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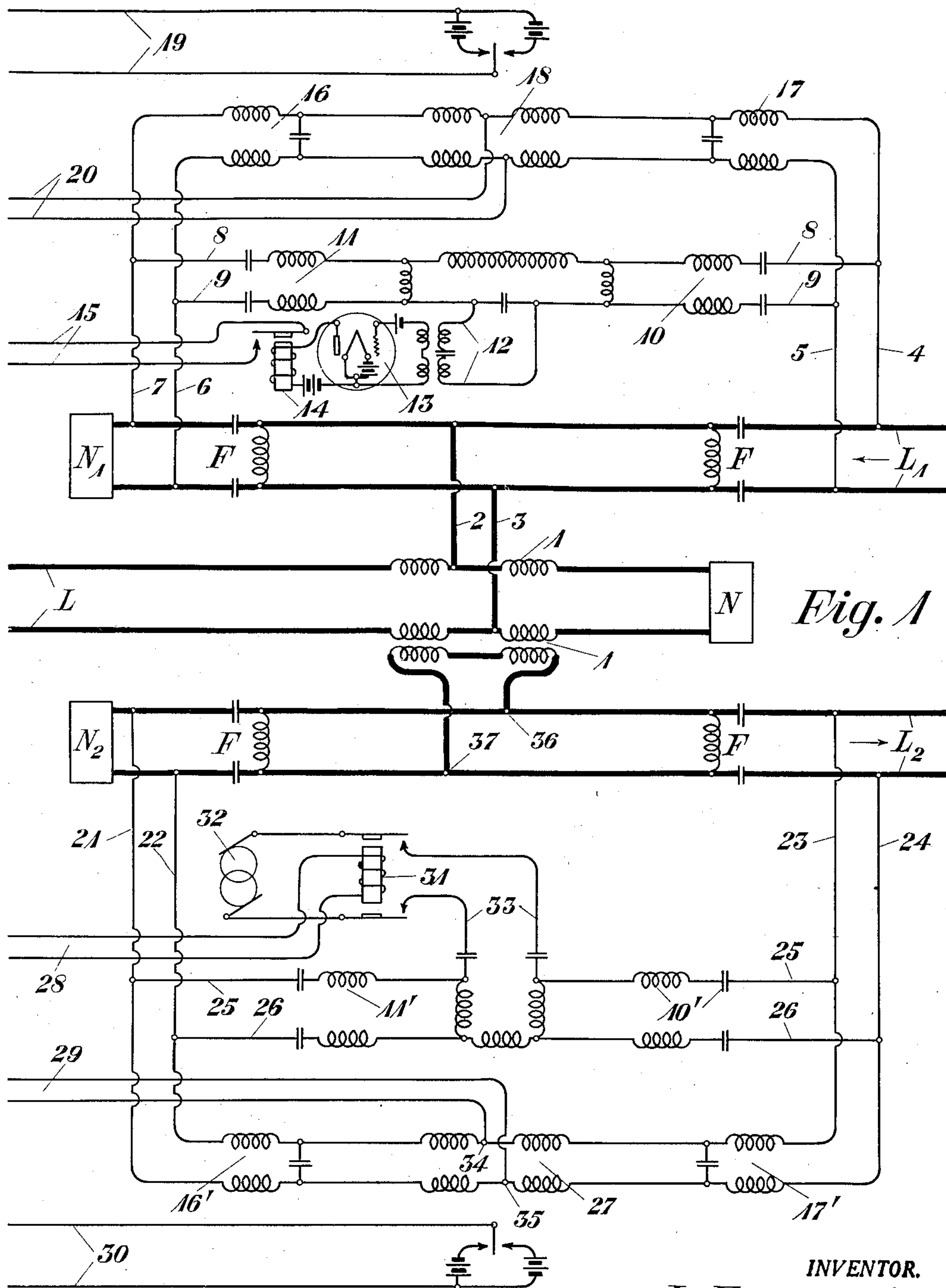
1,466,708

L. ESPENSCHIED

TRANSMISSION SYSTEM

Filed Sept. 26, 1919

2 Sheets-Sheet 1



INVENTOR.
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Sept. 4, 1923.

