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3 SHEETS—SHEET 1.

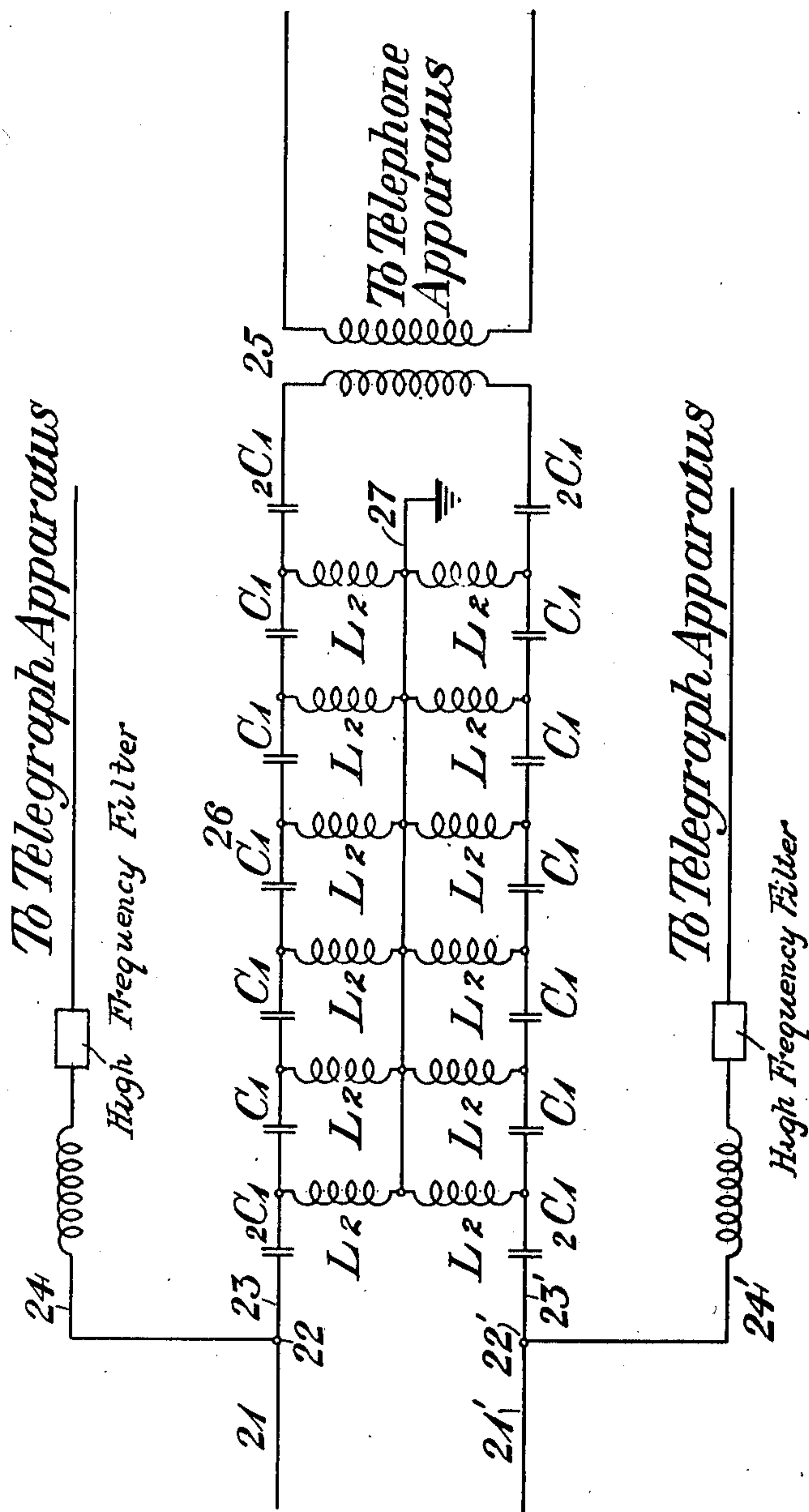


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H. S. OSBORNE.
COMPOSITE SIGNALING CIRCUITS.
APPLICATION FILED JUNE 8, 1917.

Patented Sept. 2, 1919.
3 SHEETS—SHEET 2.

