June 12, 1923. 1,458,193

H. S. OSBORNE

MULTIPLE BALANCING ARRANGEMENT FOR MULTIPLEX TRANSMISSION

Original Filed Sept. 13, 1919

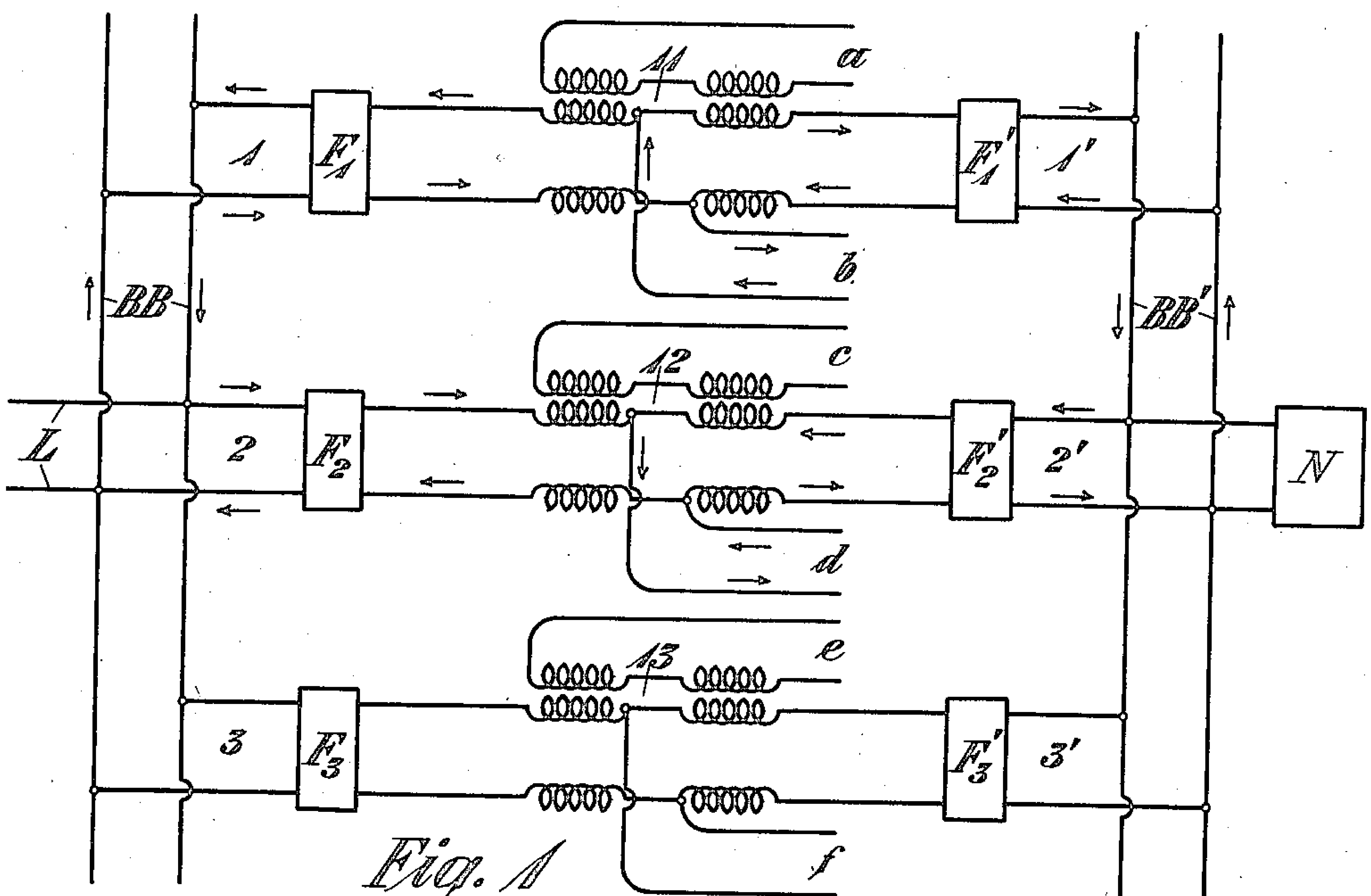

