

May 3, 1938.

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2,116,172

COMPOSITE SET

Filed Dec. 27, 1935

2 Sheets-Sheet 1

Fig. 1.

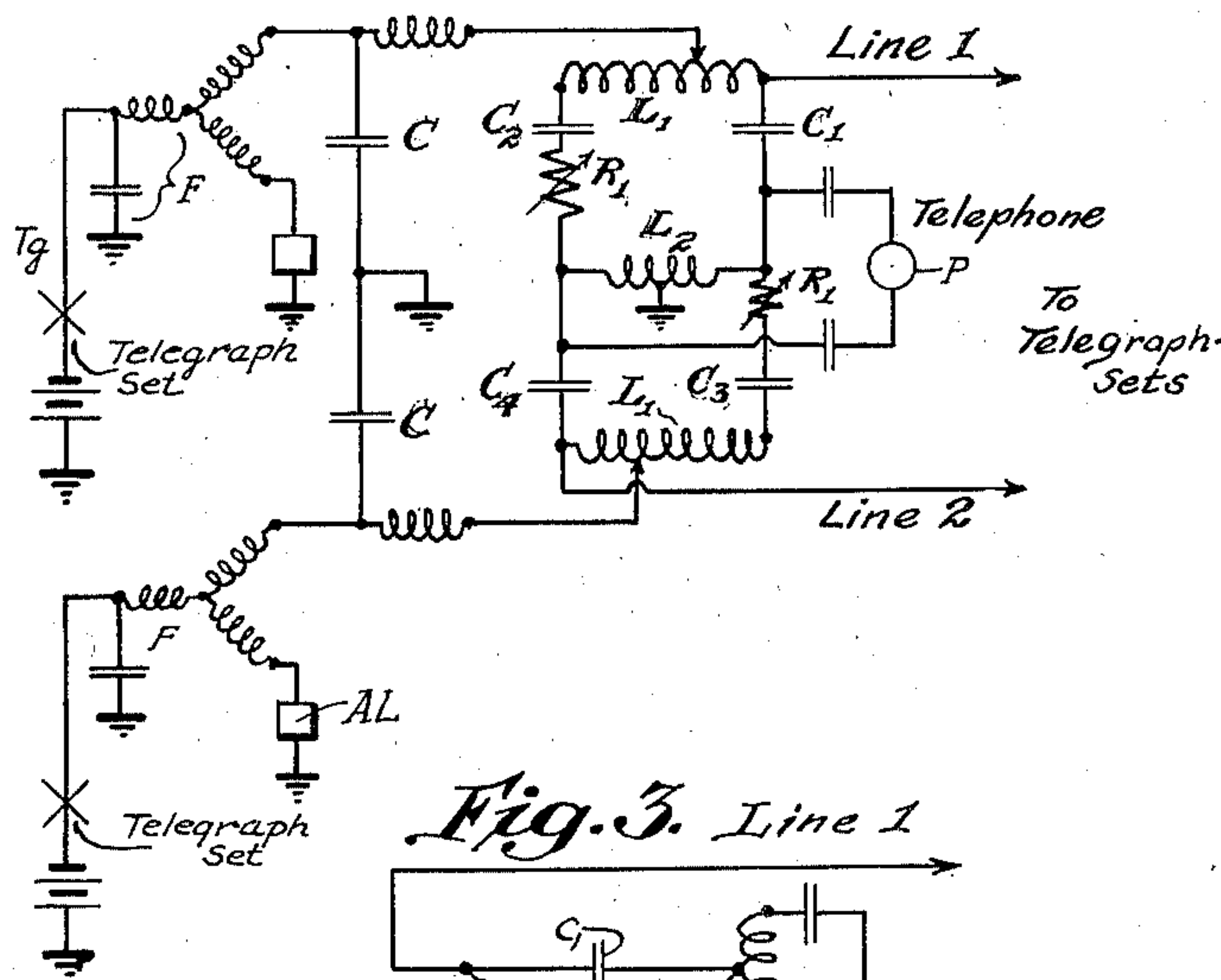


Fig. 2.