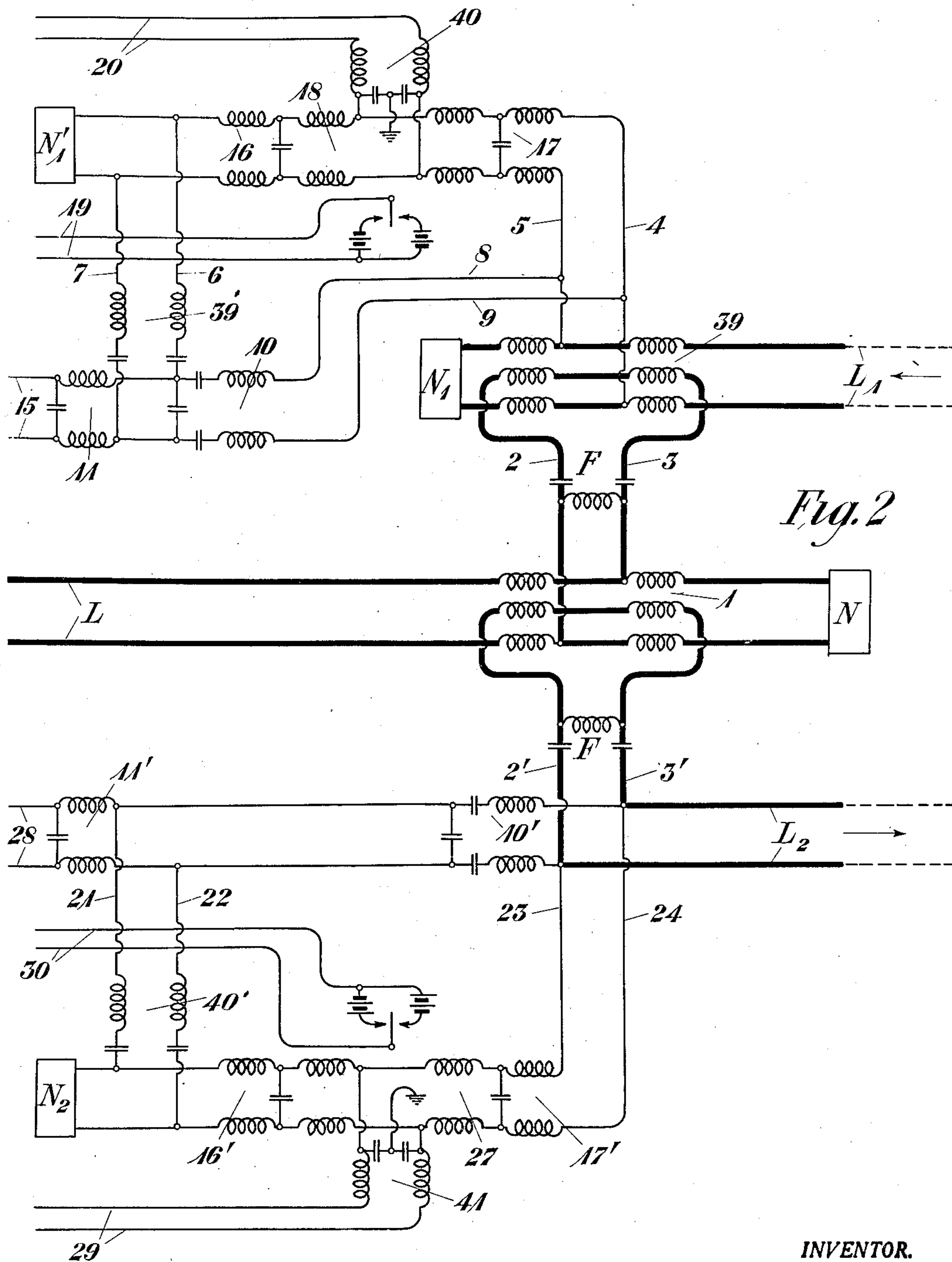
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Patented Sept. 4, 1923.