Fig. 2

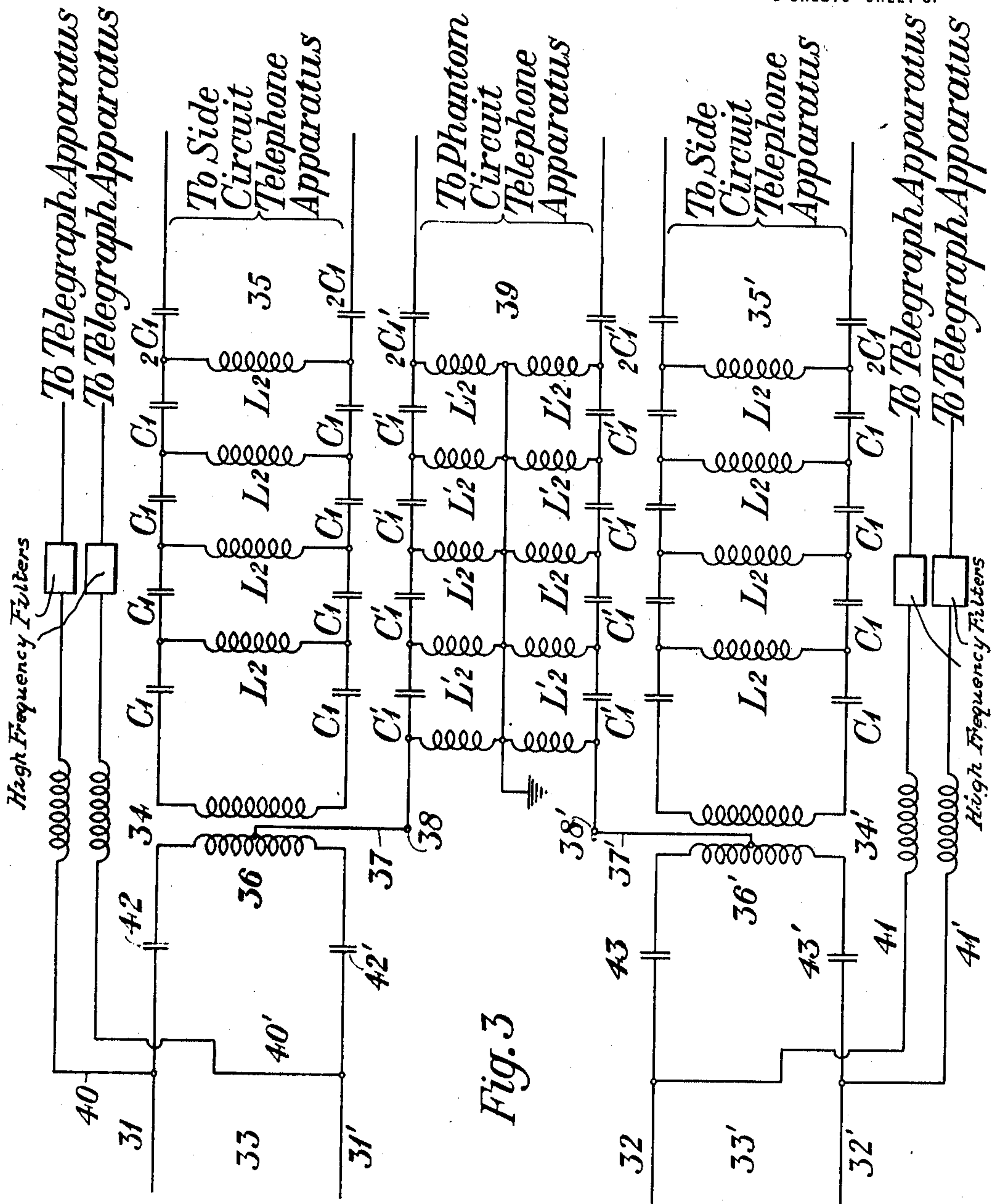


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3 SHEETS—SHEET 3.



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UNITED STATES PATENT OFFICE.

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

COMPOSITE SIGNALING-CIRCUITS.

1,314,827.

Specification of Letters Patent.

Patented Sept. 2, 1919.

Application filed June 8, 1917. Serial No. 173,526.

To all whom it may concern:

Be it known that I, HAROLD S. OSBORNE, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Composite Signaling-Circuits, of which the following is a specification.

