pairs having such repeaters being transposed at this point relatively to the pairs not having such repeaters at this point.

2. A cable conductor system comprising two shielded compartments side by side, conductor pairs therein, repeaters at the ends of said compartments, three transposition places along the compartments between the ends, and repeaters for certain of said pairs at the middle transposition point, the pairs having the repeaters at this point being relatively transposed as compared with the pairs not having the repeaters at this same point.

3. A twin cable conductor system comprising two cables extending side by side between two places, certain of the conductor pairs being transposed systemmatically from one cable to the other and back so that if one cable is interrupted, only half of the four-wire circuits will be put out of service.

4. In a two-compartment cable conductor system, a repeater and transposed conductor associated therewith, the input conductors being in one compartment and the output conductors in the other compartment to guard against feed-back around the repeater through non-transposed conductor sets of the cable.

5. In a twin cable system two sets of conductor pairs, one set being appropriated for four-wire voice frequency service and the other for four-wire high frequency service, repeaters in all these pairs at certain points and additional repeaters in the high frequency pairs at additional intermediate points, the pairs being transposed at said last mentioned repeaters so that any low frequency conductor in the same compartment with a high frequency conductor on the input side of the repeater will be in a different compartment on the output side of the same repeater.

6. A cable conductor system having an interior shield, a plurality of conductor pairs in said cable, repeaters associated with said pairs, the parts of the conductors connected to the repeater outputs being in the outer compartments of the cable and the parts of the conductors connected to the repeater inputs being in the inner compartment of the cable, the conductors being transposed to effect the foregoing arrangement.

7. A multi-conductor cable of a certain length having low frequency and high frequency pairs therein, and having an interior shield, repeaters for all these pairs at the ends of this length of cable, additional repeaters interposed in the high frequency pairs at an intermediate point of the length of the cable, the interior shield being interrupted at the place of the last mentioned repeaters and at two other places between the middle and the ends of the length of cable, and the pairs being transposed between the outer compartment and the inner compartment so that all the repeaters shall deliver their outputs directly to the outer compartment and receive their inputs directly from the inner compartment.

8. The method of disposing conductors in a two compartment cable system with repeaters, which consists in connecting all repeater inputs to conductors in one compartment and all repeater outputs to conductors in the other compartment and transposing to effect this arrangement.

9. In a multi-conductor cable system, the method of preventing feed-back at a repeater through a conductor set not repeatered at that point which consists in transposing the conductors in and out of said repeater relatively to said set.

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