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UNITED STATES PATENT OFFICE.

LLOYD ESPENSCHIED, OF HOLLIS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TRANSMISSION SYSTEM.

Application filed September 26, 1919. Serial No. 326,523.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, in the county of Queens and State of New York, have invented certain Improvements in Transmission Systems, of which the following is a specification.

This invention relates to transmission systems and more particularly to multiplex systems employing carrier currents.

Where multiplex transmission is attained by the use of carrier currents a plurality of carrier frequencies are transmitted over a common transmission line, the carrier frequencies being separated sufficiently to prevent interference and each frequency being assigned for use as a separate channel of communication; so that signals, such for instance, as telephonic variations, may be transmitted by impressing them upon the carrier frequencies. Several channels may thus be superposed upon a common transmission line and the line may be thus utilized for multiplex transmission. It is furthermore desirable to transmit over a transmission line in addition to the carrier currents impressed thereon for telephonic purposes a carrier current or channel which may be utilized for signaling, ringing or other purposes and also to provide arrangements whereby D. C. Morse or telegraphic currents may be simultaneously transmitted over the line with the carrier currents.

It is a general purpose of this invention to provide arrangements whereby a telephone transmission line of the well-known four-wire type may be utilized for the multiplex transmission of currents for telephonic purposes, signaling purposes, and telegraphic purposes. A feature of the invention consists in providing at the two-wire terminals of a four-wire line means for transmitting a low frequency signaling channel over the outgoing two-wire portion of the four-wire line and means for receiving a low frequency signaling channel transmitted over the incoming two-wire portion of the four-wire lines, these signaling channels in each instance causing no interference with the telephonic channels. A further feature of the invention consists in the provision of arrangements whereby D. C. Morse or telegraphic currents may be transmitted and received over both the outgoing and incoming two-wire portions of the four-wire

line and without causing interference with the telephonic or signaling channels. Other and further features and objects of the invention will appear more fully from the detailed description hereinafter given.

The invention may be more fully understood with reference to the following description together with the accompanying drawing in the Figures 1 and 2 of which are illustrated circuit diagrams embodying a preferred arrangement of the invention and a modification thereof. Similar reference numerals have been used to designate like parts in both figures.

In Fig. 1 is illustrated a terminal two-wire line L of the well-known four-wire type of transmission line of which is shown a portion of the incoming line L_1 thereof and a portion of the outgoing line L_2 thereof, the line L_2 being coupled with line L by means of the three winding transformer 1, and the line L_1 being connected to the mid-points of windings of transformer 1 by conductors 2 and 3. Associated with line L is the artificial line N adapted to balance line L. Included in the lines L_1 and L_2 are the filter devices F. These filters may be of the type illustrated in U. S. Patents No. 1,227,113, and 1,227,114 issued to G. A. Campbell, and are designed to readily allow the transmission of currents used for telephonic purposes but which attenuate and practically extinguish currents of other frequencies, such for purposes of illustration as currents from 0 to 300 cycles. Accordingly by means of the filters F currents other than telephonic currents are prevented from being transmitted from lines L_1 and L_2 to line L and thus causing disturbance in the telephone apparatus associated with line L. Associated with line L_1 is a receiving circuit for the low frequency signaling currents coming in over line L_1 . This receiving circuit is tuned by means of the arrangements 10 and 11 of inductance and capacity to be resonant to the frequency of the currents for signaling. Accordingly such currents may readily be transmitted over the receiving circuit and currents of other frequencies may not be transmitted thereover. In place of the tuning devices 10 and 11 it is possible to use band filters if desired. The receiving circuit includes the rectifier 13, which for purposes of convenience is shown as of the vacuum bulb

