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MULTIPLE COAXIAL CONDUCTOR SYSTEM

Filed May 9, 1930

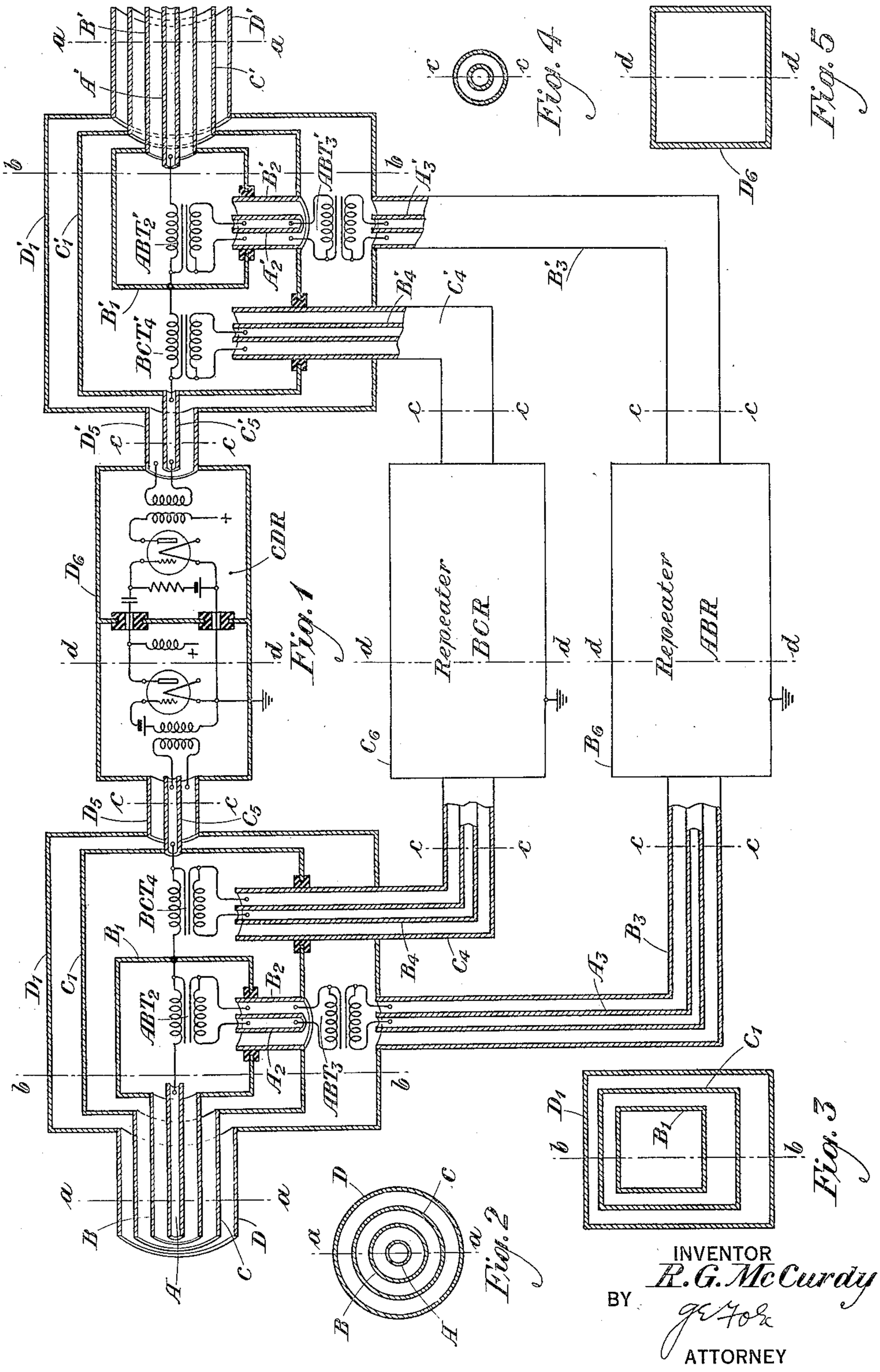

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

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MULTIPLE COAXIAL CONDUCTOR SYSTEM

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This invention relates to coaxial conductor circuits, and more particularly to terminal arrangements for such circuits.