This invention relates to telephone and telegraph systems and more particularly it relates to composited telephone and telegraph systems wherein the conductors of the telephone line serve also to convey telegraph signals. Its object is to provide circuit arrangements adapted to effectively eliminate interference in the telephone apparatus by the associated telegraph apparatus. A further object is to prevent interference between the telegraph sets which are associated with the same system of conductors. The means employed to eliminate said interference consists broadly of electric wave filters so designed and so associated with the telephone and telegraph circuits as to prevent low frequency telegraph currents from entering the telephone apparatus and also to prevent high frequency telegraph impulses from being transmitted from the telegraph apparatus to the telephone apparatus.

The arrangements of the invention are particularly adapted for use with the ordinary composited system wherein two parallel conductors constitute the full metallic circuit for the telephonic currents and wherein also each conductor serves as one side of a ground return telegraph circuit, so that two telegraph circuits and one telephone circuit are provided. It is also adapted for use with a single conductor system having a ground return for both the telephonic and telegraphic currents, or for a full metallic system in which both the telephone and telegraph apparatus are connected across the same pair of conductors. It still further embraces arrangements for use with a phantom system in which four conductors provide for three full metallic telephone circuits and for four ground-return telegraph circuits.

The invention may now be fully understood from the following description taken in connection with accompanying drawing in which, Figure 1 constitutes a diagram of

the invention as applied to a ground return telephone conductor; Fig. 2 constitutes a diagram of the invention as applied to a full metallic system; and Fig. 3 is a diagram of a phantom circuit arrangement embodying the invention.

Referring to Fig. 1, a conductor 1, which serves as one side of a ground return composite circuit for the simultaneous transmission of telephone and telegraph signals, is connected at terminal 2 with terminal telephone and telegraph apparatus by conductors 3 and 4 respectively. The telephone apparatus (not shown) is preferably connected through a transformer 5 to a wave filter 6 whose terminal 7 is connected to conductor 3. The wave filter 6 is of a form fully described in U. S. Patent 1,227,113 of May 22, 1917, to G. A. Campbell. The specific form shown consists of a plurality of similar sections each consisting of a condenser C_1 in series with the line, and an inductance L_2 in shunt to ground. The terminating condensers $2C_1$, $2C_1$ may have twice the capacity of the condenser C_1 , though this is not essential to my invention. The property of a wave filter of this form is to transmit from section to section without attenuation currents of all frequencies above a preassigned limiting frequency, and to attenuate and sensibly extinguish during transmission currents of all frequencies below said preassigned limiting frequency. The properties of the wave filter are fully explained and discussed in the above mentioned patent to which reference should be made. The limiting frequency below which currents are attenuated depends on the values of C_1 and L_2 . If said frequency is denoted by f_0 , then f_0 is determined by the formula

$$f_0 = \frac{1}{4\pi\sqrt{L_2C_1}}$$

In the arrangement of Fig. 1 the function of wave filter 6 is to exclude currents of telegraphic frequency from the terminal telephone apparatus while at the same time transmitting with small or negligible attenuation currents of all frequencies essential to the telephonic transmission of speech. Assuming that the fundamental telegraphic

frequencies are below 200 cycles per second, and that currents of less than 200 cycles per second are not essential for telephonic transmission, the constants of the wave filter in accordance with the above formula should be so proportioned that

$$L_2 C_1 = \frac{1}{(4\pi)^2 (200)^2}$$

L_2 being expressed in henrys and C_1 in farads. When so proportioned the telephone apparatus is effectively protected from low frequency telegraph currents transmitted by conductor 3.

Another condition which should be considered in the design of the filter, is that the impedance characteristic of the filter should have the proper relation to that of the circuit into which it is connected. As the method by which the filter net-work is designed to meet this condition is similar to that used in the design of any net-work under similar circumstances, it need not be described herein.