type, and the direct current relay 14 whereby the signal receiving circuit 15 is controlled. Associated with line L_2 is a circuit arrangement whereby low frequency currents for signaling purposes may be applied to line L_2 for transmission thereover. This signaling current is applied to the signal transmitting circuit from the generator 32 which is controlled by relay 31 and the circuit 28. The signal transmitting circuit includes the devices 10' and 11', similar to devices 10 and 11 heretofore mentioned, and which serve to tune the circuit to be resonant to currents of the frequency used for signaling, thereby allowing such currents to be transmitted thereover and preventing the transmission thereover of currents of other frequencies. Associated with each of the lines L_1 and L_2 are telegraphic circuits whereby D. C. Morse or telegraphic currents may be transmitted or received over either of the lines L_1 or L_2 . The telegraph circuit associated with line L_1 includes the composite sets 16 and 17 and the polar relay 18. The composite sets 16 and 17 are adapted to readily allow the transmission of currents having a frequency suitable for telegraphic purposes but which serve to attenuate and shut out currents of other frequencies. The polar relay 18 controls the receiving circuit 19 for the incoming telegraphic impulses and by means of its polarized operation may cause impulses of both positive and negative polarity to be transmitted over circuit 19. Associated with the telegraph circuit is the transmitting circuit 20 whereby D. C. Morse impulses may be transmitted to the telegraph circuit and out over line L_1 . The telegraph circuit associated with line L_2 is similar to the one associated with line L_1 and includes the composite sets 16' and 17', the polar relay 27, the telegraph receiving circuit 30, and the telegraph transmitting circuit 29. Associated with lines L_1 and L_2 are the networks N_1 and N_2 respectively which are adapted to balance said lines for purposes which will be pointed out later.

The operation of the arrangements illustrated in Fig. 1 is as follows. Telephonic currents coming in over line L_1 will be transmitted through the filter F and over conductors 2 and 3 and thence over line L . These incoming telephonic currents will not be transmitted over the low frequency signaling receiving circuit however as this circuit being tuned to be resonant by devices 10 and 11 to currents of a frequency other than those used for telephonic purposes, will attenuate and practically extinguish such currents. Neither will these incoming telephonic currents be transmitted over the telegraph circuit associated with line L_1 as they will be extinguished by the composite sets 16 and 17. Telephonic currents applied to the

line L will be transmitted through transformer 1, through filter F, and out over line L_2 . These telephonic currents will not be transmitted over the telegraph circuit associated with line L_2 as they will be extinguished by the composite devices 16' and 17' included therein. Accordingly telephonic currents either coming in over line L_1 or transmitted out over line L_2 will cause no interference with the signaling or telegraph apparatus of the system.

The relatively low frequency currents used for signaling purposes coming in over line L_1 will not be transmitted through the filter F but will be transmitted over conductors 4 and 5 and thence over conductors 8 and 9 of the signaling receiving circuit. As has been already pointed out the signaling receiving circuit is tuned to be resonant to currents of a frequency used for signaling and will readily transmit such currents. These signaling currents will then be transmitted over circuit 12 and through the rectifier 13. Connected to the output of the rectifier 13 is the direct current relay 14 which will be actuated by these signaling currents. The relay 14 serves to control the circuit 15 which in turn may control any desirable signaling apparatus (not shown).

If it is desired to transmit low frequency signaling currents out over the line L_2 of the four-wire system, the circuit 28 may be closed by any suitable means and current transmitted thereover will operate relay 31. The operation of relay 31 will connect the generator 32 to circuit 33. The generator 32 may be of any desirable type which will generate current having a frequency suitable for signaling purposes, but it is desirable to employ a generator giving out as pure a wave form as possible and without harmonics. This signaling current applied to circuit 33 will be transmitted over conductors 25 and 26 of the signaling transmitting circuit, which as has been already pointed out is tuned to be resonant to currents of such frequency and will hence readily allow the transmission thereof, and will be transmitted from conductors 25 and 26 over conductors 23 and 24 and out over line L_2 . This signaling current applied from conductors 25 and 26 to the conductors 23 and 24 and the conductors 21 and 22 will normally not be transmitted over the telegraph circuit associated with line L_2 as the composite sets 16' and 17' are designed to shut out such current. However if the signaling current was of such a character that a portion thereof should leak through the composite set 17' this current would be met at points 34 and 35 by an equal and opposite current which would have been transmitted from conductors 21 and 22 through the composite set 16'. As these currents would be equal and opposite they would neutralize or balance