Fig. 1

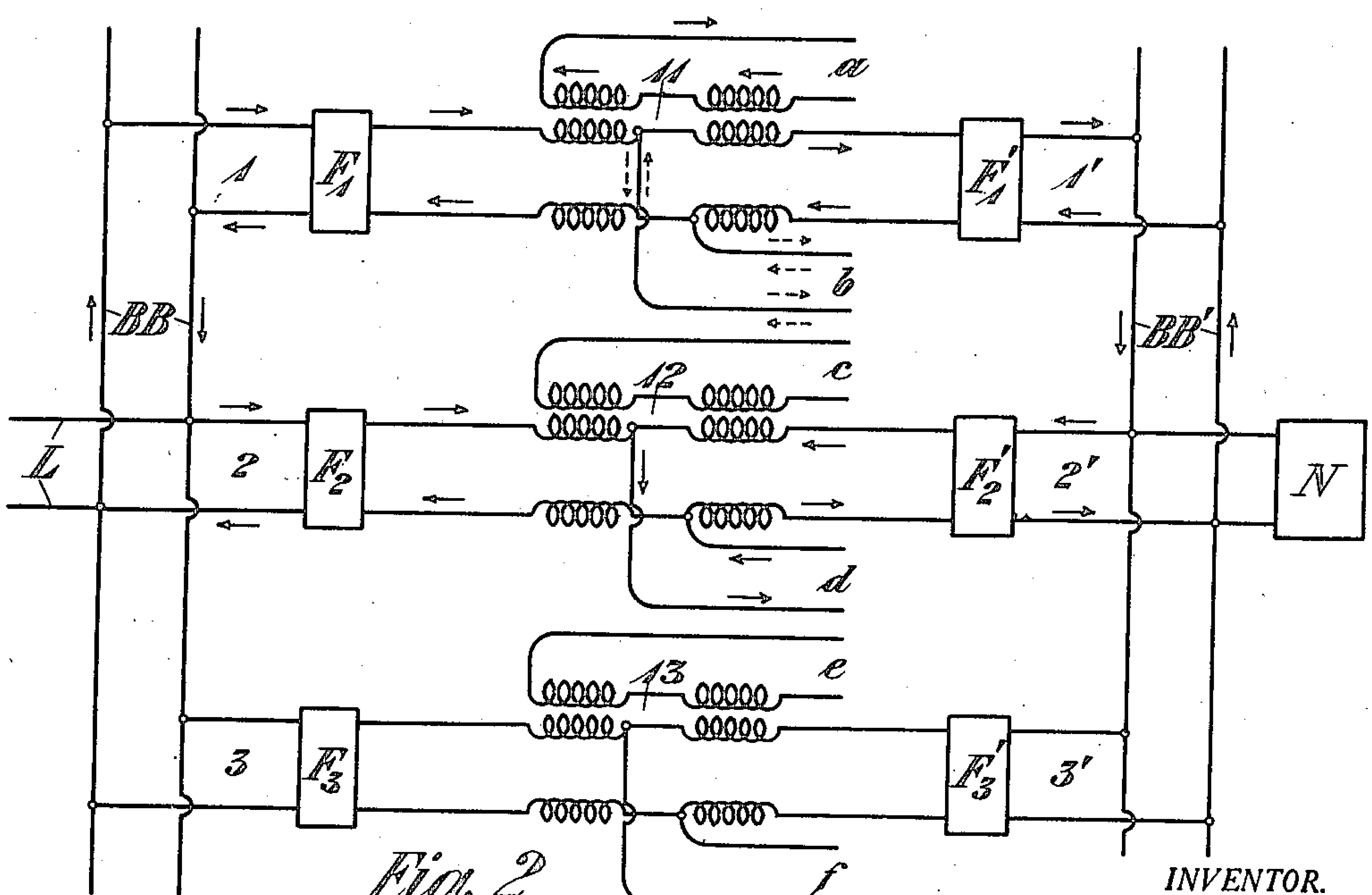

Fig. 2

INVENTOR.
H. S. Osborne
BY
[signature]
ATTORNEY

Patented June 12, 1923. 1,458,193

UNITED STATES PATENT OFFICE.