While filter 6 effectively protects the telephone apparatus from low frequency currents of the fundamental telegraph frequency, it does not protect said apparatus from the relatively high frequency currents which represent the harmonics or overtones of the fundamental telegraphic currents and which are introduced by the operation of a telegraph transmitter. In order to eliminate interference due to said harmonics there is provided a second filter 8 which connects the telegraph transmitter, conventionally represented by 9, with the apex 10 of the duplex telegraph bridge 11. Capacities 50 and 50' are provided in ground taps in shunt of the windings of the polar relay 51 to prevent any kick back through the telephone apparatus due to the inductive action of the armature 53 on the windings of the polar relay when said armature is vibrated in response to telegraph or signaling currents. An inductance 52 may also be provided in the leg 4 of the bridge to prevent loss of telephone current to ground through said leg, a similar inductance 52' being provided in the leg leading to artificial line 13. As regards telephone operation said filter might equally well be connected between terminals 2 and 12, but, as regards telegraph operation, its location as shown in Fig. 1, is attended with the following advantages. First, it affects only the transmitted telegraph currents and consequently does not appreciably reduce the receiving efficiency; secondly it is not necessary to duplicate the filter in the artificial line branch; and thirdly the artificial line need simulate the line impedance only for currents of the frequencies which pass through the filter 8 and not for the higher

harmonics of the telegraph currents. Filter 8 consists of one or more similar sections each section consisting of an inductance L_1 in series with the line and a condenser C_2 in shunt to ground. If desired, inductance 52 and capacity 50 may be so designed as to serve as one section of the filter. It will be understood that in this and succeeding figures the subscript 1 denotes an impedance element in series with the line and the subscript 2 an impedance element in shunt with the line, the letter L denoting an inductance element and the letter C a condenser or capacity element. The values of the terminating inductance coils $\frac{1}{2} L_1$, $\frac{1}{2} L_1$, may be one-half that of the inductances L_1 . This proportioning of the terminating series impedance elements is not essential to the proper functioning of the filter. The property of a filter of the type of 8 is to freely transmit without attenuation currents of all frequencies below a specified limiting frequency but to attenuate and substantially extinguish currents of all frequencies lying above said frequency, as fully explained in the above mentioned patent to G. A. Campbell. Owing to their properties filters of the type of 6 will be termed low frequency or infra filters while those of the type of 8 will be termed high frequency or ultra filters.

The function of filter 8 in the arrangement of Fig. 1 is to prevent the transmission of harmonics, produced by telegraph transmitter 9 from being transmitted to line 1 or to the telephone apparatus connected therewith, while at the same time freely transmitting the fundamental telegraphic impulses. A further function is to protect the receiving telegraph apparatus of the duplex set from said harmonics with the resulting advantage that the duplex artificial line, symbolically represented by 13, need simulate the impedance of line 1 and the associated telephone apparatus only for the range of frequency limited by the frequency transmissible through filter 8. As a consequence the construction of the artificial line may be simpler and more economical than is the case where it must also balance the harmonics of the fundamental telegraph impulses.

If filter 8 is to extinguish currents of all frequencies above a limiting frequency f_1 while freely transmitting currents of all frequencies below said limiting frequency, the constants of the filter must be so proportioned that

$$L_1 C_2 = 4 \left(\frac{1}{2\pi f_1} \right)^2 \quad (2)$$

The frequency f_1 is preferably taken as the upper limit of the fundamental telegraph frequency. If this frequency is, for example,

200 cycles per second, and if the impedance elements L_1 and C_2 are proportioned in accordance with formula (2), then only frequencies less than 200 cycles per second are transmitted from the telegraph transmitter 9 to apex 10 and terminal 2. Further since filter 6 is proportioned to transmit only frequencies greater than 200 cycles per second, in the example chosen, it will be clear that the telephone apparatus is substantially protected from all interference from telegraph transmission, and further that such protection is accomplished without materially reducing the efficiency of either the telephone or telegraph transmission, since currents of telephonic and of telegraphic frequencies are freely transmitted by filters 6 and 8 respectively.

The number of sections included in filters 6 and 8 is largely a matter of choice and is dictated by the degree of protection required. If a very high degree of protection from interference is desired a relatively large number of sections should be included in each filter, while if less perfect protection is satisfactory a small number may be used.