each other and accordingly would not effect polar relay 27. Furthermore these signaling currents transmitted from conductors 25 and 26 to conductors 21 and 22 and the conductors 23 and 24 would normally be extinguished by the filters F in line L_2 and hence would not be transmitted through transformer 1 and out over line L. However, if the signaling current generated contained harmonics of the original wave and such harmonics were of a frequency within the telephonic range, a portion of the signaling currents would be transmitted through both of the filters F. However these currents would be opposite and approximately equal and at points 36 and 37 would balance and neutralize each other and hence would not be transmitted through transformer 1 and out over line L. In order to insure that these currents will be approximately equal the network N_2 is provided which is adapted to simulate line L_2 in impedance value. In a similar manner the conductors 6 and 7 are provided associated with the line L_1 and the signaling receiving circuit associated with said line in order to neutralize and balance any of the telegraph currents transmitted over line L_1 which might leak through the filters F in such line. Accordingly the arrangements of the invention provide a means for receiving signaling currents coming in over one side of the four-wire line and transmitting signaling currents out over the other side of the four-wire line without causing any interference between them and telephonic or telegraphic circuits associated therewith.

If it is desired to transmit D. C. Morse or telegraphic currents out over line L_1 , such currents may be applied to circuit 20 and thence to the telegraph circuit associated therewith. These currents will readily be transmitted over the telegraph circuit as the composite devices 16 and 17 are designed to allow the transmission of currents used for telegraph purposes. These telegraph currents will then be applied to the conductors 6 and 7 and to conductors 4 and 5. From conductors 4 and 5 the telegraph currents will be transmitted out over line L_1 . Normally these telegraph currents will not be transmitted over line L as they will be shut out by filter F. Neither will these currents be transmitted over the signaling receiving circuit as the tuning devices 10 and 11 therein will render such circuit an inefficient path for the transmission of such currents. However any of such telegraph currents which might be of such a nature as to be transmitted from conductors 4 and 5 either through the tuning device 10 or the filter F would be neutralized by equal and opposite balancing currents which would be transmitted from conductors 6 and 7 and through the tuning device 11 or the left-

hand filter F. Accordingly telegraphic currents may be transmitted out over line L_1 without causing any disturbance with the telephonic or signaling arrangements of the system.

Telegraphic currents coming in over line L_1 would be attenuated and extinguished by filter F and tuning device 10 and would be transmitted over conductors 4 and 5 and through composite set 17 and would actuate the polarized relay 18. The polarity of the incoming telegraphic currents would determine the operation of polar relay 18 and upon the operation of this relay current of either polarity may be transmitted over the circuit 19 to apparatus (not shown) associated therewith and adapted to receive the telegraphic impulses. Associated with the telegraph circuit are the balancing conductors 6 and 7 which in the same manner as pointed out with respect to the signaling receiving circuit will serve to neutralize and balance any of the telegraphic impulses which may not be properly shut out by filter F or the tuning device 10, and accordingly an additional safeguard is provided against interference with the telephonic or signaling arrangements from the telegraph apparatus. As the arrangements for transmitting and receiving telegraphic impulses over line L_2 are substantially similar to those described with respect to line L_1 no further description thereof will be given.

In Fig. 2 is illustrated a modification of the arrangements illustrated in Fig. 1, in which a slightly different circuit arrangement is shown, similar numerals indicating like parts in both figures of the invention. The incoming two-wire line L_1 of the four-wire system is coupled through transformer 39 to the conductors 2 and 3, which are connected to the terminal two-wire line L. The line L_1 terminates in the network N_1 , adapted to balance said line. The outgoing two-wire line L_2 , of the four-wire system, is coupled to the terminal two-wire line L in the usual manner through the three-wire transformer 1. Included in conductors 2 and 3, and in conductors 2' and 3', are the filters F, adapted to readily allow the transmission of currents having a frequency suitable for telephonic purposes, but which attenuate and extinguish currents of other frequencies. Accordingly telephonic currents coming in over the line L_1 may be transmitted through transformer 39, over conductors 2 and 3, through the filter F, and over the line L. Telephonic currents applied to the line L may be transmitted through transformer 1, over conductors 2' and 3', through the filter F, and out over the line L_2 . However, currents having frequencies outside of the telephonic range of frequencies which may be applied either to the line L_1 or to the line L_2 will not be