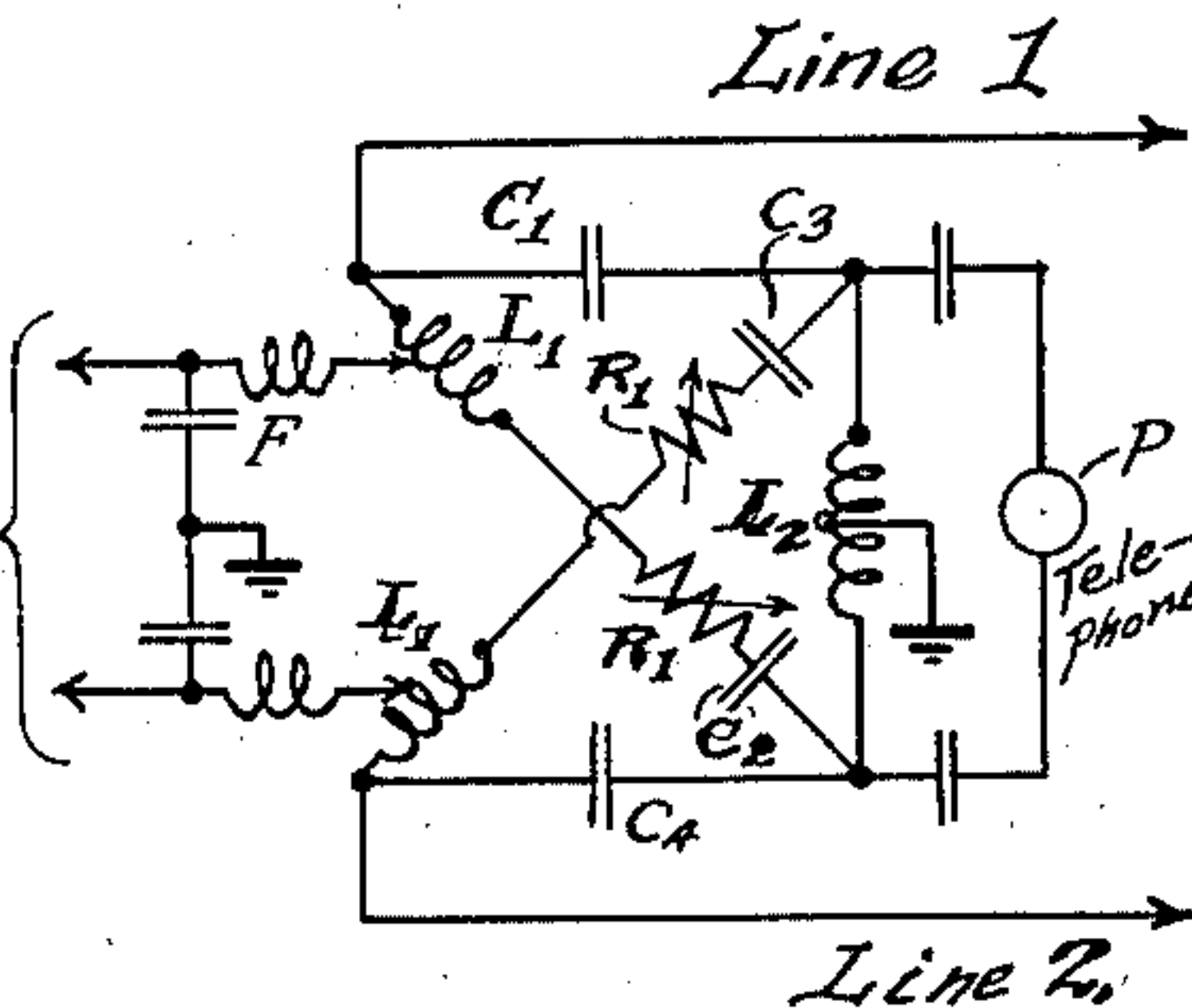


Fig. 3. Line 1

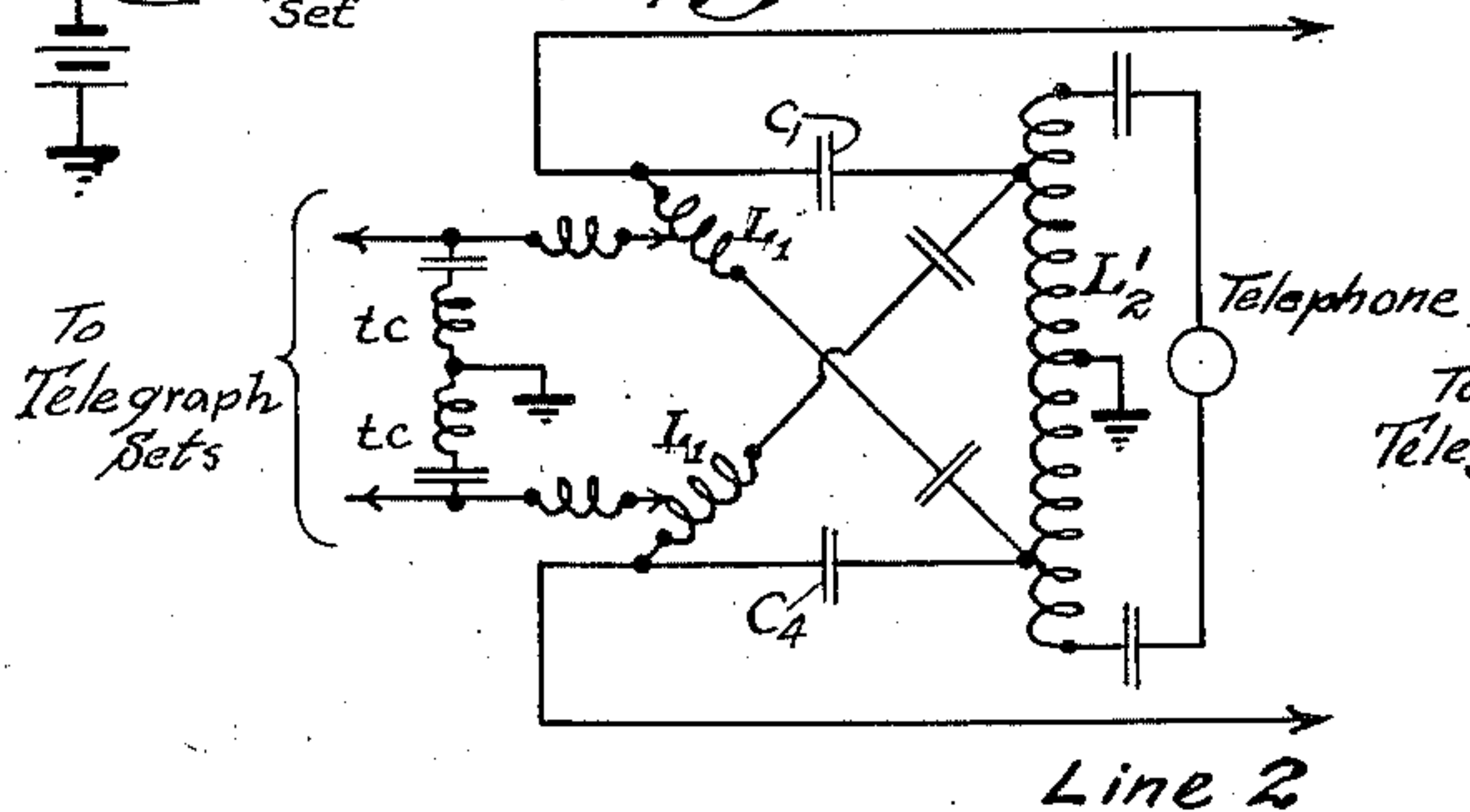


Fig. 4. Line 1