It has been proposed to use a multiple coaxial conductor system of more than two tubular conductors for the purpose of obtaining additional circuits. For example, if a triple conductor system were employed, the middle and inner conductor might be used as one circuit and the middle and outer conductors as another. At high frequencies these two derived circuits would be effectively separate since the currents of one circuit would flow on the inside of the middle conductor and those of the other circuit on the outside of the middle conductor. The chief difficulty with such an arrangement is that of applying the currents to the two circuits at the transmitting end and taking them off at the receiving end in such a manner as to avoid objectionable mutual interference.

The arrangement comprising the present invention offers a solution of this difficulty. This arrangement consists in terminating each circuit in a shielded compartment in which the line currents are passed through a double shielded transformer and then are led through a shielded circuit to the terminating apparatus which may be, for example, a repeater amplifier. Owing to the concentric arrangement of the line conductors the shielded containers are arranged one inside the other. The double shielded transformer serves as a connecting link between the apparatus circuits (such as the amplifiers) which are shielded with respect to one another in the usual way and the line circuit where the shield and the conductor are the same physical structure.

The invention will now be more fully understood from the following description, when read in connection with the accompanying drawing, Figure 1 of which is a schematic circuit arrangement embodying the principles of the invention, and Figs. 2, 3, 4 and 5 of which are cross-sectional views of the various conductors and shielded compartments used in connection with the system.

Fig. 1 illustrates an arrangement in which a multiple concentric conductor system comprising four conductors is employed in such a manner as to obtain three distinct derived circuits. In order to illustrate the principles of the invention an arrangement is shown for interposing three independent one-way repeaters between two sections of the concentric conductor, each repeater corresponding to one of the three derived circuits. The concentric conductor arrangement comprises four tubular conductors, A, B, C and D, so connected that conductors A and B constitute one transmission circuit, conductors B and C a second transmission circuit, and conductors C and D a third transmission circuit. Each conductor of a pair comprising an independent transmission circuit acts as a return for the other conductor of the pair. The section of concentric conductors A, B, C and D is to be connected through three repeaters, one for each circuit, to a similar section of multiple concentric conductors comprising conductors A′, B′, C′, and D′, these latter conductors being also arranged to constitute three independent conducting systems.

Each of the conductors B, C, and D is terminated in a shielding compartment, these compartments being shown at B_1, C_1, and D_1, respectively, and being arranged one within the other. Likewise each of the conductors B′, C′, and D′ is terminated in a shielding compartment, these compartments being shown at B_1', C_1', and D_1'.

In order to connect the repeater CDR between the two sections of circuit comprising conductors C—D and C′—D′, respectively, the terminals of the input transformer of the amplifier are connected, respectively, to two concentric conductors C_5 and D_5 which are in turn connected to the shielding compartments C_1 and D_1. Likewise the terminals of the output transformer of the repeater are connected to two concentric conductors C_5' and D_5' which are in turn connected to the shielding compartment C_1' and D_1'. By this arrangement the circuit comprising conductors C and D is connected to the input of the repeater CDR through the shielding compartments C_1 and D_1 and concentric conductors C_5 and D_5, the circuit comprising conductors C′ and D′ being likewise connected

to the output of the repeater through the shielding elements C_1' and D_1' and through the concentric conductors C_5' and D_5'. The repeater CDR itself is shielded by means of a shielding compartment D_6 connected to the conductors D_5 and D_5'. If desired, the stages of the amplifier may be shielded from each other by the provision of shielding partitions in the compartment D_6 as shown.