Fig. 2 is a diagram of certain of the arrangements of the invention as applied to a composited telephone circuit, comprising a full metallic telephone transmission circuit consisting of the two conductors 21 and 21' and two ground return telegraph circuits of which conductors 21 and 21' respectively constitute one side. To terminals 22 and 22' are connected conductors 23 and 23' respectively leading to the telephone terminal apparatus and conductors 24 and 24' respectively leading through filters such as shown at 8 in Fig. 1 to two sets of duplex telegraph apparatus (not shown), each of which sets may be similar to that shown in Fig. 1. Between terminals 22 and 22' and induction coil 25, which may be a phantom or other coil, is connected a low frequency filter 26 consisting of one or a plurality of similar sections, each section comprising a condenser C_1 in series with one side of the line, a similar and equal condenser C_1 in series with the other side of the line and two similar and equal serially connected inductances L_2 in shunt across the line. The common point of each pair of serially connected inductance elements L_2 , L_2 is connected to ground by conductor 27. It will be observed that filter 26 constitutes in effect three separate filters, one connected to the metallic circuit formed by conductors 21 21', a second filter connected in the circuit between conductor 21 and ground and a third filter connected in the circuit between conductor 21' and ground, said last two circuits being used as the telegraph circuits and the first circuit as the telephone circuit. As seen from the circuit

formed by conductors 21 and 21', the filter has in each section a capacity $\frac{1}{2} C_1$ in series with the line and an inductance $2L_2$ in shunt across the line, the product of the two being $L_2 C_1$. As seen from the second circuit between conductor 21 and ground, the filter has in each section a capacity C_1 in series with the line and inductance L_2 in shunt across the circuit, the product of the two being likewise $L_2 C_1$. Similarly the filter in the circuit between conductor 21' and ground has a capacity C_1 in series with the line and an inductance L_2 in shunt across the circuit, their product being likewise $L_2 C_1$. Reference to formula (1) shows that as regards any of the three circuits the three filters have the same cut-off frequency, that is the frequency above which currents are attenuated and extinguished and below which currents are freely transmitted.

It will thus be manifest that filter 26 protects the telephone apparatus not only from low frequency impulses coming in over the line but also from low frequency telegraphic impulses introduced by the composited telegraph apparatus connected with conductors 24 and 24'. A further important function of said filter is to prevent interference between the two composited telegraph sets. This type of interference is effectually eliminated by the particular type of filter employed in that the mid-points of the shunt inductances are grounded. As regards interference with the telephone apparatus by the telegraph sets, this connection is not essential, and an ungrounded filter might be equally well employed. However, as regards interference between the two telegraph sets, the grounding of the common points of the serially connected shunt inductances is very important in that it provides a path to ground for the transmission currents of each telegraph set which otherwise would pass to ground through the other telegraph set and thus introduce interference.

The filter illustrated in Fig. 2 will thus be seen to consist of a double or "duplex" filter having two symmetrical halves with common ground connections. It will be further seen in the light of the foregoing discussion that the "duplex" filter constitutes in effect three separate filters having the same cut-off frequency in three different circuits and that it is capable of effectively eliminating in composited transmission systems not only interference in the telephone apparatus but also interference between the telegraph sets.

Fig. 3 is a diagram of certain of the arrangements of the invention as applied to a composited phantom transmission system. Referring to said figure conductors 31 and 31' constitute a side circuit telephone line 33; similarly conductors 32 and 32' consti-

tute a second side circuit telephone line 33'. Conductors 31 and 31' in parallel constitute one side of a third or phantom telephone line, the other side of which is composed of conductors 32 and 32' in parallel. Side circuit 33 is connected to telephone apparatus (not shown) through a transformer 34 and a low frequency filter 35, while side circuit 33' is similarly connected to telephone apparatus through a transformer 34', preferably similar and equal to transformer 34, and a filter 35', preferably similar and equal to filter 35. From the mid-points of primaries 36 and 36' of transformers 34 and 34' are brought out leads 37 and 37' respectively which are connected to terminals 38 and 38' of a third filter 39 whose other terminals are connected to the phantom circuit telephone apparatus. To conductors 31 and 31' of side circuit 33 are connected conductors 40 and 40' respectively leading to two composited duplex telegraph sets (not shown). Similarly telegraph leads 41 and 41' are connected to conductors 32 and 32' respectively of side circuit 33'. The telegraph sets may be of the form shown in Fig. 1 and as stated in connection with said figure preferably include high frequency filters 8. Filters 35 and 35' are similar and equal, each comprising a plurality of identical sections consisting of a condenser C_1 in series with each side of the line and an inductance L_2 in shunt across the line, said filters differing from that described in connection with Fig. 2 only in that the middle ground connection is omitted because the filters are separated from the line by the phantom coil and in that the terminal arrangements of said filters are different. As regards said terminal arrangements, the condensers at the telephone apparatus end of said filters may be of twice the capacity of condensers C_1 and are therefore designated as $2C_1$. At the other end of filter 35 condensers 42 and 42' constitute the terminal condensers of said filter and each may be of capacity $2C_1$. Further the transformer 34 which is inserted for phantom operation may be designed and proportioned to act as the first shunt inductance and to be equivalent to an inductance of value L_2 in shunt across the line. This equivalence may be realized by having said transformer of unity ratio and of substantially perfect coupling and the inductance of each coil of value L_2 . When these conditions are realized the actual arrangement is equivalent to a circuit arrangement in which lines 31 and 31' are directly connected through condensers 42 and 42' to the two sides of the filter and the transformer is replaced by an inductance of value L_2 in shunt across the line. Precisely similar statements apply to the

