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CABLE SPLICING APPARATUS

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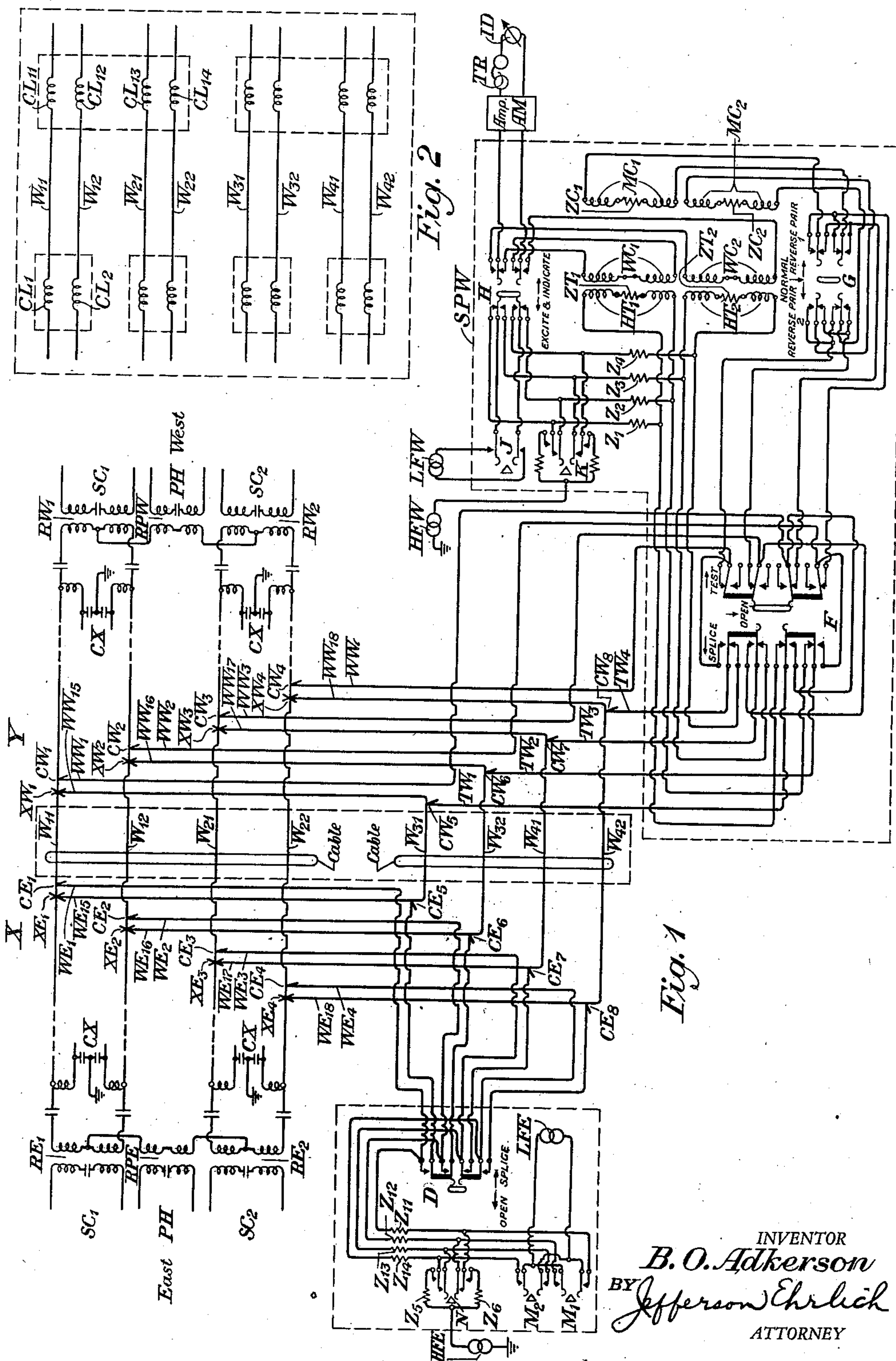


Fig. 1

Fig. 2

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CABLE SPLICING APPARATUS

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This invention relates to cable splicing systems. More particularly, this invention relates to arrangements for substituting the conductors of one cable pair or one cable quad for the conductors of another pair or quad in a different cable without interference with the transmission of signals over the telephone circuits formed by the pair or quad.