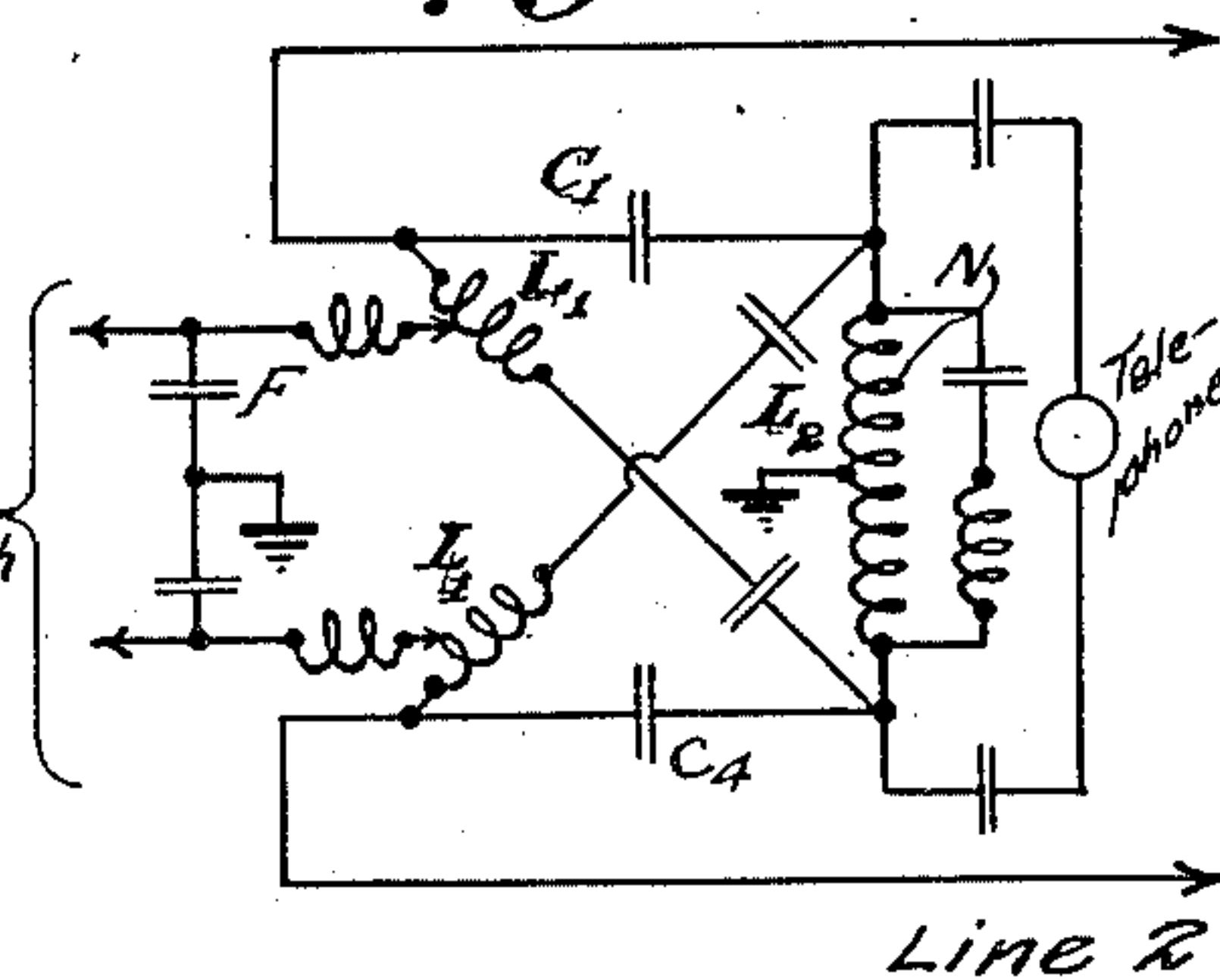


Fig. 5. Line 1

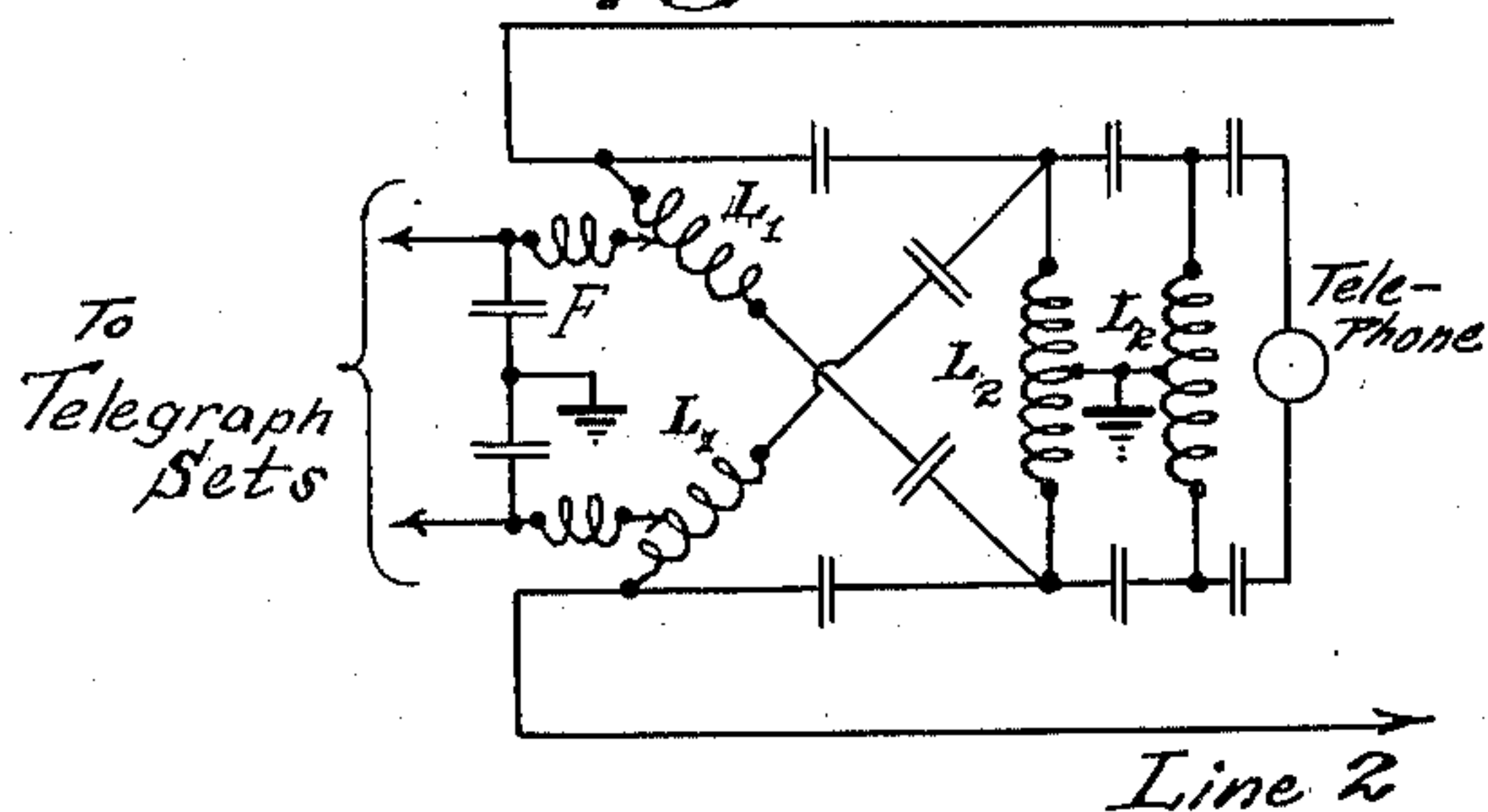
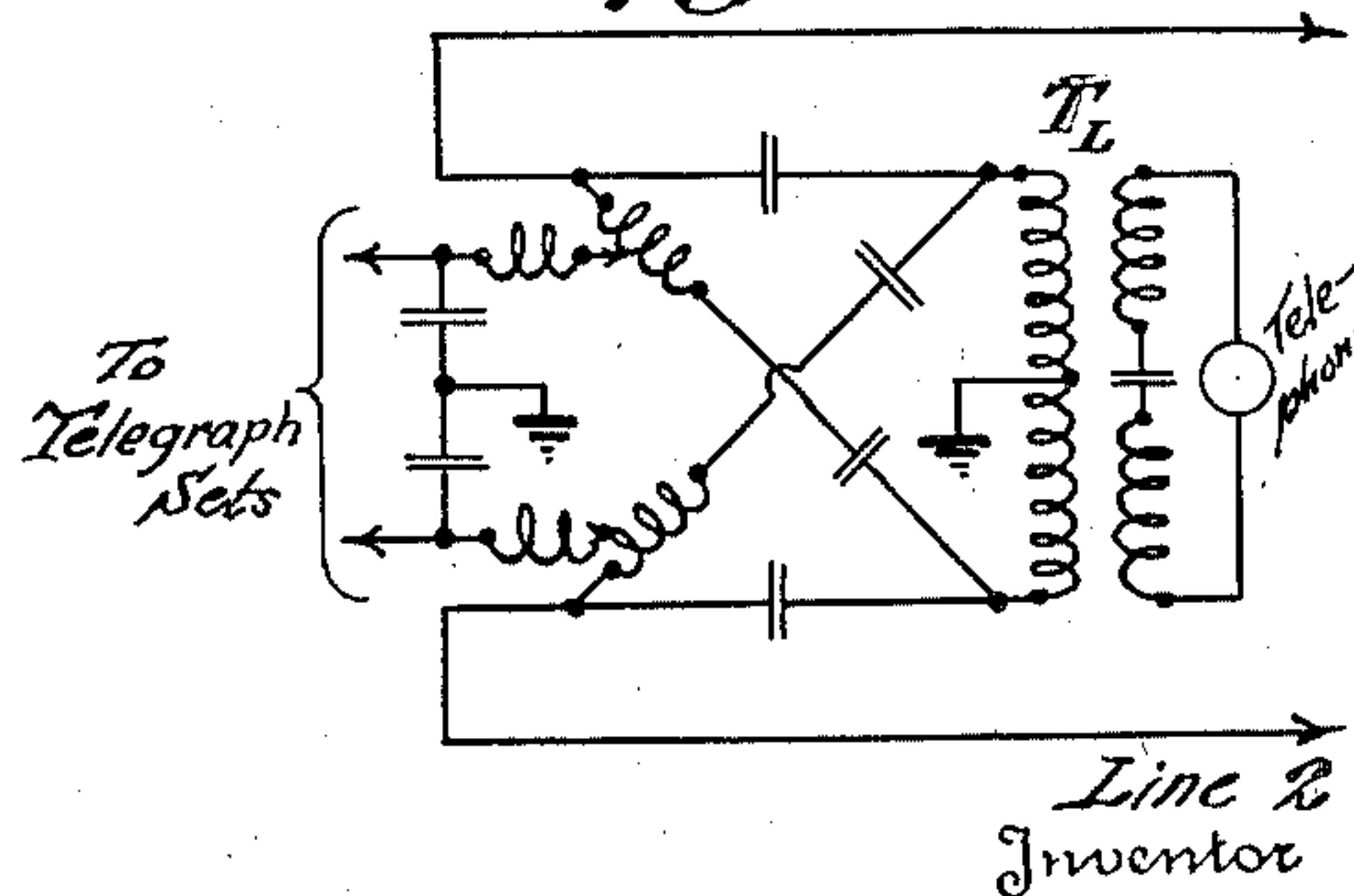


