July 9, 1940. N. BOTSFORD 2,207,531

FOUR-WIRE SIGNALING CIRCUITS

Filed Nov. 5, 1938 2 Sheets-Sheet 1

FIG. 1

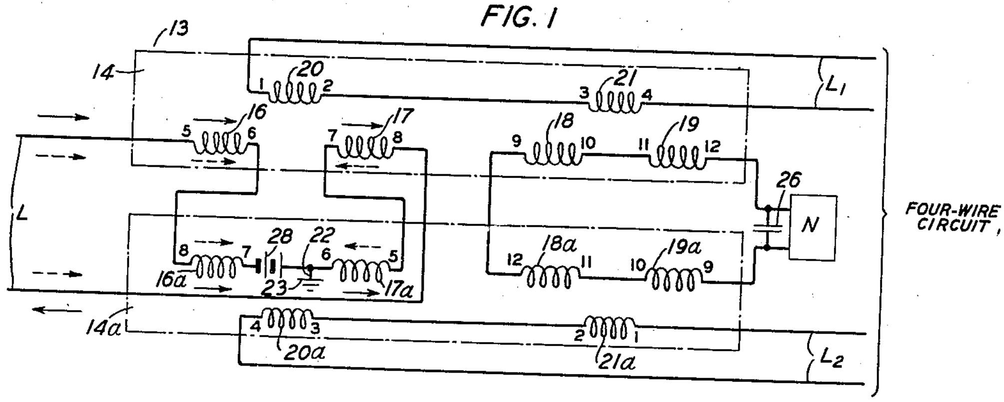


FIG. 2

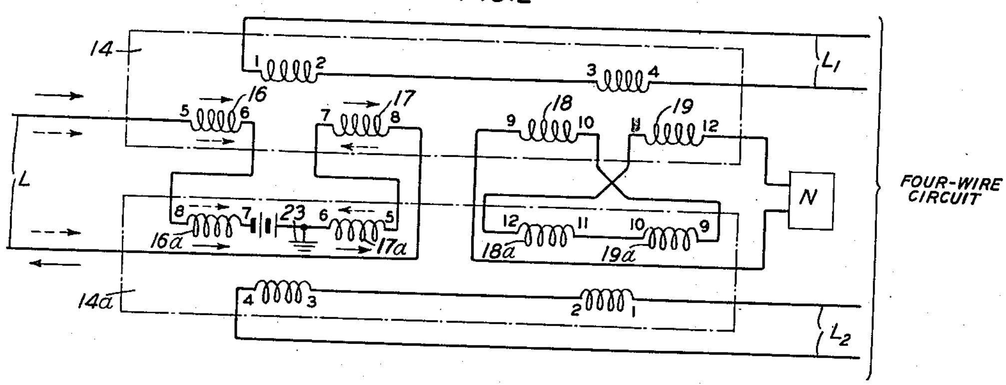
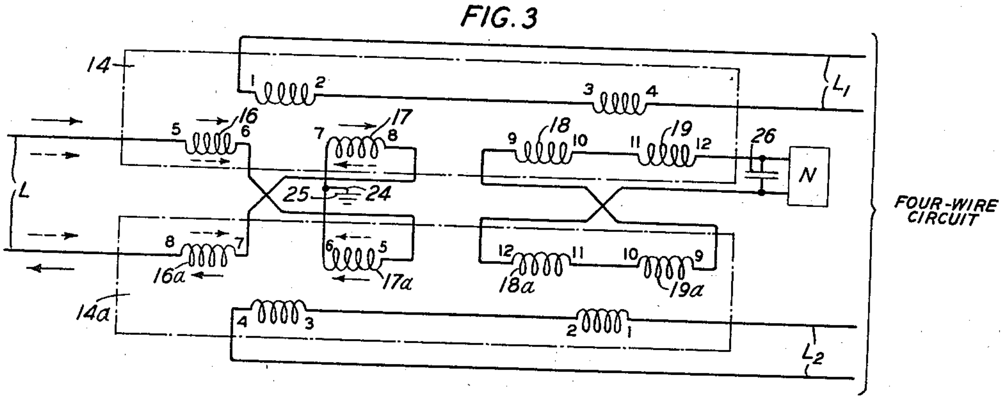