In the ordinary telephone cable there are a great many pairs and quads which extend throughout the length of the cable, each quad, for example, comprising four separate conductors which are arranged in two pairs forming two two-wire side circuits, respectively, and the two side circuits are in turn arranged to provide a phantom circuit. When the side circuits are well balanced, the quad provides three wholly independent telephone circuits, namely, the two side circuits and the phantom circuit. Telephone transmission may take place over one of the side circuits without introducing cross-talk or other interference in the other side circuit or in the phantom circuit, and conversely, telephone signals may be transmitted over the phantom circuit without introducing cross-talk or other adverse effects upon either of the side circuits.

When a cable must be replaced due to a failure at some point along its length, or for other reasons, it is often necessary, not alone to locate and identify the various quads of the cable at two or more points along the cable, but to replace these quads with other quads of another cable extending between the same points. It is also desirable that the cable "cutover" be performed without interfering with service over the various cable circuits. Heretofore each conductor of the cable quad was identified and isolated and separately replaced by a good conductor of another cable. However, the connection of an individual conductor to any one of the quad conductors results in an appreciable change in the impedance of the side circuit of the quad of which it is a part and of the phantom circuit of the quad so that these circuits are no longer properly balanced. This is due to the fact that the addition of a single conductor in parallel with a conductor of the quad changes the reactive and resistive components of the conductor with respect to ground and hence the involved side circuit and the phantom circuit then become unbalanced. The phantom current or other longitudinal current on the side circuit, for example, will become introduced into the side circuit, causing noise, cross-talk and other undesirable effects therein and, moreover, the side circuit unbalance will likewise affect the phantom circuit.

It is, therefore, one of the objects of this invention to provide an arrangement for replacing cable conductors so that a new pair or quad of conductors may be substituted for an old pair or quad by simultaneously connecting the two pairs or

quads to each other so that the splice may be made without adversely affecting transmission over any of the circuits.

It is another object of this invention to provide apparatus for simultaneously connecting the conductors of one pair or quad to the conductors of another pair or quad, the apparatus including means for ascertaining whether the tip conductors of the original circuit or side circuits are connected to the corresponding tip conductors of the replacing circuit or side circuits and for ascertaining also whether the ring conductors of the original circuit or side circuits are likewise connected to the replacing ring conductors of the circuit or side circuits.

These general objects of the invention may be accomplished in a cable having a plurality of quads by simultaneously connecting both of the side circuits of the original quad to both of the side circuits of the replacing quad at one point along the cable so that the signals traversing the original side circuits will be applied also to the side circuits of the replacing quad at the same time. At another point along the cable, one winding of a three-winding transformer may be connected to one side circuit of the original quad, another winding of the transformer connected to a side circuit of the replacing quad, and the third transformer winding connected to an indicating device. The indicating device will then register a maximum current when the connections between the side circuits are properly made. If the connections of the side circuits at the point where they have been joined together have not been made properly, the detected current will be at a minimum value (or zero). The error may then be readily observed by the splicer and the connections therefor reversed. The arrangement may also include a switching device for reversing the first-mentioned winding of the transformer to facilitate the determination of the maximum and minimum detected currents. Another three-winding transformer may be similarly employed for checking the connections of the remaining side circuits of the quads. In accordance with this invention, the arrangement may also include a source of oscillations of low frequency, for example, which may be connected to the two circuits under consideration for obtaining effects similar to those obtained from the signal currents traversing the side circuits. Moreover, the arrangement may include a source of oscillations of high frequency for identifying the quads which contain loading coils, as will be explained later.