Fig. 6. Line 1



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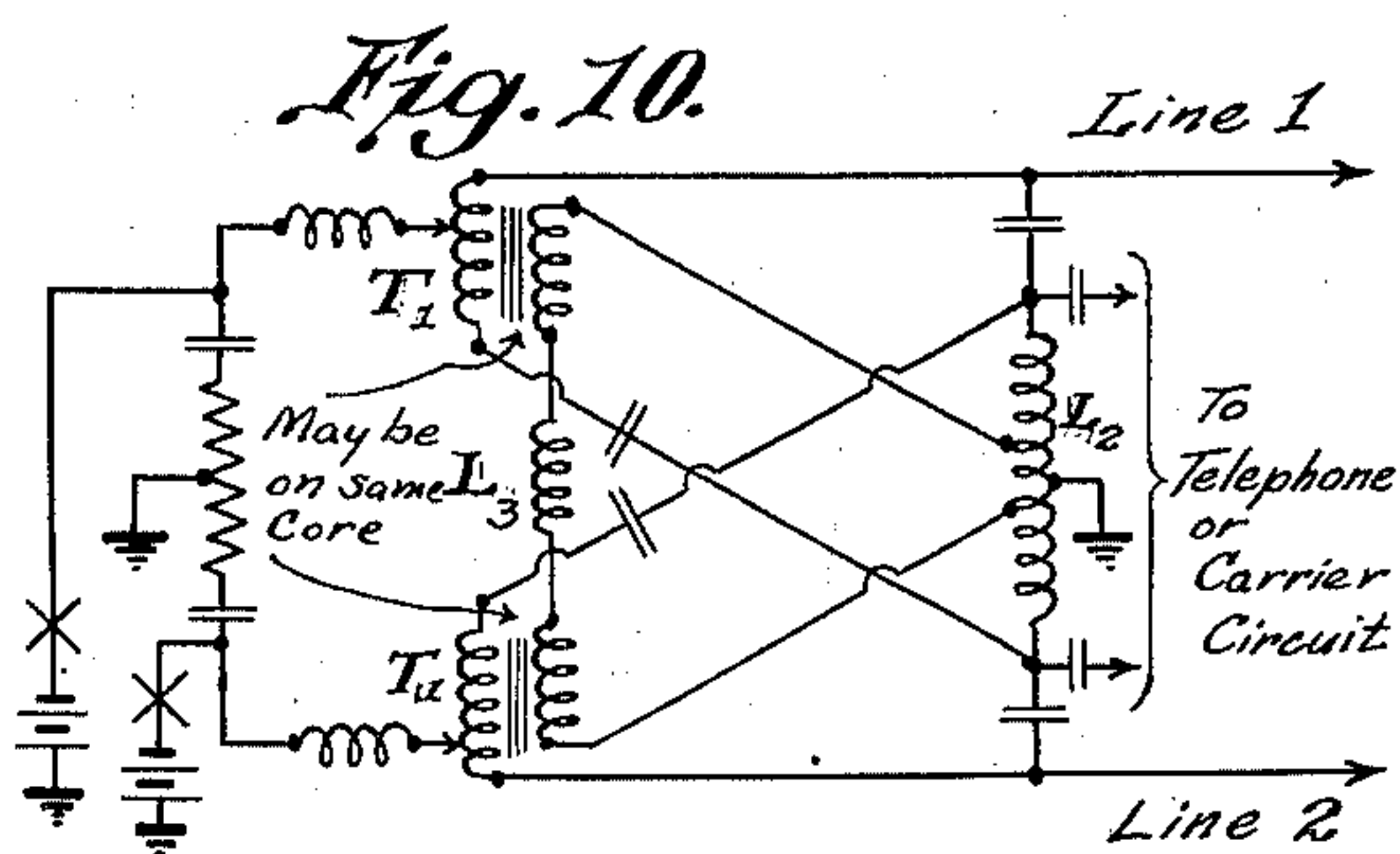
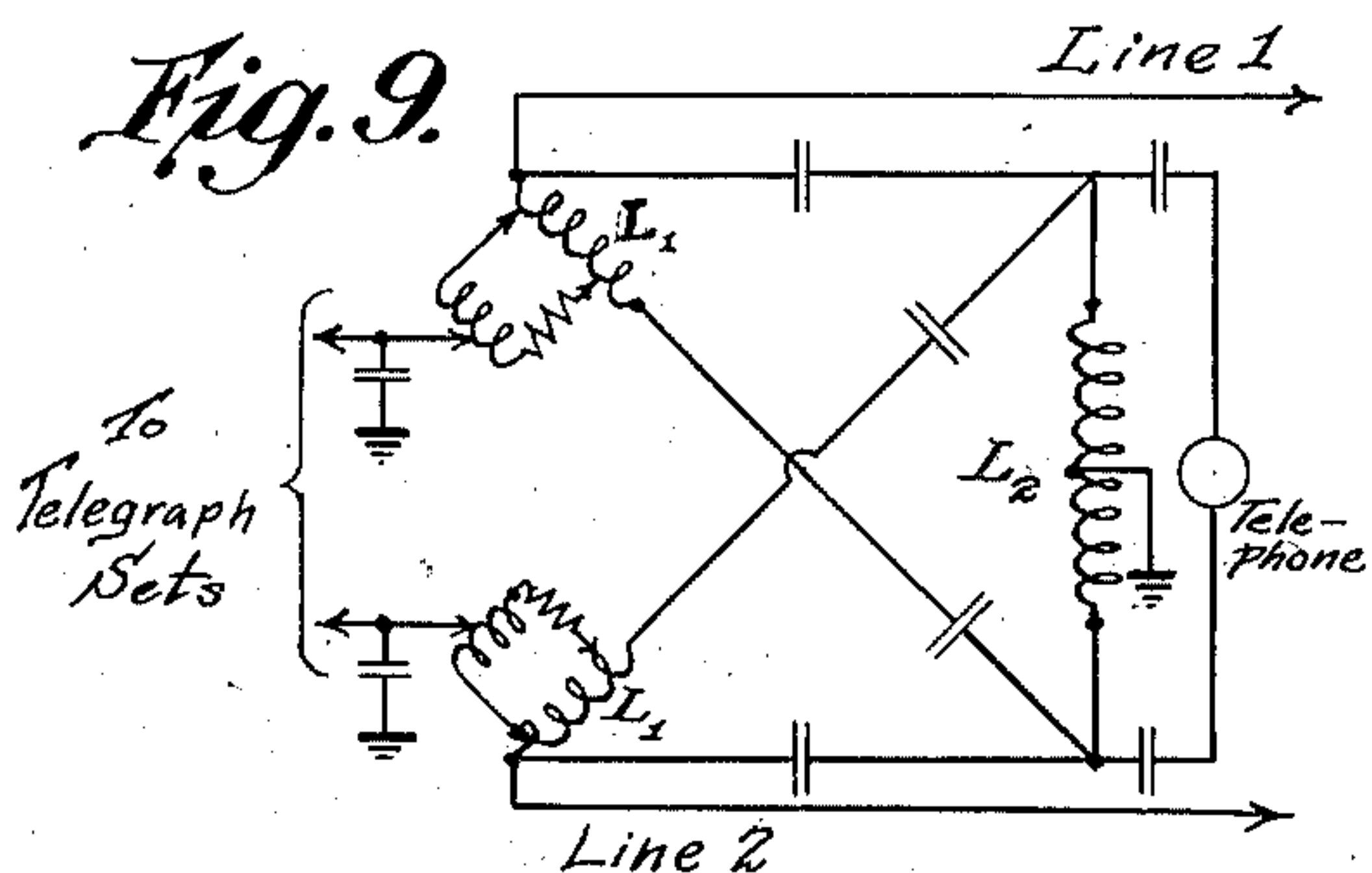