arrangements of side circuit 33', condensers 43 and 43' similar and equal to condensers 42 and 42' serving as the terminal condensers and transformer 34' acting as the first shunt inductance of filter 35'.

Filter 39 is of the duplex type illustrated in Fig. 2, the series condensers being denoted by C_1' and each shunt inductance consisting of two serially connected inductances L_2' and L_2' whose common point is connected to ground. Condensers 42 and 42' in parallel and condensers 43 and 43' in parallel constitute the terminal condensers of filter 39 and consequently the terminal capacity of each side of the line of said filter is $4C_1$. If filter 39 is to have the same cut-off frequency as filters 35 and 35', the capacity of each condenser C_1' should be $2C_1$ and the inductance of each coil L_2' should be $\frac{1}{2} L_2$.

The operation of the organization of Fig. 3 will be readily understood in the light of the explanation of the arrangements of Figs. 1 and 2. Filters 35, 35' and 39 effectively protect the three sets of telephone apparatus corresponding to the two side circuits and the phantom circuit from low frequency interference by the telegraph sets, while the ground connection of filter 39 practically eliminates interference between the telegraph sets associated with different pairs of wires and substantially reduces interference between telegraph sets associated with the same pair.

In the light of the foregoing disclosure the arrangements of my invention will be seen to provide for the efficient protection of telephone apparatus from interference by composited telegraph apparatus and of the composited telegraph sets from mutual interference, the specific means employed consisting of high frequency filters associated with the telegraph apparatus to substantially eliminate high frequency telegraphic impulses and of low frequency filters associated with the telephone apparatus and adapted to prevent low frequency impulses of the fundamental telegraphic frequency from entering the telephone apparatus and from passing from one telegraph set to another telegraph set. It will be understood that while particular types of filters have been illustrated the invention is not limited to these specific types and that any other known type of filter may be used.

What is claimed is:

1. The combination of a transmission line, telephone and telegraph apparatus associated with said line, an electric wave filter connecting said telephone apparatus with said line, said filter being adapted to transmit with negligible attenuation currents between the upper and lower limits of tele-

phonic frequency and to attenuate and substantially extinguish currents of telegraphic frequency and a second filter connecting said telegraph apparatus with said line, said second filter being adapted to transmit with negligible attenuation currents of telegraphic frequency and to attenuate and substantially extinguish currents of telephonic frequency.

2. The combination of a transmission line, telephone and telegraph apparatus associated with said line, an electric wave filter connecting said telephone apparatus with said line, said filter being adapted to transmit with negligible attenuation currents of telephonic frequency and to attenuate and substantially extinguish currents of telegraphic frequency, and a second filter connecting the transmitting and receiving elements of said duplex telegraph apparatus, said second filter being adapted to transmit with negligible attenuation currents of telegraphic frequency and to attenuate and substantially extinguish currents of telephonic frequency.

3. The combination of a transmission line, telephone and telegraph apparatus associated with said line, an electric wave filter connecting said telephone apparatus with said line, said filter consisting of a connecting line comprising a plurality of identical sections, each section consisting of a capacity in series with the line and an inductance in shunt across the line, and a second filter connecting said telegraph apparatus with said line, said filter consisting of a connecting line comprising a plurality of identical sections, each section consisting of inductance in series with the line, and a condenser in shunt across the line.