This invention will be better understood from the more detailed description hereinafter following, when read in connection with the accompanying drawing in which Figure 1 illustrates the essential apparatus required in the practice of the invention, and Fig. 2 shows an arrangement

of loaded circuits to which the invention may also be applied.

Referring to Fig. 1 of the drawing, there is shown four conductors designated W_{11} , W_{12} , W_{21} and W_{22} , comprising one of the many quads of a cable extending between two points designated X and Y. Conductors W_{11} and W_{12} represent a pair providing one side circuit SC_1 , these conductors interconnecting the repeating coil RE_1 and RW_1 in a well known manner. Likewise, the conductors W_{21} and W_{22} constitute another pair providing a second side circuit SC_2 , the latter conductors interconnecting the repeating coils RE_2 and RW_2 in a well known manner. The third or phantom circuit PH is formed as shown by connecting one of the windings of the repeating coil RPE to the midpoints of the corresponding windings of repeating coils RE_1 and RE_2 and by similarly connecting one of the windings of the repeating coil RPW to the midpoints of the repeating coils RW_1 and RW_2 . Since the two wires on each side of the circuit are identical, any current transmitted from the east end of the phantom circuit PH, for example, will divide equally between the two halves of the repeating coil RE_1 and then travel over the two side circuit conductors W_{11} and W_{12} so as to produce equal and opposite magnetic effects in the two halves of one of the windings of the repeating coil RW_1 . These phantom currents in the repeating current RW_1 will neutralize each other and thus the phantom current will not reach the receiver (not shown) at the west end of the side circuit SC_1 . The phantom current will return over the conductors W_{21} and W_{22} of the other side circuit SC_2 and also become neutralized so as to be non-effective in the side circuit SC_2 . Thus, the three circuits SC_1 , SC_2 and PH will constitute three separate channels which are independent of each other and free from noise, cross-talk, etc.

The conductors W_{31} — W_{32} and W_{41} — W_{42} comprise two similar pairs of wires forming a quad in another cable extending between the same points X and Y. It is intended to associate these four conductors with the corresponding conductors W_{11} — W_{12} and W_{21} — W_{22} of the original quad in such a way that the tip conductors W_{11} and W_{31} will be connected together, the ring conductors W_{12} and W_{32} will be likewise connected together, and the tip conductors W_{21} and W_{41} and the ring conductors W_{22} and W_{42} similarly connected together. Transmission may continue over any or all of the circuits SC_1 , SC_2 or PH unaffected by the splicing operations and without interference with signaling over the three circuits of the quad. The splicer at the east terminal X will connect the clips CE_1 , CE_2 , CE_3 and CE_4 to the conductors W_{11} , W_{12} , W_{21} and W_{22} , respectively, of the original cable as shown. He will also connect the clips CE_5 , CE_6 , CE_7 and CE_8 to the corresponding conductors W_{31} , W_{32} , W_{41} and W_{42} , respectively, of the quad of the new cable which is to replace the original quad. The splicer at the west end Y will connect the clips CW_1 , CW_2 , CW_3 and CW_4 to the conductors W_{11} , W_{12} , W_{21} and W_{22} , respectively, of the original cable. He will also connect the clips CW_5 , CW_6 , CW_7 and CW_8 to the corresponding conductors W_{31} , W_{32} , W_{41} and W_{42} , respectively, of the new cable. The splicer at the east terminal X may operate the key D (to the right) whenever desired, after he has connected all of his clips.

The operation of key D will then connect the conductor W_{11} to the conductor W_{31} through the upper outer make contacts of key D. Likewise,

conductor W_{12} will be connected to conductor W_{32} through the upper inner make contacts of key D. Similarly, the conductor W_{21} will be connected to the conductor W_{41} through the lower inner make contacts of key D and conductor W_{22} will be connected to conductor W_{42} through the lower outer make contacts of key D. Thus, the east end of the side circuit SC_1 will be connected at point X not alone to the original side circuit W_{11} — W_{12} , but also to the corresponding side circuit W_{31} — W_{32} of the new cable. Consequently, all signals transmitted over the side circuit W_{11} — W_{12} will be similarly transmitted over the corresponding side circuit W_{31} — W_{32} of the new cable.