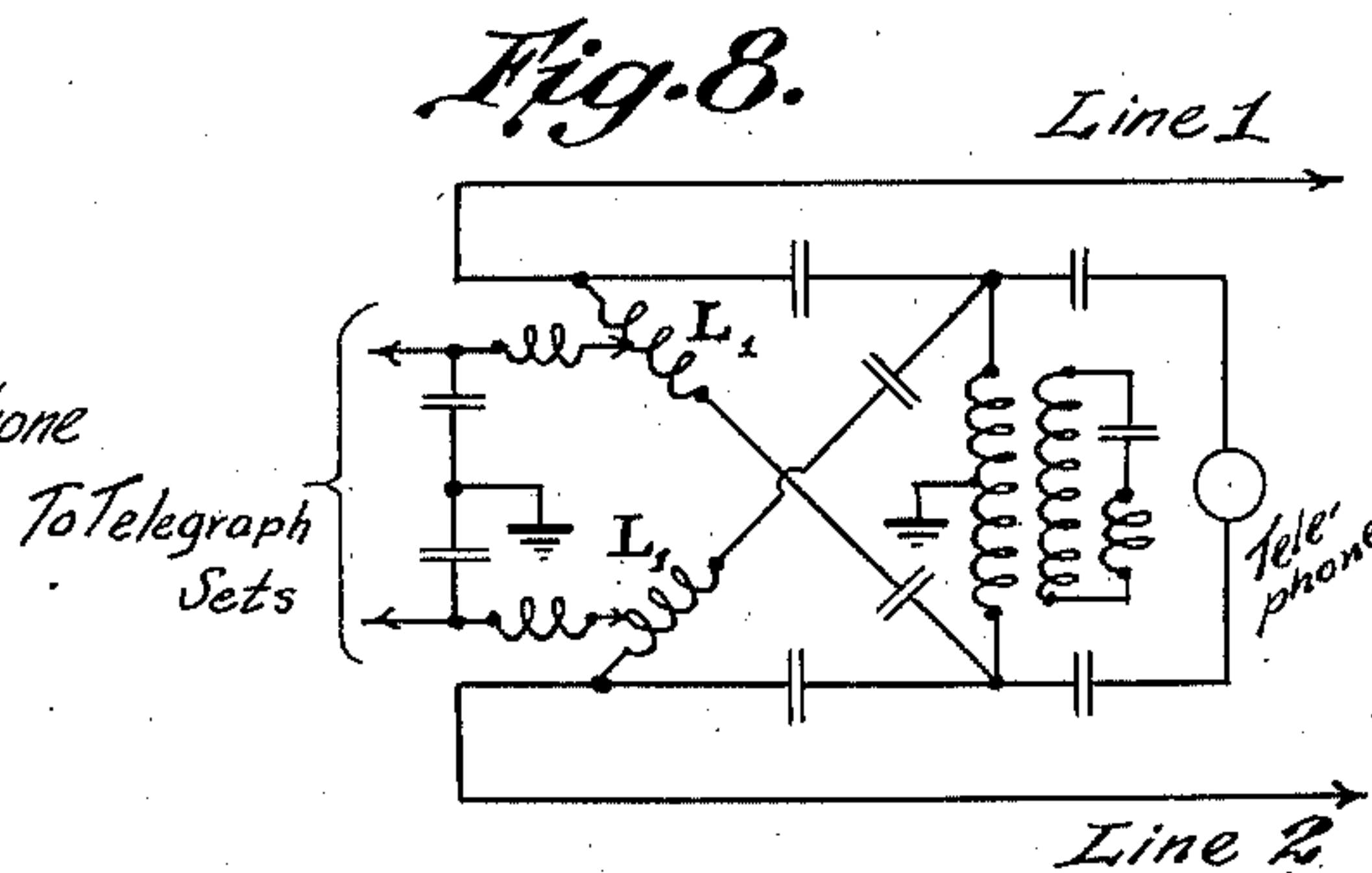
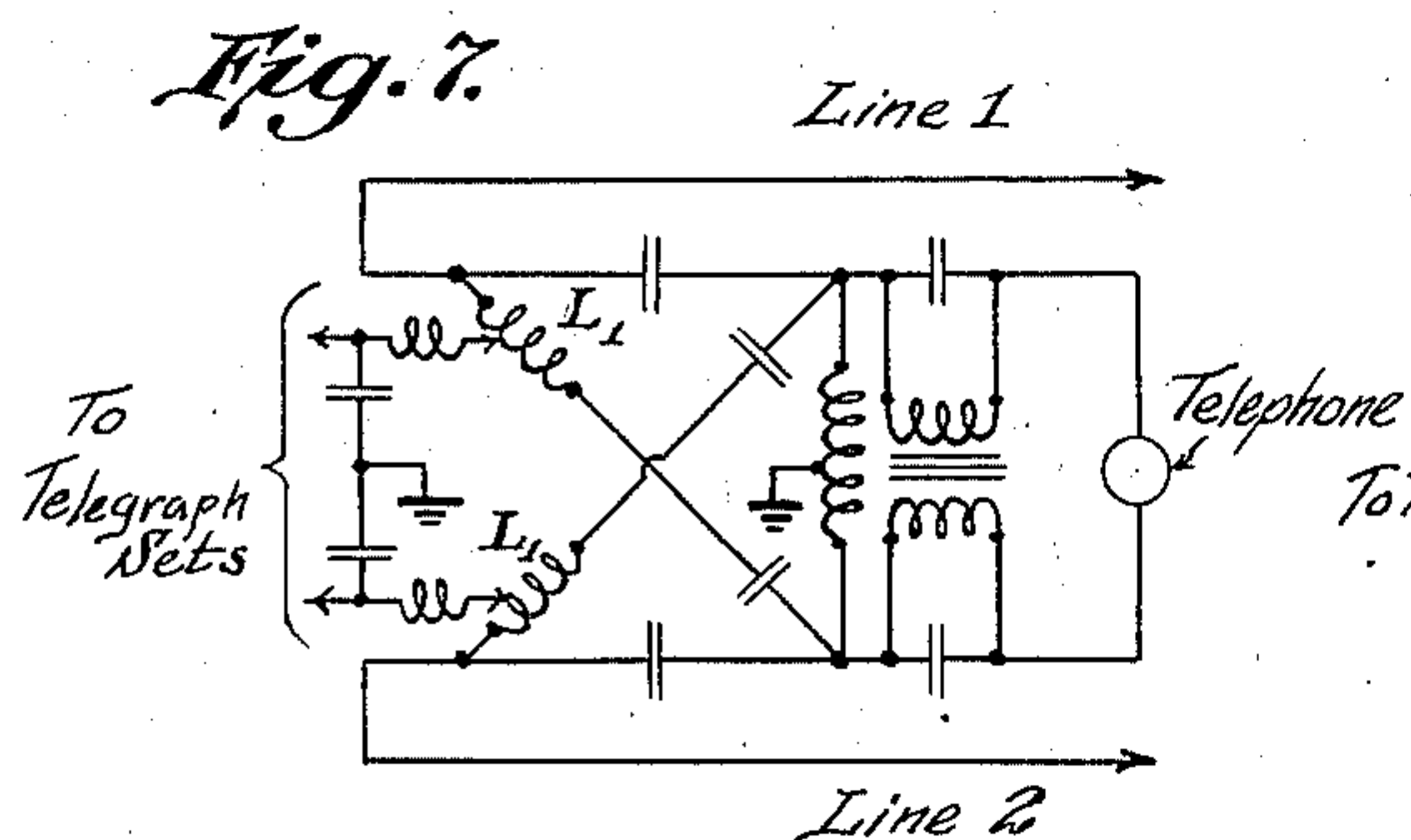
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COMPOSITE SET