FIG. 3



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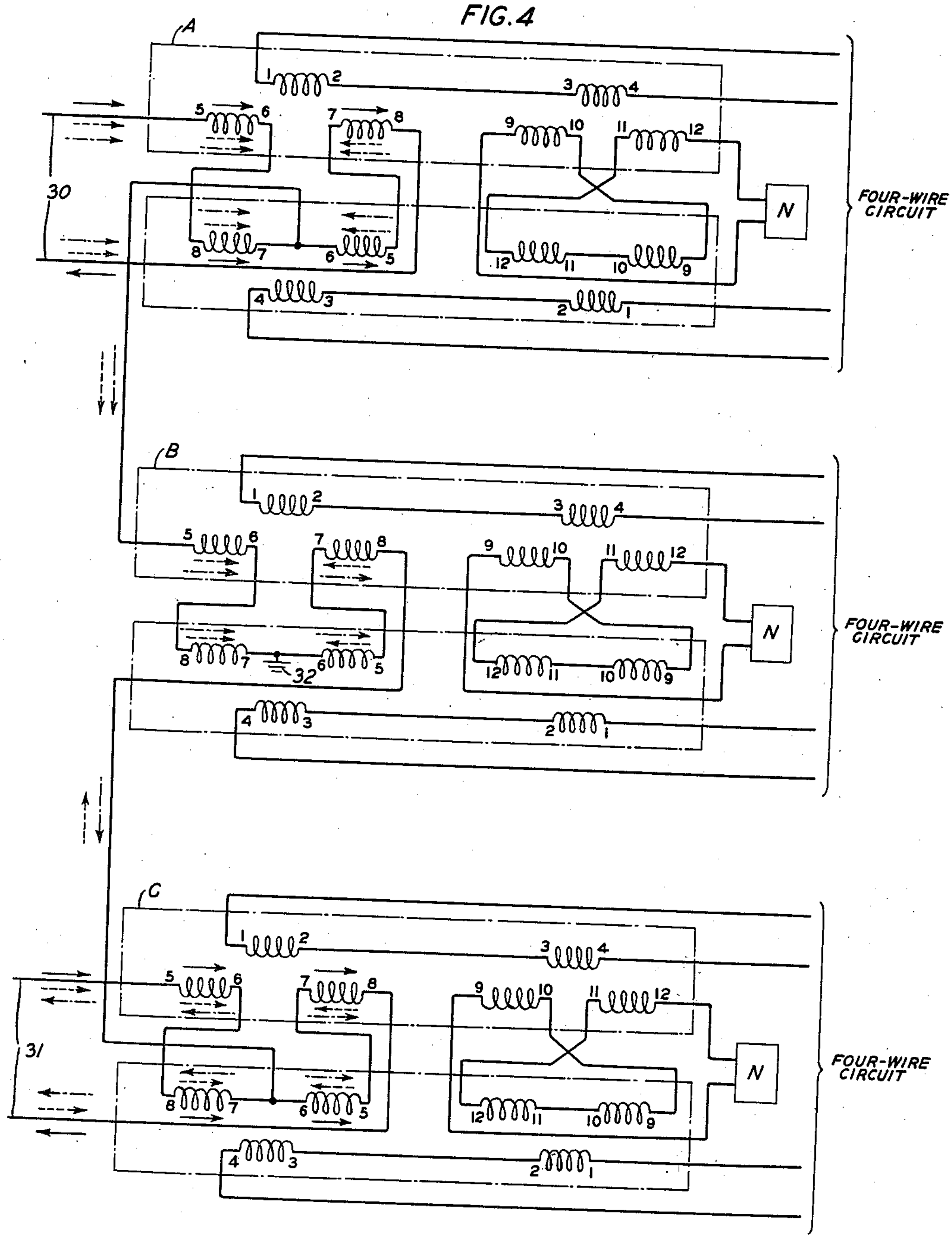
Filed Nov. 5, 1938 2 Sheets-Sheet 2

FIG. 4



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FOUR-WIRE SIGNALING CIRCUITS

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1 Claim. (Cl. 179—170)

This invention relates to signaling circuits embodying hybrid coils and more particularly to hybrid coil arrangements for associating two-wire circuits with four-wire circuits.