transmitted over the line L , as they will be effectually attenuated by the filters F , and accordingly such currents will cause no interference with the telephonic apparatus associated with line L . Associated with line L_1 is a low frequency signaling receiving circuit terminating in circuit 15, adapted to receive the low frequency signaling currents coming in over line L_1 . Associated with line L_1 is a telegraphic circuit, with which are associated the circuits 19 and 20, whereby currents suitable for telegraphic purposes may either be received from the line L_1 or transmitted out over the line L_1 . Associated with line L_2 is a low frequency signaling transmitting circuit, terminating in the circuit 28, whereby low frequency signaling currents may be transmitted out over the line L_2 . Associated with line L_2 is a telegraphic circuit, with which are associated the circuits 29 and 30, whereby currents suitable for telegraphic purposes may either be received over the line L_2 or transmitted out over the line L_2 . The low frequency signaling receiving circuit associated with line L_1 includes the tuning devices 10 and 11, which serve to make the circuit resonant to the low frequency currents used for signaling purposes. Accordingly this circuit will readily allow the transmission of such currents, but will attenuate and extinguish currents of other frequencies. In a similar manner the low frequency signaling transmitting current associated with line 2 includes the tuning devices 10' and 11', which serve to make this circuit resonant to the low frequency currents used for signaling purposes, and accordingly tend to prevent the transmission over this circuit of currents of other frequencies. The low frequency signaling currents coming in over L_1 will be transmitted through transformer 39, and over conductors 4 and 5 and conductors 8 and 9, and through the tuning devices 10 and 11, and out over the circuit 15. The circuit 15 may include any suitable means for receiving these signaling currents. Accordingly the signaling currents coming in over the L_1 will cause no interference with the telephonic apparatus associated with the line L . These incoming signaling currents, furthermore, will cause no interference in the telegraphic circuit associated with line L_1 , as they will normally be attenuated and extinguished by the composite sets 16 and 17 included therein. Furthermore, the balancing conductors 6 and 7 are provided so that any of the incoming signaling currents, which might be transmitted through the composite set 17, would be opposed and neutralized by equal and opposite currents which would have been transmitted over the balancing conductors 6 and 7 and through composite set 16. Included in conductors 6 and 7 is the tuning device

39', similar to the tuning device 10, in order to balance the tuning device 10. Low frequencies signaling currents transmitted over circuit 28, and thence out over the line L_2 , will normally cause no interference with the telegraphic apparatus associated with the line L_2 , as such currents will be extinguished by the composite sets 16' and 17'. Furthermore, the balancing conductors 21 and 22 are provided, over which equal and opposite currents may be transmitted to neutralize any of the signaling currents which might be transmitted over conductors 23 and 24 and through the composite set 17'. The conductors 21 and 22 include the tuning device 40', adapted to balance the tuning device 10'. Associated with the telegraphic circuits are the additional composite sets 40 and 41. In other respects the telegraphic circuits associated with the lines L_1 and L_2 are substantially the same as already described with respect to Fig. 1, and no description thereof will be given.

While the invention has been disclosed in certain specific arrangements which have been deemed desirable, it is understood that it is capable of embodiment in many and widely varied forms without departing from the spirit of the invention as defined by the appended claims. For example, the circuit which has been referred to above and is specified in the claims below as a signaling channel may be used for carrier or alternating current telegraph transmission as well as for signaling of the type incident to telephone operating.

What is claimed is:

1. The combination of a four-wire transmission system including an incoming two-wire line and an outgoing two-wire line and a terminal two-wire line and arrangements whereby said system may be utilized for the simultaneous transmission of currents for purposes of telephoning, telegraphing and signaling, said arrangements comprising a circuit associated with said incoming two-wire line and adapted to efficiently transmit signaling currents coming in over said line, signaling apparatus controlled by said circuit, means in said circuit for preventing telephonic currents coming in over said two-wire line from being transmitted over said circuit, and means in said incoming two-wire line for preventing signaling currents coming in over said line from being transmitted from said line to said terminal line.