When key F is operated to "test" and key G operated to "normal" at the west point Y, the side circuit conductors W_{11} and W_{12} will be connected to the winding MC_1 of a three-winding transformer, the interconnected circuit including conductor W_{11} , clip CW_1 , conductor WW_1 , the lower inner right make contacts of key F, the upper normal right contacts of key G, the winding MC_1 of the transformer, the lower normal right contacts of key G, the lower outer right contacts of key F, conductor WW_2 , clip CW_2 to conductor W_{12} . Thus, the signals transmitted over the side circuit SC_1 will be received by the transformer winding MC_1 . Another winding HT_1 of the same transformer will be connected to the corresponding side circuit conductors W_{31} and W_{32} of the new cable, the interconnected circuit including conductor W_{31} , clip CW_5 , conductor TW_1 , the lower inner left normal contacts of key F, the winding HT_1 of the transformer, the lower outer left normal contacts of key F, conductor TW_2 , clip CW_6 to conductor W_{32} . Transformer winding HT_1 will therefore receive the same signals transmitted from the side circuit SC_1 over the corresponding side circuit W_{31} — W_{32} of the new cable. If the clip CE_1 is connected to the tip conductor W_{11} and the clip CE_2 connected to the ring conductor W_{12} and the clip CE_5 connected to the tip conductor W_{31} and the clip CE_6 connected to the ring conductor W_{32} , as shown in the drawing, the magnetic fields established by winding MC_1 and HT_1 of the transformer will then aid each other and produce an increased magnetic field through the third winding WC_1 of the transformer. The winding WC_1 of the transformer is connected through the normal right contacts of key H to an amplifier AM in the output of which there may be a pair of head phones such as TR and/or an indicator ID. The phone TR and indicator ID will indicate that the currents received from the two side circuits are aiding each other. Were the two side circuits connected in opposition to each other, as would be caused, for example, by a reversal of clips CE_1 and CE_2 or by a reversal of clips CW_5 and CW_6 , the magnetic fields within coils MC_1 and HT_1 of the transformer would then oppose each other. Hence the magnetic field within the coil WC_1 would be at a minimum value and the amplified current received by the phones TR and the indicator ID would be at a very small or negligible value. The arrangement just described, therefore, permits the splicer at the west terminal Y to determine whether the tip conductor W_{11} is connected to the tip conductor W_{31} at terminals X and Y and whether the ring conductor W_{12} is connected to the ring conductor W_{32} at the same terminals. This is one of the features of the splicing arrangement involved in this invention. In this test, key D is operated to its "splice" posi-

tion, key F is operated to its right position, key H is operated to its left position, and key G remains in its normal position, as already noted.

To ascertain whether or not maximum currents are reaching the phones TR and indicator ID over the corresponding side circuits W_{11} — W_{12} and W_{31} — W_{41} , the splicer at the west terminal Y may operate the key G to the right. This will reverse the winding MC_1 with respect to the side circuit W_{11} — W_{12} . When the key G is so operated, the amplified current should be at a minimum for the same received signals, provided the tip and ring conductors W_{11} and W_{12} of the original cable are connected respectively to the tip and ring conductors W_{31} and W_{32} of the new cable. Thus, by moving the key G between its normal position and its operated position at the right, the splicer may detect any undesired transposition of the conductors in the corresponding side circuits of the two cables.