Since the repeater CDR must have its filament grounded to the surrounding shield D_6, the outer conductors D and D′ and the corresponding compartments D_1 and D_1' will be grounded. This of course does not produce any effect on the currents flowing over the several concentric conductors A, B, C and D as the electric field between conductors C and D, for example, and substantially the entire magnetic field, due to the current flow over said conductors, is confined within the outer conductor D.

The repeater BCR, for interconnecting the circuit comprising conductors B—C to the circuit comprising the conductors B′—C′, and the repeater ABR, for similarly connecting the circuit comprising conductors A—B to the circuit comprising conductors A′—B′, are likewise included in shielded compartments C_6 and B_6, which will likewise be grounded in order to provide a ground connection for the filaments of the amplifier contained within the shielding compartments of the repeaters. The two concentric conductor sections comprising conductors B_4 and C_4 and conductors B_4' and C_4' for connecting the repater BCR to the circuit including conductor sections B—C and B′—C′, respectively, must pass into the proper shielding compartments of the four-conductor system through the outer compartments D_1 and D_1'. Likewise the concentric conductor sections A_3—B_3 and A_3'—B_3' for connecting repeater ABR to the circuit sections comprising conductors A—B and A′—B′, respectively, must also pass through the outer shielding compartments D_1 and D_1'. These outer compartments D_1 and D_1' are grounded, and since the conductors A, B, and C and likewise the conductors A′, B′, and C′ are not at ground potential, it is necessary to establish the connections to the repeaters ABR and BCR by means of transformers.

Accordingly the conductor system B—C is associated with the conductor system B_4—C_4 through a transformer BCT_4 having its terminals connected between the shielding elements B_1 and C_1 and having its secondary connected to the conductors B_4 and C_4. The transformer is thus included within a shielding compartment to shield it from external influence. The primary and secondary windings of the transformer are likewise provided with separate shields for reducing the effect of capacity between the windings. In a similar manner the conductors B′ and C′ are associated with the conductors B_4' and C_4' through a transformer BCT_4' having the terminals of its primary winding connected to the shielding compartments B_1' and C_1' and having its secondary winding connected to the conductors B_4' and C_4'. The outer conductors C_4 and C_4' while conductively related to the shielding compartments D_1 and D_1' are insulated from the shielding compartments C_1 and C_1'.

A further complication in establishing the connections to the repeater ABR arises from the fact that the concentric conductors B_3 and B_3' must in effect pass through all three of the shielding compartments associated with the main concentric conductor sections. The outer compartment such as D_1 is grounded, the next compartment C_1 is at a different potential from ground, and the inner compartment B_1 is at still a different potential. Therefore the circuit comprising conductors A and B is connected through a transformer ABT_2 whose primary winding has its terminals connected to conductors A and B and whose secondary winding has its terminals connected to a short concentric conductor section comprising conductors A_2 and B_2 extending through the inner compartment B_1 and to the intermediate compartment C_1. The outer conductor B_2 is directly connected to the shielding compartment C_1 but is insulated from the inner shielding compartment B_1. The outer conductor of the concentric conductor section A_3—B_3 is connected directly to the outer shielding compartment D_1 and the two concentric conductor sections A_2—B_2 and A_3—B_3 are then interconnected through a transformer ABT_3 having its primary winding connected to the conductors A_2 and B_2 and its secondary winding connected to the conductors A_3 and B_3. This transformer by being included between the compartments C_1 and D_1 is shielded from external influences and each of its windings is separately shielded one from another to reduce the effect of the capacity between windings.

Similarly the concentric conductor section A_3'—B_3' is connected through a transformer ABT_3' to a short concentric conductor system A_2'—B_2' passing from the compartment C_1' to the inner compartment B_1' and insulated from the latter. The concentric conductor section A_2'—B_2' is in turn connected through a transformer ABT_2' to the circuit comprising concentric conductors A′ and B′. The capacity between the windings of the transformers ABT_3' and ABT_2' is reduced by the provision of shielding arrangements between the windings.