HAROLD S. OSBORNE, OF MONTCLAIR, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

MULTIPLE BALANCING ARRANGEMENT FOR MULTIPLEX TRANSMISSION.

Application filed September 13, 1919, Serial No. 323,504. Renewed November 14, 1922. Serial No. 600,986.

To all whom it may concern:

Be it known that I, HAROLD S. OSBORNE, residing at Montclair, in the county of Essex and State of New Jersey, have invented certain Improvements in Multiple Balancing Arrangement for Multiplex Transmission, of which the following is a specification.

This invention relates to the art of signalling, and more particularly to systems in which a plurality of signals may be transmitted over a common medium of communication.

One feature of the invention resides in an arrangement whereby a common transmission circuit, over which a plurality of signals may be simultaneously transmitted, may be balanced with regard to all of the signalling channels by a single balancing network or artificial line, and in which the signalling channels are associated with the main transmission circuit and the artificial line through the medium of parallel connecting circuits.

Another feature of the invention resides in an arrangement of the terminal connections of the parallel connecting circuits of a system of the character just described in such a manner that the relation of conjugacy between the channels associated with different connecting circuits may be varied as desired.

Other and further objects of the invention will be clear from the following description when read in connection with the appended drawing, Figure 1 of which illustrates a circuit arrangement in which the normal conjugate relations exist between the several signalling channels, and Figure 2 of which illustrates an arrangement of the connecting circuits such that the relation of conjugacy between different channels may be varied.

Referring to Fig. 1, L designates a transmission circuit which may be either a transmission line or the antenna of a wireless system, while N designates an artificial line or balancing network for balancing the line L with regard to a plurality of signalling channels *a*, *b*, *c*, *d*, *e*, and *f*. In order to associate the signalling channels with the transmission circuit L and the artificial line N, the circuit L is provided with bus-bars BB, and the artificial line N is provided with bus-bars BB′. Between the two sets of bus-bars parallel connecting circuits 1, 1′, 2, 2′, 3, 3′ are connected. A pair of signalling channels is associated with each connecting circuit in such a manner that the two signalling channels will be conjugate with respect to each other, that is, they will be so related that a disturbance arising in one will be substantially without effect upon the other. Thus the signalling channel *a* is associated in series inductive relation with the connecting circuit 1, 1′ through a balancing transformer arrangement 11 of well known type, while the channel *b* is arranged in bridged relation to the connecting circuits by having its terminals connected across mid points of the windings of the transformer 11. Channels *c* and *d* are similarly associated with the connecting circuit 2, 2′ through the balanced transformer 12, while channels *e* and *f* are in a like manner associated with the connecting circuit 3, 3′ through the transformer arrangement 13.

It will be clear from the arrangement above described that channels *a* and *b* are conjugate with respect to each other, and that in a similar manner the other pairs of signalling channels are also conjugate. Since the pairs of signalling channels are similarly associated with the connecting circuits, and the connecting circuits are symmetrically connected to the bus-bars of the line and artificial line, a condition of conjugacy exists between a channel associated in either bridged or a series inductive relation with a given connecting circuit, and the channels oppositely associated with each of the other connecting circuits. Such a channel will, however, be non-conjugate with respect to channels associated with other connecting circuits in the same manner in which it is associated with its own connecting circuit. For example, a current flowing in the channel *d* in the direction indicated by the arrows will flow over the sections 2 and 2′ of its connecting circuit, over the bus-bars BB and BB′ and over the sections 1 and 1′ of the connecting circuit with which channels *a* and *b* are associated, as indicated by the arrows. It will be apparent from the directional relation of the currents as indicated by the arrows that the current in the two halves of the primary windings of the transformers 11 and 12 will flow in opposite directions, so that no current is induced in the secondary windings; consequently no current will flow in channels *a* and *c*. The currents flowing in the two halves of the primary windings of the transformer 11, however, are cumulative with respect to the channel *b*, so that a current flows in said channel. It will also be obvious that in response to a current flowing in the channel *d*, a current will flow in the channel *f*, but not in the channel *e*.