Heretofore hybrid coil arrangements have been used in signaling circuits for connecting a two-wire circuit with a four-wire circuit. Certain of such arrangements are disclosed in the patent to H. Nyquist No. 1,504,135, granted August 5, 1924. The present invention is an improvement over the Nyquist circuit in that provision is made for minimizing or obviating the effects of longitudinal currents induced in the two-wire circuit. The effects of these currents are blocked from the four-wire circuit thereby precluding interference therein with the transmission of signaling currents.

It is an object of the present invention to provide a hybrid coil arrangement for coupling a two-wire circuit to a four-wire circuit in a manner such that the effects of longitudinal currents in the two-wire circuit are canceled and therefore do not appear in the four-wire circuits.

In a preferred embodiment the invention comprises a pair of multiwinding inductance coils, two windings of the one connected in series with two windings of the other and both pairs applied to a two-wire circuit. A mid-point of these windings is connected to ground. Accordingly, longitudinal currents induced in the two-wire circuit flow to ground in opposite directions in each of the two windings on the same core. This causes the flux due to the longitudinal current in one winding to oppose the flux due to the longitudinal current in the other winding on the same core. Consequently, the effects of the longitudinal currents are calceled and therefore do not reach the four-wire circuit.

The invention will be more readily understood from the following description taken together with the accompanying drawings in which:

Fig. 1 is a circuit diagram showing a preferred embodiment of the invention;

Fig. 2 is a circuit diagram illustrating a modification of Fig. 1;

Fig. 3 is a circuit diagram showing an alternate form of the invention; and

Fig. 4 is a circuit diagram showing the invention used in a signaling system for deriving phantom circuits.

In the drawings the same reference numerals are employed to designate identical elements appearing in the several figures.

Fig. 1 shows a two-wire two-way transmission circuit L associated with transmission paths L_1 and L_2 through a hybrid coil 13. The paths L_1 and L_2 may constitute the four wires of a four-wire circuit or those leading to a four-wire repeater circuit. But one end of the four-wire circuit is shown for the reason that the other end is identical therewith and is well understood in the art.

The hybrid coil 13 comprises individual coils 14 and 14*a*, each coil including six windings, 16, 17, 18 and 19, which are preferably wound as a quad although wound in layers would serve equally as well as long as they are well balanced and closely coupled and a pair of serially-connected windings 20 and 21. The windings 18 and 19 on coil 14 are connected in series and the windings 18*a* and 19*a* on coil 14*a* are also connected in series. In addition, the windings 18 and 19 are connected in series with the windings 18*a* and 19*a*, and the terminals 9 and 12 of the respective windings 19*a* and 19 are applied to a well-known balancing network N. It is understood that the coils 14 and 14*a* are provided with cores of suitable magnetic material on which the various windings are wound.

The winding 16 of coil 14 is connected in series with the winding 16*a* on coil 14*a*, the latter winding being connected in series with the winding 17*a* on the same coil. The winding 17*a* is also connected in series with the winding 17 on the coil 14. The terminals 5 and 8 of the respective windings 16 and 17 are applied to the circuit L. Thus the arrangements of the windings 16 and 17 on coil 14 and of the windings 16*a* and 17*a* on coil 14*a* are such that the windings on the same core are connected in a series-aiding relationship. The flow of signaling current in the windings of each coil is in the same direction and is indicated by the solid arrows associated therewith.

The mid-point of the windings 16*a* and 17*a* is connected by a lead 22 to ground 23. This also serves to connect to ground the mid-point of the serially-connected windings 16, 16*a*, 17*a* and 17.

The serially-connected windings 20 and 21 on coil 14 serve to couple windings 16, 17, 18 and 19 to path L_1 while the serially-connected windings 20*a* and 21*a* on coil 14*a* serve to couple windings 16*a*, 17*a*, 18*a* and 19*a* to path L_2. It is understood that the impedance of the circuit L, balancing network N, and paths L_1 and L_2 may be so related by the coils 14 and 14*a* that signaling energy transfer may be accomplished in desired proportions. As such transfer is well understood in the art, a further discussion thereof is deemed unnecessary here but reference is made to the patent to H. Nyquist, supra.

In Fig. 1, the numerals 1 through 12 indicating the winding terminals serve to designate the polarity thereof, that is, current flowing in any winding from an even to an odd numbered terminal produces flux in the core associated therewith in one direction while current flowing in any winding from an odd to an even numbered terminal produces flux in the core associated therewith in an opposite direction. This is also true with regard to Figs. 2, 3 and 4 in which the respective windings of the hydbrid coils are similarly designated as in Fig. 1 and which will be hereinafter described.