2. The combination of a four-wire transmission system including an incoming two-wire line and an outgoing two-wire line and a terminal two-wire line and arrangements whereby said system may be utilized for the simultaneous transmission of currents for purposes of telephoning, telegraphing and signaling, said arrangements comprising,

a circuit associated with said incoming two-wire line and adapted to efficiently transmit signaling currents coming in over said line, signaling apparatus controlled by said circuit, means in said circuit for preventing telephonic currents coming in over said two-wire line from being transmitted over said circuit, means in said incoming two-wire line for preventing signaling currents coming in over said line from being transmitted from said line to said terminal line, a circuit associated with said outgoing two-wire line and adapted to efficiently transmit currents suitable for signaling purposes, means for applying signaling currents to said circuit for transmission out over said outgoing two-wire line, means in said circuit for preventing telephonic currents transmitted over said outgoing line from being transmitted over said circuit, and means in said outgoing line for preventing the signaling currents applied thereto from being transmitted from said line to said terminal line.

3. A four-wire transmission system arranged for the simultaneous transmission over the four-wire portion thereof of currents for telephonic purposes, for signaling purposes, and for telegraphic purposes, means associated with the four-wire portions of said system at the terminals thereof for preventing the telephonic currents from interfering with the signaling or telegraphic apparatus of the system, means associated with the four-wire portions of said system at the terminals thereof for preventing the signaling currents from interfering with the telephonic or telegraphic apparatus of the system, and means associated with the four-wire portions of said system at the terminals thereof for preventing the telegraphic currents from interfering with the telephonic or signaling apparatus of the system.

4. The combination of a four-wire transmission system including an incoming two-wire line and an outgoing two-wire line and a terminal two-wire line and arrangements whereby said system may be utilized for the simultaneous transmission of currents for purposes of telephoning, telegraphing and signaling, said arrangements comprising a circuit associated with said incoming two-wire line and tuned to be resonant to signaling currents coming in over said line, signaling means controlled by said circuit, a second circuit associated with said incoming two-wire line, composite sets in said

second circuit adapted to readily allow the transmission of telegraphic currents and to shut out currents used for telephonic or signaling purposes, a telegraph receiving circuit and a telegraph transmitting circuit associated with said second circuit, and a filter included in said incoming two-wire line adapted to readily allow the transmission of telephonic currents and to attenuate and extinguish telegraphic and signaling currents.

5. The combination of a four-wire transmission system including an incoming two-wire line and an outgoing two-wire line and a terminal two-wire line and arrangements whereby said system may be utilized for the simultaneous transmission of currents for purposes of telephoning, telegraphing and signaling, said arrangements comprising, a circuit associated with said incoming two-wire line and tuned to be resonant to signaling currents coming in over said line, signaling means controlled by said circuit, a second circuit associated with said incoming two-wire line, composite sets in said second circuit adapted to readily allow the transmission of telegraphic currents and to shut out currents used for telephonic or signaling purposes, a telegraph receiving circuit and a telegraph transmitting circuit associated with said second circuit, a filter included in said incoming two-wire line adapted to readily allow the transmission of telephonic currents and to attenuate and extinguish telegraphic and signaling currents, a circuit associated with said outgoing two-wire line and tuned to be resonant to signaling currents transmitted out over said line, means for applying signaling currents to said circuit and out over said outgoing two-wire line, a second circuit associated with said outgoing two-wire line, composite sets in said last mentioned second circuit adapted to readily allow the transmission of telegraphic currents and to shut out currents used for telephonic or signaling purposes, a telegraph receiving and a telegraph transmitting circuit associated with said last mentioned second circuit, and a filter included in said outgoing two-wire line adapted to readily allow the transmission of telephonic current and to attenuate and extinguish telegraphic and signaling currents.

In testimony whereof, I have signed my name to this specification this 25th day of September 1919.

LLOYD ESPENSCHIED.