Similar tests for the polarity of the second side circuit W_{21} — W_{22} of the original cable with respect to the second side circuit W_{41} — W_{42} of the replacing cable may be performed at point Y. In this case the coil MC_2 of the transformer will be connected to the second side circuit W_{21} — W_{22} , the interconnecting circuit including conductor W_{21} , clip CW_3 , conductor WW_3 , the upper inner right make contacts of key F, the upper left normal contacts of key G, coil MC_2 , the lower normal left contacts of key G, the upper outer right make contacts of key F, conductor WW_4 , clip CW_4 to conductor W_{22} . Thus, coil MC_2 will be energized by the signals traversing the second side circuit SC_2 . The coil HT_2 of the transformer will be connected to the second pair W_{41} — W_{42} of the new cable, the interconnecting circuit including conductor W_{41} , clip CW_7 , conductor TW_3 , the upper inner left normal contacts of key F, coil HT_2 , the upper outer left normal contacts of key F, conductor TW_4 , clip CW_8 to conductor W_{42} . Thus, the coil HT_2 will be connected to the pair W_{41} — W_{42} and to the east end of the side circuit SC_2 . Consequently the signals in the latter circuit SC_2 will be received by the coil HT_2 . The two coils MC_2 and HT_2 will produce a common magnetic field which will act upon the third coil WC_2 of the transformer to produce an effect which will be transmitted through the make right contacts of key H to the amplifier AM when key H is operated to the right. The amplified currents will produce a registration in the receiver TR and indicator ID. The registration will be at its maximum value if the two side circuits W_{21} — W_{22} and W_{41} — W_{42} are connected tip to tip and ring to ring. On the other hand, the registration will be at its minimum value if the connections between the two side circuits are reversed so that the tip of one side circuit is connected to the ring of the other. A more positive test may be performed by operating key G to its left operated position, thereby reversing the winding MC_2 with respect to the winding HT_2 . If the maximum indication is obtained with key G in its left operated position, then the clips CW_7 and CW_8 may be reversed to obtain the desired polarity. When these clips are so reversed, the maximum indicated current will be obtained with key G in its normal position. Thus, by moving the key G between its normal and left positions, the splicer may quickly determine whether the two side circuits W_{21} — W_{22} and W_{41} — W_{42} are properly poled, i. e., tip conductor W_{21} to tip conductor W_{41} and ring conductor W_{22} to ring conductor W_{42} .

It will be observed that resistors ZC_1 and ZT_1 are shown connected at the midpoints of coils MC_1 and HT_1 and that similar resistors ZC_2 and ZT_2 are connected at corresponding points in coils MC_2 and HT_2 , respectively. These resistors may have values of, for example, 20,000 ohms and are intended to provide high impedances in the circuits of these coils. Such high impedances will reduce to a negligible extent the amount of loss introduced into the side circuits SC_1 and SC_2 during the splicing and testing operations. These losses may be overcome by amplifier AM so far as the testing apparatus is concerned. It will be understood that these resistors just referred to may be positioned at any other points in the circuits but always in series with the respective coils. The provision of high impedances in the testing circuits permits the splicer to make polarity tests without interfering with signaling over the side circuit SC_1 or over the phantom circuit PH.

The splicer at point Y need not rely upon the signals emanating from the east end of the side circuit SC_1 , for example, for performing the test already outlined. If desired, the splicer may connect a low frequency oscillator LFW to the testing circuits by operating key J. When key J is so operated (with key H retained in its left operated position as shown) the oscillator LFW will be connected to the winding MC_1 over a circuit which includes oscillator LFW, the upper contacts of key J, the upper left make contacts of key H, resistors Z_1 , the inner lower normal left contacts of key F, conductor TW_1 , clip CW_5 , conductor W_{31} , clip CE_5 , the upper outer make contacts of key D, conductor WE_1 , clip CE_1 , conductor W_{11} , clip CW_1 , conductor WW_1 , the lower inner right make contacts of key F, the normal upper right contacts of key G, winding MC_1 , the lower normal right contacts of key G, the lower outer right make contacts of key F, conductor WW_2 , clip CW_2 , conductor W_{12} , clip CE_2 , conductor WE_2 , the upper inner make contacts of key D, clip CE_6 , conductor W_{32} , clip CW_6 , the lower outer left normal contacts of key F, resistor Z_2 , the lower left make contacts of key H, the lower contacts of key J to generator LFW. The generator LFW will thus be connected to the coil MC_1 over a series circuit which includes both conductors of both side circuits W_{11} — W_{12} and W_{31} — W_{32} . The oscillator LFW will likewise be connected through the make contacts of keys J and H and resistors Z_1 and Z_2 to the winding HT_1 of the same transformer. The coil WC_1 will then pick up the combined magnetic effects of both coils MC_1 and HT_1 and register the amplified effect upon the receivers TR and indicator ID. The key G may be moved between its normal position and its operated position at the right to reverse coil MC_1 so as to test the polarity of the two side circuits in the manner already explained. Similarly, the oscillator LFW may be connected to both coils MC_2 and HT_2 . The connection to coil MC_2 will extend through a corresponding series path provided by the side circuits W_{21} — W_{22} and W_{41} — W_{42} . The polarity of these side circuits may be likewise tested by moving the key G between its normal position and its operated position at the left in the manner already described. The use of the oscillator LFW enables the splicer at the west point Y to perform his tests either with the aid of or in the absence of signals in the side circuits SC_1 and SC_2 . This is another feature of the invention.