The effect of the relations of conjugacy existing between the several channels is such that substantially no interference will occur between channels connected in bridged relation and channels connected in series inductive relation, but interference is possible between channels connected in the same relation. The interference between channels connected in the same relation may be practically eliminated by means of frequency separation between the channels. For this purpose filters F_1, F_2, and F_3 may be inserted in the sections 1, 2 and 3 of the connecting circuits, and similar filters F_1', F_2' and F_3' may be inserted in the sections 1′, 2′, 3′. These filters may be of any character suitable to produce the desired degree of separation, such as tuned circuits or broad band filters of the type described in the United States patents to George A. Campbell No. 1,227,113 and 1,227,114, dated May 22, 1917.

It is frequently desirable that a condition of conjugacy should exist between channels which are associated with different connecting circuits in the same manner, since a bridged channel and a channel arranged in series inductive relation to the bridged circuit are not always equally suitable for all uses; for example a bridged channel is preferable for the receiving end of a vacuum tube repeater, and is very much preferable for the connection of direct current circuits, it being impractical to use series inductive circuits for direct current signalling without largely increased energy losses.

Two bridged channels may be balanced with respect to each other by employing the system of connections illustrated in Fig. 2. It will be noted that in Fig. 2 the arrangement of the several parts is practically the same as in Fig. 1, the only difference being that section 1 of connecting circuit 1, 1′ has its connections to the bus-bars BB reversed with respect to the connections shown in Fig. 1. By this simple expedient of reversing the connections, the relation of conjugacy between the several channels is altered. Channels *a*, *d*, and *f* are now conjugate with respect to *b*, *c*, and *e*, whereas in the case of Fig. 1, channels *a*, *c*, and *e* were conjugate with respect to channels *b*, *d*, and *f*. This interchange of the conjugate relations will be apparent from the consideration of the directions of current flow in the several circuits in response to a disturbance arising in the channel *d*. Current flowing in the channel *d* in the direction indicated by the arrows will flow over sections 2 and 2′, over bus-bars BB and BB′, and over section 1 and 1′ in the directions indicated by the arrows. It will be seen that the current flows in opposite directions in the two halves of the primary windings of the transformer 12, so that no current is induced in the channel *c*. Due to the interchange of connections between the section 1 and the bus-bars BB, however, the currents flowing in the two halves of the primary windings of the transformer 11 are series aiding, so that a current is induced in the channel *a*. The currents flowing in section 1 and 1′, however, are of such direction as to tend to produce oppositely directed currents in the channel *b*, so that no current actually flows in said channel. It will be apparent, therefore, that channels *b* and *d* are conjugate and that channels *a* and *c* are conjugate.

Since the relation of the bus-bar connections of the connecting circuits 2, 2′, and 3, 3′ are the same in Fig. 2 as already described in connection with Fig. 1, it follows that the same conditions as to conjugacy exist between channels *c*, *d*, *e*, and *f* as in Fig. 1. In other words, channels *c* and *e* are conjugate with respect to channels *d* and *f*.

While the invention has been illustrated in what is believed to be its preferred form, it will be obvious that the general principles herein described 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 signaling system, a transmission circuit, a balancing circuit therefor, bus-bars extending from each of said circuits, a plurality of parallel connecting circuits between said bus-bars, a signaling channel in bridged relation with respect to each of said connecting circuits, another signaling channel in series inductive relation with respect to each of said connecting circuits whereby the channels associated with a given connecting circuit are conjugate with respect to each other, and the connection between said connecting circuits and said bus-bars being so arranged that a channel in bridged relation with respect to a given connecting circuit will be conjugate with regard to a channel in bridged relation with another connecting circuit.

2. In a signaling system, a transmission circuit, a balancing circuit therefor, bus-bars extending from each of said circuits, a plurality of parallel connecting circuits between said bus-bars, a signaling channel in bridged relation with respect to each of said connecting circuits, another signaling channel in series inductive relation with respect to each of said connecting circuits whereby the channels associated with a given con-

necting circuit are conjugate with respect to each other, and the connection between said connecting circuits and said bus-bars being so arranged that a channel in series inductive relation with respect to a given connecting circuit will be conjugate with regard to a channel in series inductive relation with another connecting circuit.