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2 Sheets-Sheet 2



PRIOR ART

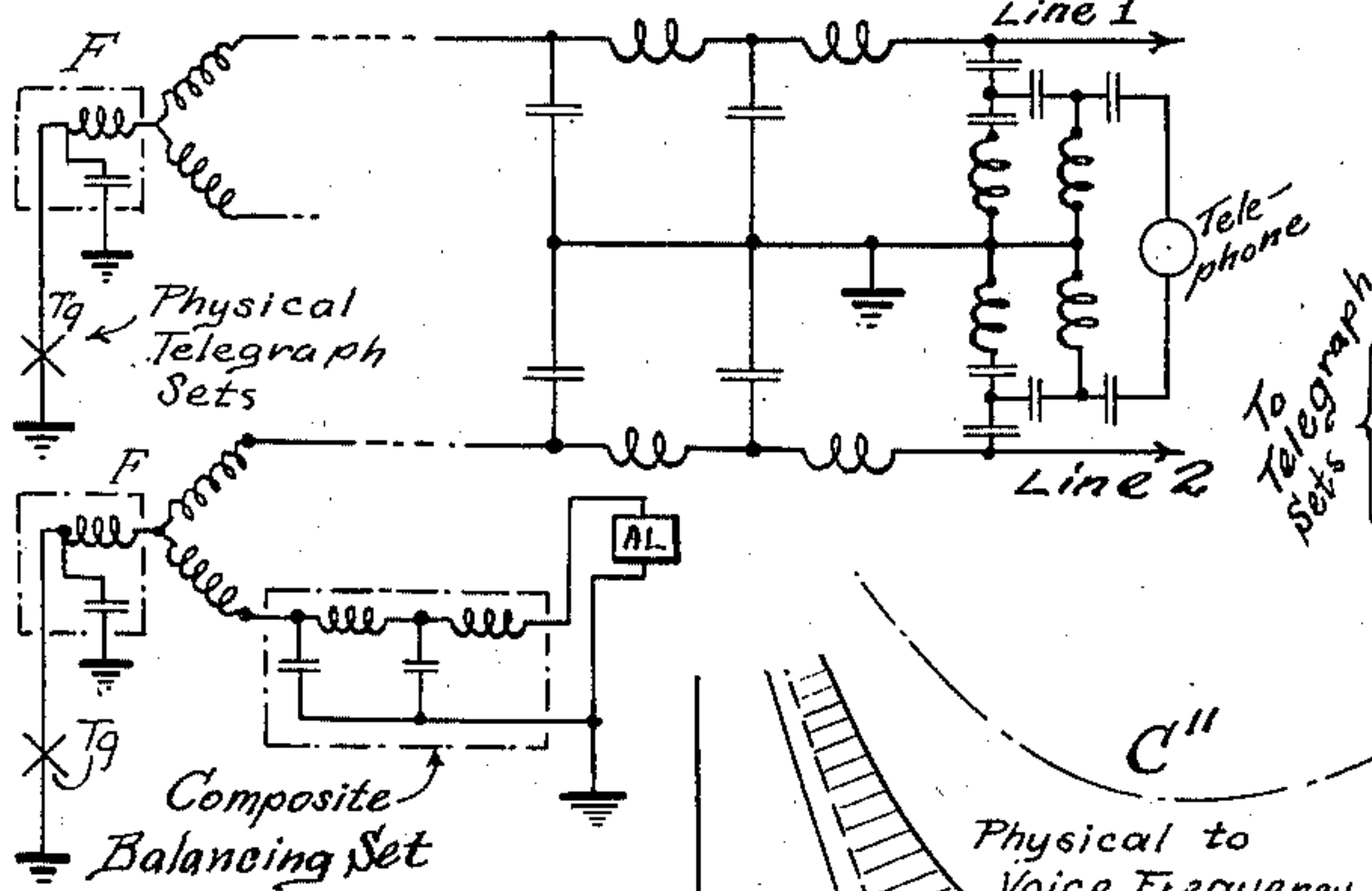


Fig. 11.