The arrangement shown in Fig. 1 is particularly adaptable for use in toll circuits in which it is desired that current from a battery 28 located at a toll office be transmitted over the circuit L to a subscriber connected to the terminal thereof, not shown. In the event of longitudinal or noise currents being induced in the circuit L and transmitted toward the toll office, these currents would flow to ground 23 through the windings 16, 16*a*, 17*a* and 17 in the directions indicated by the dotted arrows. It will be observed that the noise currents flow in opposite directions through the windings 16 and 17 of the coil 14 and also in opposite directions through the windings 16*a* and 17*a* of the coil 14*a*. Hence, the flux produced in the cores of the coils 14 and 14*a* and due to the noise currents flowing in the respective windings will be in opposition. Consequently, the effects of the noise currents will be canceled in the coils 14 and 14a, and will not enter either path L_1 or path L_2.

The arrangement of Fig. 1 provides for a high loss from path L_1 to path L_2 for the reason that loss therebetween depends solely on the equality of the windings 16, 17 and 18, 19 on coil 14 and of the windings 16*a*, 17*a* and 18*a*, 19*a* on coil 14*a*, assuming that the impedance of the network N equals that of the circuit L. These windings on the individual coils 14 and 14*a* are inherently excellent since they are very closely associated, being wound at the same time as a quad. While winding as a quad is preferable, it is not necessarily limited thereto as pointed out hereinbefore.

Longitudinal currents on the side of the balancing network N are normally negligible and usually there is no need of grounding the midpoint of windings 18, 19, 18*a* and 19*a*. Consequently, windings 18 and 19 on coil 14 and windings 18*a* and 19*a* on coil 14*a* may be wound on the respective coils as a single winding. This does not affect the balance of the circuit L although it may lower the loss from the path L_1 to the path L_2 by placing less winding capacity across the network N than is placed across the circuit L. The high loss from the path L_1 to the path L_2 may then be brought back to a desirable level by placing a condenser 26 of proper capacity across the network N in Fig. 1. Thus the condenser 26 serves to render the effective winding capacity across the network N equal to the effective winding capacity across the circuit L.

Fig. 2 is identical with Fig. 1 except the winding 19 on coil 14 is connected in series wth the serially-connected windings 18*a* and 19*a* on coil 14*a* while the latter are also connected in series with the winding 18 on coil 14. The terminals 9 and 12 of the respective windings 18 and 19 are applied to the network N. Thus the connections of the windings applied to the network N are equivalent from a capacity standpoint to the connection of the windings 16, 17, 16*a* and 17*a* applied to the circuit L. This arrangement obviates the condenser 26 of Fig. 1.

The arrangement of Fig. 2 is particularly adaptable for use in the derivation of phantom circuits as illustrated in Fig. 4. Referring to the latter, signaling currents flow in the physical circuits 30 and 31 and the respective hybrid coil sets A and C in the directions indicated by the solid arrows. In this connection it will be observed that the flow of signaling current in the windings of each coil 14 and 14*a* comprising the respective hybrid coil sets A and C is in the same direction. Transfer of signaling energy between the two-wire circuits 30 and 31 and the four-wire circuits associated therewith is effected in the manner mentioned above relative to Fig. 1.

Phantom currents flow in the physical circuits 30 and 31, the hybrid coil sets A, B, and C, and the connections therebetween in the directions indicated by the dot-dash arrows. These currents flow in opposite directions in the windings of the coils 14 and 14*a* comprising the hybrid coil sets A and C. The flux due to these currents will be in opposition in the cores associated with the respective coils 14 and 14*a* and the effects of the phantom currents will therefore be canceled in the respective hybrid coil sets A and C. Consequently, the effects of the phantom currents will not reach the four-wire circuit associated with the hybrid coil sets A and C. However, in the windings of the coils 14 and 14*a* comprising the hybrid coil set B, phantom currents flow in the same direction. The flux due to this current in the hybrid coil set B will be in an aiding relationship and the effects of the phantom currents will be therefore transferred to the four-wire circuit associated with the hybrid coil set B. The transfer of this energy between the two-wire and the four-wire circuits is effected in the proportion mentioned above in connection with Fig. 1.