3. In a signaling system, a transmission circuit, a balancing circuit therefor, bus-bars extending from each of said circuits, a plurality of parallel connecting circuits between said bus-bars, a signaling channel in bridged relation with respect to each of said connecting circuits, another signaling channel in series inductive relation with respect to each of said connecting circuits whereby the channels associated with a given connecting circuit are conjugate with respect to each other, and the connection between said connecting circuits and said bus-bars being so arranged that a channel in bridged relation with respect to a given channel will be conjugate with regard to a channel in briged relation with another connecting circuit and non-conjugate with regard to the channel in series inductive relation to said other connecting circuit.

4. In a signaling system, a transmission circuit, a balancing circuit therefor, bus-bars extending from each of said circuits, a plurality of parallel connecting circuits between said bus-bars, a signaling channel in bridged relation with respect to each of said connecting circuits, another signaling channel in series inductive relation with respect to each of said connecting circuits whereby the channels associated with a given connecting circuit are conjugate with respect to each other, and the connection between said connecting circuits and said bus-bars being so arranged that a channel in series inductive relation with respect to a given channel will be conjugate with regard to a channel in series inductive relation to another connecting circuit and non-conjugate with regard to the channel in bridged relation to said other connecting circuit.

5. In a signaling system, a transmission circuit, a balancing circuit therefor, bus-bars extending from each of said circuits, a plurality of parallel connecting circuits between said bus-bars, a signaling channel in bridged relation with respect to each of said connecting circuits, another signaling channel in series inductive relation with respect to each of said connecting circuits whereby the channels associated with a given connecting circuit are conjugate with respect to each other, and the connection between said connecting circuits and said bus-bars being so arranged that a channel in bridged relation with respect to a given connecting circuit will be conjugate with regard to channels in bridged relation with certain other connecting circuits and non-conjugate with regard to channels in bridged relation to the remaining connecting circuits.

6. In a signaling system, a transmission circuit, a balancing circuit therefor, bus-bars extending from each of said circuits, a plurality of parallel connecting circuits between said bus-bars, a signaling channel in bridged relation with respect to each of said connecting circuits, another signaling channel in series inductive relation with respect to each of said connecting circuits whereby the channels associated with a given connecting circuit are conjugate with respect to each other, and the connection between said connecting circuits and said bus-bars being so arranged that a channel in series inductive relation with respect to a given connecting circuit will be conjugate with regard to channels in series inductive relation to certain other connecting circuits and non-conjugate with regard to channels in series inductive relation to the remaining connecting circuits.

7. In a signaling system, a transmission circuit, a balancing circuit therefor, bus-bars extending from each of said circuits, a plurality of parallel connecting circuits between said bus-bars, a signaling channel in bridged relation with respect to each of said connecting circuits, another signaling channel in series inductive relation with respect to each of said connecting circuits whereby the channels associated with a given connecting circuit are conjugate with respect to each other, and the connection between said connecting circuits and said bus-bars being so arranged that a channel in bridged relation with respect to a given connecting circuit will be conjugate with regard to channels in bridged relation with certain other connecting circuits and conjugate with regard to channels in series inductive relation to the remaining connecting circuits.

8. In a signaling system, a transmission circuit, a balancing circuit therefor, bus-bars extending from each of said circuits, a plurality of parallel connecting circuits between said bus-bars, a signaling channel in bridged relation with respect to each of said connecting circuits, another signaling channel in series inductive relation with respect to each of said connecting circuits whereby the channels associated with a given connecting circuit are conjugate with respect to each other, and the connection between said connecting circuits and said bus-bars being so arranged that a channel in series inductive relation with respect to a given connecting circuit will be conjugate with regard to channels in series inductive relation to certain other connecting circuits and conjugate with regard to channels in bridged relation to the remaining connecting circuits.

9. In a signaling system, a transmission

line, a balancing circuit therefor, a plurality of connecting circuits between said line and balancing circuit, a pair of signaling channels associated with each connecting circuit, one signaling channel of each pair being so associated with the connecting circuit as to be conjugate with respect to the other signaling channel of the pair, and the connecting circuits being so arranged with respect to the line and balancing circuit that a channel associated with one of said connecting circuits will be conjugate with respect to a channel similarly associated with another of said connecting circuits.

In testimony whereof, I have signed my name to this speicfication this 12th day of September, 1919.

HAROLD S. OSBORNE.