If so desired, the oscillator LFE at the east point X may be connected to the system for testing the

polarity of the corresponding side circuits of the original and replacing cables. Upon operating key M₁ the oscillator LFE will be substituted for the oscillator LFW in the circuit previously described for testing the polarities of the side circuits W₁₁—W₁₂ and W₃₁—W₃₂. By releasing key M₁ and then operating key M₂, a similar test may be performed upon the other side circuits W₂₁—W₂₂ and W₄₁—W₄₂. The circuits interconnecting the generator LFE with the coils MC₂ and HT₂ of the transformer may be readily traced without further description.

The two side circuits W₁₁—W₁₂ and W₂₁—W₂₂ of the original cable quad and the two side circuits W₃₁—W₃₂ and W₄₁—W₄₂ of the replacing cable quad may be of an unloaded type as shown in Fig. 1 or they may be of the loaded type as shown in Fig. 2. The lines shown in Fig. 2 would be part of the system shown in Fig. 1 and may be assumed to be positioned within the box shown in dotted lines between points X and Y of Fig. 1.

If the lines of Fig. 1 are loaded as shown in Fig. 2, each side circuit will include one or more pairs of loading coils such as CL₁ and CL₂, each pair of these coils being mounted on a common core of iron so that the side circuit therein will produce additive effects in the common core but phantom circuit currents traversing these windings will neutralize each other. Moreover, each pair of side circuits of a quad arranged for phantom use will be equipped with at least one iron core having four windings thereon, such as CL₁₁, CL₁₂, CL₁₃ and CL₁₄, the latter coils being effectively part of the phantom circuit. The side circuit currents traversing coils CL₁₁ and CL₁₂ will neutralize each other, but they will produce additive effects with respect to phantom currents traversing the side circuit W₁₁—W₁₂. The other coils CL₁₃ and CL₁₄ will likewise produce cumulative effects with respect to phantom currents traversing the side circuit W₂₁—W₂₂. By this arrangement the magnetic effects of the side circuit loading coils such as CL₁ and CL₂ will not introduce reactance, noise, or cross-talk into the phantom circuit and the phantom circuit loading coils CL₁₁, CL₁₂, CL₁₃ and CL₁₄ will not introduce reactance, noise, or cross-talk into the two side circuits W₁₁—W₁₂ and W₂₁—W₂₂.

When it is desired to identify one of the loaded quads of the original cable, the key D will be returned to its open position (at the left) and key N will be operated. The high frequency oscillator HFE will then be connected through resistors Z₅ and Z₆ and then through resistors Z₁₁, Z₁₂, Z₁₃ and Z₁₄ to all four conductors W₁₁, W₁₂, W₂₁ and W₂₂, at the east point X of the system. At the west point Y this same quad of conductors may be separated from the other conductors by the aid of probing and detecting apparatus of well known type. The patent to D. Fisher et al., No. 2,133,384, dated October 18, 1938, shows one form of probing and detecting apparatus, and it will be apparent from the latter patent that the probing and detecting apparatus may be arranged to be responsive to the current of the high frequency emitted by the oscillator HFE. The high frequency current of oscillator HFE will traverse the loading coils which are now connected to each other in parallel relationship and the magnetic effects of this current in the various coils will be of such magnitudes and directions as to substantially neutralize and balance each other.