4. The combination of a transmission line, telephone and duplex telegraph apparatus associated with said line, an electric wave filter connecting said telephone apparatus with said line, said filter consisting of a connecting line comprising a plurality of identical sections, each section consisting of a capacity in series with the line and an inductance in shunt across the line, and a second filter connecting the transmitting and receiving elements of said duplex telegraph apparatus, said filter consisting of a connecting line comprising a plurality of identical sections, each section consisting of inductance in series with the line, and a condenser in shunt across the line.

5. The combination of two conductors constituting a telephone circuit, a duplex telegraph apparatus connected with one of said conductors, a second telegraph apparatus connected with the other of said conductors, telephone apparatus and a duplex electric wave filter connecting said telephone apparatus with said metallic cir-

cuit, said filter consisting of two similar and equal halves similarly connected to ground.

6. The combination of two conductors constituting a telephone circuit, a duplex telegraph apparatus connected with one of said conductors, a second telegraph apparatus connected with the other of said conductors, telephone apparatus and a duplex electric wave filter connecting said telephone apparatus with said metallic circuit, said filter consisting of two similar and equal halves, one-half being connected to one of said two conductors and comprising a plurality of identical sections, each section having a condenser in series with the conductor and an inductance in shunt to ground, and the other half being connected to the other of said conductors and consisting of a plurality of identical sections each section having a condenser in series with the associated conductor and an inductance in shunt to ground.

7. The combination of two conductors constituting a telephone circuit, a duplex telegraph apparatus connected with one of said conductors, a second telegraph apparatus connected with the other of said conductors, telephone apparatus and a duplex electric wave filter connecting said telephone apparatus with said metallic circuit and with ground, said filter being adapted to attenuate and substantially extinguish currents of telegraphic frequency in said metallic circuit, and in the two circuits between the individual conductors and ground.

8. The combination of a phantom transmission system comprising two side circuits and a phantom circuit, composited telegraph apparatus associated with said transmission system, telephone apparatus associated with each of said side circuits and with said phantom circuit, low frequency electric wave filters connecting said side circuits with their associated telephone apparatus and a duplex low frequency filter connecting the phantom circuit with its associated telephone apparatus.

9. The combination of a three conductor transmission system and a duplex electric wave filter, said filter consisting of two similar and equal halves, the first half consisting of a plurality of identical sections, each section having an impedance element in series with one of said three conductors, and an impedance element in shunt between said conductor and another of said three conductors, and said second half of said duplex filter consisting of a plurality of identical sections, each of said sections having an impedance element in series with the third of said three conductors and an impedance element in shunt between said third conductor and said second mentioned conductor.

10. The combination of a transmission line, and an electric wave filter, connected therewith, said filter consisting of a plurality of sections each comprising a series capacity and a shunt inductance, the inductance of one of said sections consisting of a two winding transformer.

11. A broad band wave filter and a conducting circuit inductively related thereto, said wave filter having an end section grounded at its midpoint.

12. A broad band wave filter comprising a plurality of sections and having an end section grounded at its midpoint.

13. A broad band wave filter comprising a line consisting of a plurality of sections, each section including an impedance element in series with the line and an impedance element in shunt with the line, said wave filter having an end section grounded at its midpoint.

14. In a transmission system, a main transmission line adapted to transmit both low frequency currents and currents of higher frequency, branches leading from said line, a broad band filter in one branch so constructed and arranged as to transmit a band of low frequencies below a limiting frequency and substantially exclude frequencies

above said limiting frequency and a broad band filter in the other branch so constructed and arranged as to transmit frequencies above and substantially suppress frequencies below said limiting frequency.

15. In a transmission system a main transmission line having a plurality of branches, broad band wave filters in each branch, each wave filter comprising a plurality of sections, each section having series and shunt impedances, the impedances of one filter being so proportioned that a band of frequencies below an upper limiting frequency will be transmitted to one branch while frequencies above that limit will be substantially excluded, and the impedances of the other filter being so proportioned that a band of frequencies above said limit will be transmitted to the other branch and frequencies below said limit will be substantially excluded.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 19th day of May, 1917.

HAROLD S. OSBORNE.

Witnesses:

CHESTER WALLACE,
ALFRED KAUFMANN.