Notwithstanding the fact that the individual repeaters of each of the three transmission systems above described have their shielding compartments grounded and connected together, the above described arrangement enables the connections from the repeaters to be

made to the transmission circuits which have their potentials above ground without objectionable mutual interference. Let us assume that due to signaling currents passing over the circuit section comprising conductors C and D a potential difference exists between those two conductors. This produces a corresponding potential difference between the shielding compartments C′ and D′ so that current flows through the primary winding of the input transformer of the repeater CDR and the signal is passed through the repeater. Conductors D, D_1, D_5, and D_6 are at ground potential and hence current flows to ground through the primary winding of the input transformer of the repeater CDR. If it were not for the shielding arrangements above described, current due to the potential of the conductor C_1 would find an alternative path to ground from the inner shielding compartment C_1 through the capacity between the windings of the transformer BCT_4 and thence over the outer conductor C_4 to ground. Since this current would pass through the primary windings of the transformer BCT_4, a disturbing current would be induced in the secondary winding of the transformer which would be transmitted to the repeater BCR over the conductors B_4 and C_4. This is prevented, however, due to the double shielding arrangement between the windings of the transformer BCT_4 which provides a path to ground from the inner shielding conductor C_1 directly across the capacity between the two shields of the windings of the transformer BCT_4 and thence to the conductor C_4 without passing through the capacity between the windings of the transformer, the capacities between the windings being in effect short-circuited by the two shielding elements.

The potential difference between the conductors C and D might also cause a disturbing effect upon the repeater ABR were it not for the shielding arrangements already described. This is due to the fact that a path from the conductor C_1 to ground would exist through the primary winding of the transformer BCT_4, and thence through the capacity between the windings of the transformer ABT_2 to the outer conductor A_2, and thence through the capacity between the windings of the transformer ABT_3 to the grounded conductor B_3. The current flowing through the primary of the transformer ABT_2 would induce a current in the secondary winding of said transformer which would be transmitted through the transformer ABT_3 to the repeater ABR. The effect upon the transformers ABT_2 and ABT_3 is prevented by the double shielding between the windings of said transformers which causes the disturbing current to pass to ground through the capacities between the shields of the transformers without passing through the capacity between the windings of the transformers. This would still leave a current flowing through the primary of the transformer BCT_4 which would cause a disturbance in the repeater BCR but this is prevented by reason of the fact that both conductors C_1 and B_1 are at the same potential with respect to a potential difference between C_1 and D_1 due to the connection from the conductors C_1 through the outer conductor B_2 of the concentric section A_2—B_2 and thence through the capacity between the two shields of the windings of the transformer ABT_2 to the left-hand terminal of the transformer BCT_4. This connection prevents any potential difference existing across the terminals of the primary of the transformer BCT_4 due to a potential difference between the conductors C_1 and D_1.

Let us now consider the case of a signaling potential difference between the conductors B and C. Such a difference in potential would cause a current to flow from the conductor C_1 through the primary winding of the transformer BCT_4 to the conductor B_1, thereby inducing a current in the secondary winding of the transformer BCT_4 which is transmitted over the concentric conductor section B_4—C_4, to the repeater BCR. The corresponding signal will therefore be transmitted through the repeater. Due to the potential difference between conductors B_1 and C_1 a path to ground exists from the conductor C_1 through the capacity of the double shielding arrangement of the transformer BCT_4 and over the outer conductor C_4. A disturbing current which might be expected to reach ground from the conductor C_1 over the inner conductor C_5 and through the primary of the input transformer of the repeater CDR and thence over the outer conductor D_6 to ground, does not exist due to the fact that both terminals of the input transformer of the repeater CDR are at ground potential with respect to a potential difference between conductors B_1 and C_1 by reason of the direct connection from the lower terminal of the input winding of the repeater over conductor D_5, over conductor D_1, conductor C_4, capacity between the shields of the transformers BCT_4, and thence over conductor C_5 to the upper terminal of the input transformer of the repeater CDR.