After the desired cable quad has been located and identified, the pairs of the quad may be segregated from each other. Pair W₁₁—W₁₂ may be

identified by operating key M₁ and operating key F to "test" while key D is held open. In that case the low frequency oscillator LFE will produce an audible tone in the receiver TR and a visible indication on indicator ID. The circuit interconnecting the oscillator LFE to the indicating apparatus includes oscillator LFE, the lower make contacts of key M₁, resistor Z₁₁, conductor WE₁, clip CE₁, conductor W₁₁, clip CW₁, conductor WW₁, the lower inner right make contacts of key F, the upper right normal contacts of key G, winding MC₁, the lower right normal contacts of key G, the outer lower right make contacts of key F, conductor WW₂, clip CW₂, conductor W₁₂, clip CE₂, conductor WE₂, resistors Z₁₂, the upper make contacts of key M₁, back to oscillator LFE. The current traversing coil MC₁ will be transmitted through coil WC₁, then through the normal right contacts of key H, to the amplifier AM and thence to the receiver TR and indicator ID. However, should the indicator equipment fail to indicate the presence of the low frequency tone of oscillator LFE, the key H may then be operated to its position at the right. If the tone is then audible, the clips for the two pairs W₁₁—W₁₂ and W₂₁—W₂₂ would have to be interchanged so as to apply the oscillator current to pair W₁₁—W₁₂. When so interchanged, the audible tone will be received when key H is operated to its position at the left. Similarly, by operating key M₂ the low frequency tone obtained from oscillator LFE may be transmitted to coil MC₂, this tone then being transmitted by coil WC₂ to the amplifier AM and to the indicating equipment. For the latter test key H will have to be operated to its position at the right.

After the two pairs of the loaded quad have been properly identified, the matching of the conductors of the side circuits W₁₁—W₁₂ and W₃₁—W₃₂ may then be obtained in the manner already described hereinabove with respect to the non-loaded conductors of Fig. 1. As already explained, the tip conductors W₁₁ and W₃₁ will then be associated with each other and the ring conductors W₁₂ and W₃₂ will be similarly associated with each other.

Whether the cable conductors are of the loaded or of the non-loaded type, the splicing operations may be performed after the conductor identifications have been completed, after key D has been operated to the right and key F to the left. These keys simultaneously connect conductor W₁₁ to conductor W₃₁, conductor W₁₂ to conductor W₃₂, conductor W₂₁ to conductor W₄₁ and conductor W₂₂ to conductor W₄₂ at points X and Y. The conductor W₃₁ may be permanently connected to conductor W₁₁ at point XE₁ at the east terminal X while these two conductors may also be permanently connected to each other at point XW₁ at the west terminal Y. The other corresponding conductors, such as W₁₂ and W₃₂, may also be permanently connected to each other at the two terminals X and Y. After the permanent connections have been completed for all four of the cable quad conductors, further tests MC₁₂ will be transmitted through coil WC₁, then sections, if so desired. The original cable conductors W₁₁, W₁₂, W₂₁ and W₂₂ may be severed beyond the points where the splices have been made as quickly as possible at each point. The new cable quad will now completely replace the old quad.

The resistors Z₁, Z₂, Z₃ and Z₄, resistors Z₅ and Z₆, and resistors Z₁₁, Z₁₂, Z₁₃ and Z₁₄ are prefer-

ably of large magnitudes of, for example, 10,000 ohms.

While this invention has been shown and described in certain particular embodiments merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In a telephone system, the combination of a two-wire main line transmitting signals, a second two-wire line to replace said main line, means for connecting the two distant terminals of the main line to the two corresponding distant terminals of the second line, a three-winding transformer having one winding connected to the two near terminals of the main line, another winding of the transformer being connected to the two near terminals of the second line, and a detector connected to the third winding of said transformer.