Noise or longitudinal currents induced in the two-wire circuits 30 and 31 in Fig. 4 flow therein and in the windings of the hybrid coil set A, B and C to ground 32 connected to the mid-point of the windings of the coils 14 and 14*a* comprising the hybrid coil set B in the directions indicated by the dotted arrows in a manner siminar to that for the flow of noise currents in Fig. 1 as explained above. Thus the noise currents flow in opposite directions in the windings of each of the coils 14 and 14*a* comprising the hybrid coil sets A, B and C. As the flux due to noise currents is also in opposition in the same cores associated with the respective coils 14 and 14*a*, the effects of noise currents will be canceled and will therefore not reach any of the four-wire circuits.

It is to be understood that the organization of Fig. 1 may also be used for the derivation of phantom circuits in the manner aforedescribed with regard to Fig. 4.

Fig. 3 is generally similar to Fig. 1. In Fig. 3 winding 16 on coil 14 is connected in series with winding 17*a* on coil 14*a*. The latter winding is connected in series with winding 17 on coil 14 and winding 17 is connected in series with winding 16*a* on coil 14*a*. The terminals 5 and 8 of the respective windings 16 and 16*a* are applied to the circuit L. Thus, the windings 16 and 17, and also 16*a* and 17*a* are arranged in a series-aiding relationship on the respective cores. The midpoint of the windings on the coils 14 and 14*a* is connected by a lead 24 to ground 25. The serially-connected windings 18 and 19 on coil 14 are connected in series with the serially-connected windings 18a and 19a on coil 14a. The terminals 12 and 12 of the respective windings 19 and 18a are applied to the network N.

In Fig. 3 signaling currents flow in the two-wire circuit L and the windings of the coils 14 and 14a in the same direction as indicated by the solid arrows. The transfer of signaling energy between the two-wire and the four-wire circuits is accomplished as mentioned in connection with Fig. 1. Noise or longitudinal currents induced in the two-wire circuit L and flowing therein and in the windings of the coils 14 and 14a to ground 25 are indicated in Fig. 3 by dotted arrows. It is seen that these noise currents flow in opposite directions in the windings 16 and 17 and also in the windings 16a and 17a. The flux due to these currents is in opposition in the same cores and the effects of the noise currents will be canceled. Consequently, the effects of the noise currents will not reach the four-wire circuit. The hybrid coil according to Fig. 3 may also be used in the derivation of phantom circuits in a manner similar to that illustrated in Fig. 4. This arrangement also includes the condenser 26 whose function was mentioned above relative to Fig. 1. The use of this condenser may be avoided by connecting the windings applied to the network N in such manner that the latter are equivalent from a capacity standpoint to the connection of the windings applied to the circuit L, as mentioned above with regard to Fig. 2.

It is to be understood that the invention is not limited to the precise details of the circuits illustrated and described for it is apparent that numerous modifications thereof could be made without departing from the spirit of the invention, the scope of which is to be determined by the appended claim.

What is claimed is:

A hybrid apparatus for associating a two-wire circuit, a four-wire circuit and a balancing network, said apparatus comprising a pair of multi-winding coils, a first pair of windings on a first coil connected in series, a first pair of windings on a second coil connected in series, the two first pairs of serially-connected windings connected in series and arranged so that one winding of each thereof is applied to the balancing network, a second pair of windings on said first coil connected in series, a second pair of windings on said second coil connected in series with the serially-connected second pair of windings on said first coil, each of the second pairs of windings disposed in a series-aiding relationship, the serially-connected second pairs of windings arranged so that the second pair of windings on said second coil is connected to the two-wire circuit, the first and second pairs of windings on each of said coils applied thereto as a quad, grounding means, a lead connecting the grounding means to a mid-point of the serially-connected second pairs of windings so that longitudinal currents induced in the two-wire circuit flow in opposite directions in each winding of the second pairs of windings thereby canceling the effects thereof in each of said coils, a third pair of serially-connected windings on each of said coils for coupling of the first and second pairs of windings thereon to the four-wire circuit, and a capacity in bridge of the network for rendering the effective capacity of the windings applied thereto substantially equal to the effective capacity of the windings applied to the two-wire circuit.

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