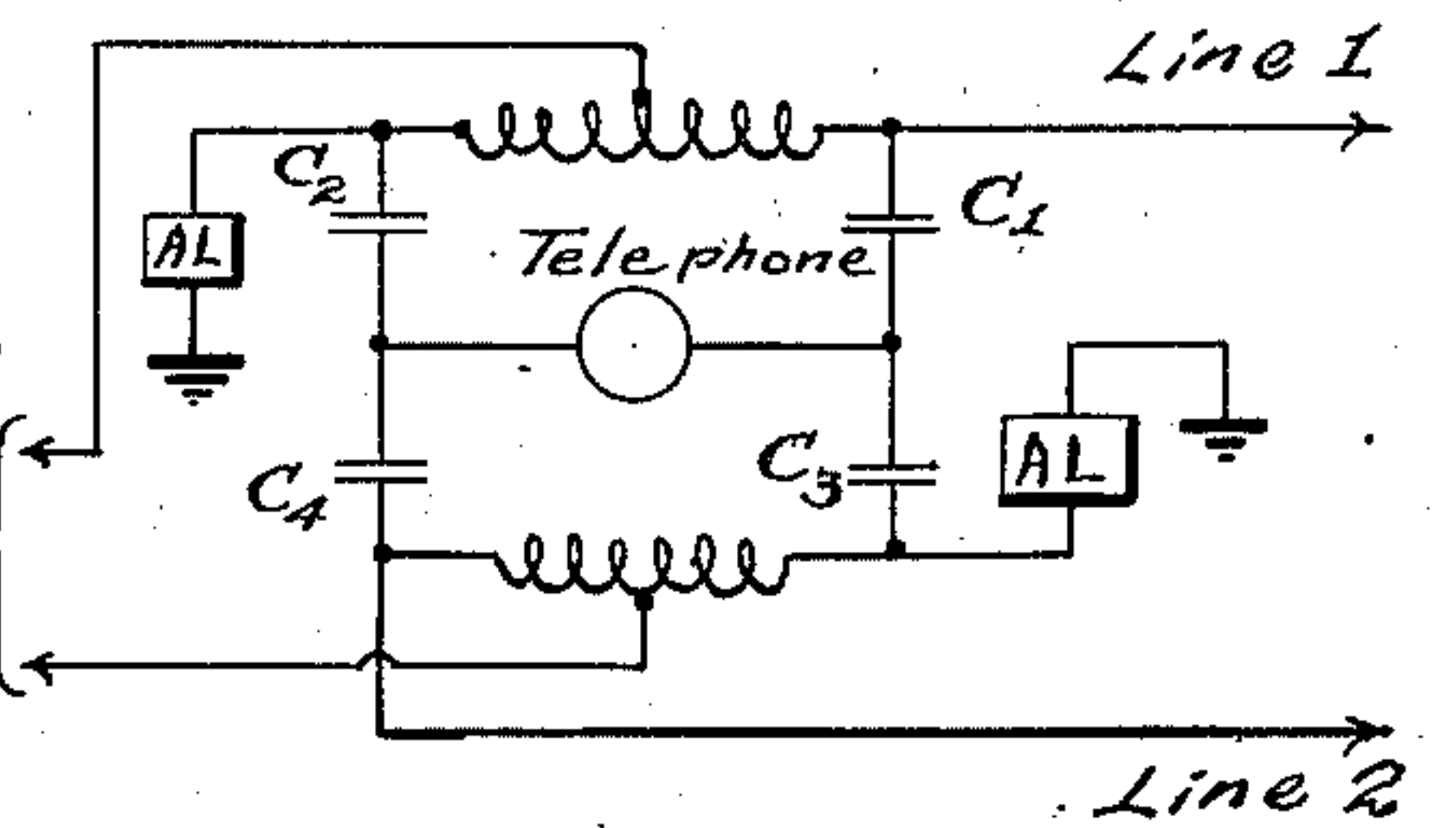


Fig. 12.

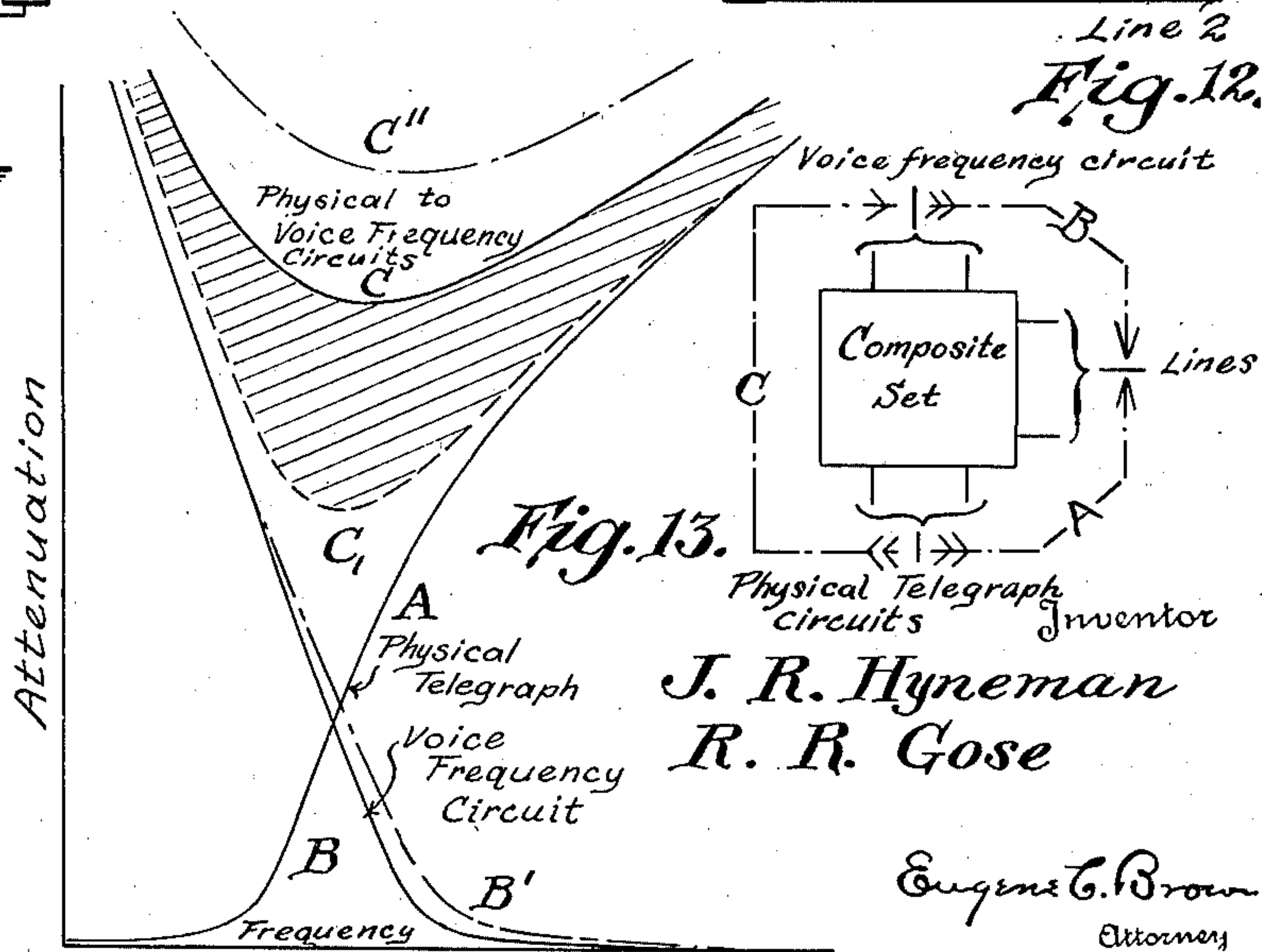


Fig. 13.