2. In a telephone system, the combination of a two-wire main line transmitting signals between first and second points, a second two-wire line extending between the same points, means for connecting the two wires of the main line to the corresponding two wires of the second line at said first point, a first winding connected to the two wires of the main line at said second point, a second winding connected to the two wires of the second line at said second point, a third winding magnetically coupled to said first and second windings, and detecting means connected to said third winding.

3. In a telephone system, the combination of a two-wire main line transmitting signals between first and second points, a second two-wire line extending between the same points, means for connecting the two wires of the main line to the corresponding two wires of the second line at said first point, a first winding connected to the two wires of the main line at said second point, a second winding connected to the two wires of the second line at said second point, a third winding magnetically coupled to said first and second windings, detecting means connected to said third winding, and means for reversing the connection between said main line and said first winding.

4. In a telephone system, the combination of a two-wire main line extending between first and second points, a second two-wire line also extending between said first and second points, means for connecting the two terminals of said main line to the corresponding two terminals of said second line at said first point, a transformer having first, second and third windings, a low frequency oscillator, means for connecting said oscillator over both two-wire lines in series with the first winding of said transformer, said means including means for connecting said oscillator in series with the second winding of said transformer, and a detector connected to the third winding of said transformer.

5. In a telephone system, the combination of a main line having tip and ring conductors extending between first and second points, a second line having tip and ring conductors also extending between said first and second points, means for connecting the tip conductors of both lines to each other and the ring conductors of both lines to each other at said first point, an oscillator, a transformer having first, second and third windings, means for connecting said oscillator over a circuit including the tip conductors of both

lines, the first winding of said transformer and the ring conductors of both lines, and means for simultaneously connecting said oscillator to the second winding of said transformer, and detecting means connected to the third winding of said transformer.

6. In a telephone system, the combination of a main line having tip and ring conductors extending between first and second points, a second line having tip and ring conductors also extending between said first and second points, means for connecting the tip conductors of both lines to each other and the ring conductors of both lines to each other at said first point, an oscillator, a transformer having first, second and third windings, means for connecting said oscillator over a circuit including the tip conductors of both lines, the first winding of said transformer and the ring conductors of both lines, said means including means for simultaneously connecting said oscillator to the second winding of said transformer, detecting means connected to the third winding of said transformer, and means for reversing the connection of the first winding of said transformer.

7. In a signaling system, the combination of two circuits each including a tip conductor and a ring conductor, means for transmitting the same signals over both circuits simultaneously, first and second coils connected respectively to said two circuits, a third coil coupled to said first and second coils, detecting apparatus connected to said third coil, and means for reversing said first coil, whereby the detecting apparatus will indicate whether the tip conductors of both circuits are connected to each other and the ring conductors are likewise connected to each other.

8. In a signaling system, the combination of a source of signals, first and second lines each connected to said source of signals, each line including tip and ring conductors, first and second coils connected respectively to said first and second circuits, a detector, and a third coil coupled to said first and second coils, whereby said detector will indicate whether the tip conductors of both lines are connected to one terminal of said source and the ring conductors to the opposite terminal of said source.

9. In a signaling system, the combination of a first line transmitting signals continuously between first and second points, a second line to replace said first line, means for paralleling both lines at said first point, first and second coils, two equally high impedances connecting said first and second coils to said first and second lines respectively at said second point, an amplifier, a third coil coupled to said first and second coils and connected to said amplifier, and indicating means connected to said amplifier.

10. Apparatus for identifying a predetermined quad of conductors each having a load coil in series therewith, the predetermined quad of conductors being one of many quads in a cable, comprising a source of current of super-audible frequency, means for applying said current to said predetermined quad at one point along said cable, a probing device, and a detector connected to said probing device, said probing device being used at the other end of said cable to locate the predetermined quad to which said current is applied, whereby said detector will register a large effect when said probing device is closely adjacent to said quad.

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