The potential difference between the conductors B_1 and C_1 might also be expected to produce a disturbance in the repeater ABR due to the path to ground from the conductor B_1 through the capacity between the windings of the transformer ABT_2 over the conductor B_2 and through the capacity between the windings of the transformer ABT_3 and thence over outer conductor B_3 to ground. The current flowing over this path would produce disturbing impulses in the secondary windings of the transformers ABT_2 and

ABT_3 were it not for the double shielding arrangements provided between the windings of each transformer which in effect short-circuit the capacities between the windings of the two transformers so that current passes to ground from the conductor B_1, through the capacity between the shields of the transformer ABT_2, over the conductor B_2, and through the capacity between the shields of the transformer ABT_3, and thence to ground over the conductor B_3 without producing a disturbing effect in the secondary windings of the two transformers.

Finally, let us suppose that a signaling potential difference exists between the conductors A and B causing current to flow through the primary winding of the transformer ABT_2, so that the signal will be transmitted through the transformer ABT_2, over the conductors A_2 and B_2, and through the transformer ABT_3, and thence over the conductors A_3 and B_3 to the repeater ABR. A path to ground now exists from the conductor B_1 through the capacity between the double shielding arrangement of the transformer ABT_2, over the conductor B_2, through the capacity of the double shielding arrangement of the transformer ABT_3, and over the outer conductor B_3 to ground. An alternative path to ground might be expected to exist from the conductor B_1 through the primary of the transformer BCT_4, through the inner conductor C_5, and through the primary winding of the input transformer of the repeater CDR, and thence over the conductor D_6 to ground. Current flowing in this path would produce a disturbing impulse in both repeaters BCR and CDR. Such disturbing current does not flow, however, due to the fact that both terminals of the primary of the transformer BCT_4 are at the same potential with respect to a potential difference between conductors A and B due to the connection from the right-hand terminal of the primary winding of the transformer BCT_4 over the conductor C_1, over the outer conductor B_2, and through the capacity between the double shielded arrangement of the transformer ABT_2 to the left-hand terminal of the transformer BCT_4. Likewise both terminals of the input transformer of the repeater CDR are at the same potential due to the connection from the lower terminal over the conductor D_5, thence over conductor D_1, outer conductor C_4, and the capacity between the shielding arrangement of the transformer BCT_4, and thence over the conductor C_5 to the upper terminal of the input winding of the transformer of the repeater CDR. Consequently, no disturbing influence results in either of the repeaters BCR and CDR due to a potential difference across the conductors A and B.

It will be obvious that the general principles herein disclosed may be embodied 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. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from the translating device of another circuit passing through the outer compartment to an inner compartment, and a transformer within said last mentioned compartment for associating said last mentioned shielded connections with the circuit formed by the concentric conductor connected to said inner compartment and the concentric conductor within said last mentioned conductor.

2. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from the translating device of another circuit passing through the outer compartment to an inner compartment and a transformer within said last mentioned compartment for associating said last mentioned shielded connections with the circuit formed by the concentric conductor connected to said inner compartment and the concentric conductor within said last mentioned conductor, said transformer having double shielding between its windings.

3. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment

and the next compartment in order to the translating device of one circuit, shielded connections from the translating device of another circuit passing through the outer compartment to an inner compartment, a transformer within said last mentioned compartment for associating said last mentioned shielded connections with the circuit formed by the concentric conductor connected to said inner compartment and the concentric conductor within said last mentioned conductor, said transformer having double shielding between its windings, and means to shield each of said translating devices.

4. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from the translating device of another circuit passing through the outer compartment to an inner compartment, a transformer within said last mentioned compartment for associating said last mentioned shielded connections with the circuit formed by the concentric conductor connected to said inner compartment and the concentric conductor within said last mentioned conductor, said transformer having double shielding between its windings, and means to shield each of said translating devices, said shielding means being grounded.

5. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from a second translating device extending through the outer compartment and the next compartment in order to the interior of said next compartment, and a transformer within said next compartment for associating said shielded connections with the circuit comprising the conductor connected to said next compartment and the succeeding inner conductor.

6. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from a second translating device extending through the outer compartment and the next compartment in order to the interior of said next compartment, a transformer within said next compartment for associating said shielded connections with the circuit comprising the conductor connected to said next compartment and the succeeding inner conductor, said transformer having double shielding between its windings.

7. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associated each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from a second translating device extending through the outer compartment and the next compartment in order to the interior of said next compartment, a transformer within said next compartment for associating said shielded connections with the circuit comprising the conductor connected to said next compartment and the succeeding inner conductor, said transformer having double shielding between its windings, and means to shield each of said translating devices.

8. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from a second translating device extending through the out-

er compartment and the next compartment in order to the interior of said next compartment, a transformer within said next compartment for associating said shielded connections with the circuit comprising the conductor connected to said next compartment and the succeeding inner conductor, said transformer having double shielding between its windings, and means to shield each of said translating devices, said shielding means being grounded.

9. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from a second translating device extending through the outer compartment and the next compartment in order to the interior of said second compartment, a transformer within said next compartment for associating said shielded connections with the circuit comprising the conductors connected to said next compartment and the succeeding inner conductor, shielded connections from a third translating device extended through the compartments in order to the innermost compartment, and a transformer within the innermost compartment for associating said last mentioned shielded connections with the circuit formed by the concentric conductor connected to said innermost compartment and the extreme innermost conductor.

10. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from a second translating device extending through the outer compartment and the next compartment in order to the interior of said second compartment, a transformer within said next compartment for associating said shielded connections with the circuit comprising the conductors connected to said next compartment and the succeeding inner conductor, shielded connections from a third translating device extended through the compartments in order to the innermost compartment, and a transformer within the innermost compartment for associating said last mentioned shielded connections with the circuit formed by the concentric conductor connected to said innermost compartment and the extreme innermost conductor, said transformers having double shielding between their windings.

11. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from a second translating device extending through the outer compartment and the next compartment in order to the interior of said second compartment, a transformer within said next compartment for associating said shielded connections with the circuit comprising the conductors connected to said next compartment and the succeeding inner conductor, shielded connections from a third translating device extending through the compartments in order to the innermost compartment, a transformer within the innermost compartment for associating said last mentioned shielded connections with the circuit formed by the concentric conductor connected to said innermost compartment and the extreme innermost conductor, said transformers having double shielding between their windings, and means to shield each of said translating devices.

12. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other, there being one shielded compartment connected to each concentric conductor except the inner conductor, shielded connections from the outer compartment and the next compartment in order to the translating device of one circuit, shielded connections from a second translating device extending through the outer compartment and the next compartment in order to the interior of said second compartment, a transformer within said next compartment for associating said shielded connections with the circuit comprising the conductors connected

to said next compartment and the succeeding inner conductor, shielded connections from a third translating device extending through the compartments in order to the innermost compartment, a transformer within the innermost compartment for associating said last mentioned shielded connections with the circuit formed by the concentric conductor connected to said innermost compartment and the extreme innermost conductor, said transformers having double shielding between their windings, and means to shield each of said translating devices, said shielding means being rounded.

13. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other and individually connected to certain of said concentric conductors, shielded connections leading from the compartments to said translating devices, and transformers within said compartments for associating said shielded connections with the concentric conductors comprising each transmission circuit.

14. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other and individually connected to certain of said concentric conductors, shielded connections leading from the compartments to said translating devices, and transformers within said compartments for associating said shielded connections with the concentric conductors comprising each transmission circuit, said transformers having double shielding between their windings.

15. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other and individually connected to certain of said concentric conductors, shielded connections leading from the compartments to said translating devices, transformers within said compartments for associating said shielded connections with the concentric conductors comprising each transmission circuit, said transformers having double shielding between their windings, and means to shield each of said translating devices.

16. In a multiple concentric conductor system of which the conductors are connected to form a plurality of independent transmission circuits, a separate translating device for each circuit, and means to associate each translating device with a corresponding transmission circuit, said means comprising a plurality of shielded compartments one within the other and individually connected to certain of said concentric conductors, shielded connections leading from the compartments to said translating devices, transformers within said compartments for associating said shielded connections with the concentric conductors comprising each transmission circuit, said transformers having double shielding between their windings, and means to shield each of said translating devices, said shielding means being grounded.

17. A system comprising two coaxial conductor circuits whose conductors are at different potentials with respect to ground, and means to connect said circuits in tandem, said means including a double shielded transformer.

18. A system of transmission circuits derived from a plurality of conductors arranged concentrically, certain of said conductors being used jointly in two different transmission circuits, a second system of transmission circuits wherein each transmission circuit is derived from two separate concentric conductors, connections for joining together corresponding circuits of the two systems, and means for avoiding inter-circuit interference interposed in said connections.

19. A system of transmission circuits derived from a plurality of conductors arranged concentrically, certain of said conductors being used jointly in two different transmission circuits, a second system of transmission circuits in which each transmission circuit consists of two conductors arranged concentrically, each conductor being used in only one transmission circuit, and connections for joining together corresponding circuits of the two systems, said connections being such as to preserve the shielding which is provided by the concentric conductor transmission systems.

20. A system of transmission circuits derived from a plurality of conductors arranged concentrically, certain of said conductors being used jointly in two different transmission circuits, a second system of transmission circuits in which each transmission circuit consists of two conductors arranged concentrically, each conductor being used in only one transmission circuit, and connections for joining together corresponding circuits of the two systems, said connections including shielding compartments whose walls have thickness comparable with the thickness of

the walls of the concentric conductors to which the shielding compartments are connected.

21. A system of transmission circuits derived from a plurality of conductors arranged concentrically, certain of said conductors being used jointly in two different transmission circuits, a second system of transmission circuits in which each transmission circuit consists of two conductors arranged concentrically, each conductor being used in only one transmission circuit, and connections for joining together corresponding circuits of the two systems, said connections including means to shield the circuits from interference due to external causes.

22. A system of transmission circuits derived from a plurality of conductors arranged concentrically, certain of said conductors being used jointly in two different transmission circuits, a second system of transmission circuits in which each transmission circuit consists of two conductors arranged concentrically, each conductor being used in only one transmission circuit, and connections for joining together corresponding circuits of the two systems, said connections being such as to preserve the shielding which is provided by the concentric conductor transmission systems, and means for amplifying the signal energy in said second system of transmission circuits.

23. A system of transmission circuits derived from a plurality of conductors arranged concentrically, certain of said conductors being used jointly in two different transmission circuits, a second system of transmission circuits in which each transmission circuit consists of two conductors arranged concentrically, each conductor being used in only one transmission circuit, and connections for joining together corresponding circuits of the two systems, said connections including shielding compartments whose walls have thickness comparable with the thickness of the walls of the concentric conductors to which the shielding compartments are connected, and means for amplifying the signal energy in said second system of transmission circuits.

24. A system of transmission circuits derived from a plurality of conductors arranged concentrically, certain of said conductors being used jointly in two different transmission circuits, a second system of transmission circuits in which each transmission circuit consists of two conductors arranged concentrically, each conductor being used in only one transmission circuit, and connections for joining together corresponding circuits of the two systems, said connections including means to shield the circuits from interference due to external causes, and means for amplifying the signal energy in said second system of transmission circuits.

In testimony whereof, I have signed my name to this specification this 8th day of May, 1930.

RALPH G. McCURDY.