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UNITED STATES PATENT OFFICE

2,116,172

COMPOSITE SET

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Application December 27, 1935, Serial No. 56,366

12 Claims. (Cl. 179—3)

This invention relates to communication systems and more particularly to improvements in arrangements, such as composite sets, usually associated with the terminal facilities of such systems for the purpose of separating different types of signal transmission employing separate frequency ranges. In a signaling system in which both telegraph and telephone currents are transmitted simultaneously over the line circuits thereof, the composite set, furthermore, functions to prevent the outgoing telegraph currents from entering the telephone path at the terminal facilities and vice versa.

The conventional composite set consists of one or more sections of low pass filter in conjunction with one or more sections of high pass filter having approximately coincident cut-off points. In case the telegraph circuits are operated duplex, it is also customary to include one or more low pass sections in the apex of the duplex terminal set. We have illustrated in Figures 11 and 12, two of such prior arrangements. The former is a common type of composite set, and the latter is disclosed in expired Patent No. 510,508.

For lines carrying high speed telegraph circuits simultaneously with sensitive voice frequency circuits reaching to a low frequency range, it has been found that composite sets of the above type must comprise at least three sections of low pass filter and at least two sections of high pass filter in order to reduce the noise in the voice frequency circuit to tolerable levels. This requirement results in some attenuation and distortion in the voice frequency circuit and also considerably impairs the telegraph circuit.

It is desirable, of course, to have a minimum of attenuation and distortion in the voice frequency circuit with as wide a frequency range as possible, and also to have the impedance of the composite set match the terminal equipment on the one side, and the line on the other side. Further, the noise levels resulting from the physical circuits, that is, the grounded telegraph circuits, must meet rather severe requirements. On the other hand for high quality physical circuits, resistances must be held to a minimum, attenuation at telegraph frequencies must be small and the composite set must match in impedance the lines on the one side and the physical terminal sets on the other. Some characteristic distortion also appears, due to unequal attenuation and phase displacement of the various frequencies comprising the telegraph signal and, further, if any direct ungrounded circuit paths are present between the two lines, there will be crossfire between the two telegraph circuits.

In the case of duplex working, it is necessary that the impedance elements contained in the line circuit shall be duplicated in the artificial line, therefore, requiring a bulky and expensive composite balancing set. In order to prevent the generation of harmonic frequencies which may produce interference in the voice frequency range, the line coils, in particular the one adjacent to the line, must be of very high quality.

From the above-mentioned requirements, it can be seen that the ultimate design of a composite set of the above type is subject to a considerable degree of compromise between the physical and voice frequency circuits and at best, results in appreciable impairment to both circuits.

For the purpose of rendering the telephone substantially immune to noise from the local telegraph transmitters, the principle of conjugacy or balance was employed as illustrated in Fig. 12. It will be observed that the telephone set P is disposed conjugately with respect to the local telegraph transmitters Tg, while it is in direct series circuit with the lines for the handling of telephone currents. Artificial lines were employed to achieve this condition of balance. This arrangement, however, was subject to the objection that both the telegraph and telephone circuits were shunted by the artificial lines, and thus resulted in a loss of approximately half of their energy. Furthermore, the direct paths from line to line via condensers C₁, C₃ and C₂, C₄ permitted severe cross-fire between the two telegraph circuits.

The objects of our invention are—(1) to provide a composite set of the conjugate type in which the telegraph legs are substantially conjugate to the voice frequency terminal and which is substantially free of telegraph cross-fire; (2) to provide a composite set substantially free of attenuation and substantially immune from disturbances due to harmonic generation in the magnetic devices of the physical circuits; (3) to provide a composite set having a variable element which serves to reduce noise into the voice frequency circuit over a wide range of frequencies while increasing voice frequency attenuation over only the low frequency end of the range. The above and other objects will be clearly understood from the following description in connection with the accompanying drawings, in which—

Figure 1 is a diagrammatic illustration of a pair of duplex telegraph lines arranged for simultaneous transmission of currents of telegraph fre-

quency and voice frequency currents by means of our composite set of the conjugate type;

Figure 2 shows the same device illustrated in a somewhat different manner;

Figures 3 to 10 inclusive, illustrate various modifications embodying our composite set;

Figures 11 and 12, illustrate typical sets of the prior art; and

Figure 13 is a graphical illustration of the magnitude and nature of the attenuation characteristics produced by the balanced circuits of our composite arrangement.

Referring to the form of our invention shown in Figs. 1 and 2, it will be seen that we have eliminated the artificial lines employed in the prior art devices to achieve the condition of balance and render the telephone immune from disturbances due to the telegraph transmitters. We employ a center-tapped inductance L_2 of relatively low value in shunt to the telephone set P and insert condensers in series therewith. By adjustment of the variable taps on the coils L_1 , L_1 and adjusting the resistances R_1 , R_1 the disturbance potentials at the terminals of the coil L_2 can be made approximately equal in magnitude and phase, thereby effecting a minimum of noise in the telephone receiver. When the currents traveling toward the symmetrical ground of coil L_2 are balanced in this manner, the coil L_2 presents substantially no inductance and hence causes only a very small potential drop across its terminals. Due to the central ground connection on the coil L_2 , the cross-fire between the two telegraph circuits is rendered negligible. This balanced ground connection is an essential of our composite set and it is most effective in connection with the differential coil L_2 . A further advantage of this low resistance ground path is that the pairs of line wires when so grounded, exert a shielding effect upon neighboring conductors, thus assisting to reduce the level of general interference on neighboring wires.

An added advantage achieved by our composite set is that the requirements are relaxed as to the quality of coils comprising the low pass filter F in the telegraph legs, inasmuch as high frequency harmonics, generated in these coils are applied in conjugate fashion to the voice frequency circuit and are thus relatively impotent to produce interference in this circuit.

Since the characteristics of a composite set involve a considerable compromise, the final values of the elements can usually best be chosen through experiment based on experience. Points to be observed in this design are that the cut-off point of the high pass portion shall occur at the resonant frequency of the circuit L_1 , C_2 , L_2 , C_3 , L_1 , that the condensers C_1 , C_2 , C_3 , C_4 which are approximately equal, must be kept small because of their effect on the physical circuits, and that the circuit impedance, as usual, is governed by the proportion between the inductances and the capacities.

While the resistances R_1 in the balancing circuits may be omitted, they produce a reduction in noise over a very wide range of frequencies, while they produce added attenuation only in the neighborhood of the cut-off frequency; consequently, these resistances if desired, may be employed as a frequency equalizing device in addition to their effect in reducing noise. The single section of low pass filter F , now required in each of the telegraph legs, may be balanced in the case of duplex working by a similar section in the composite balancing set. This permits an ap-

preciable reduction in bulk and cost for this device as well.

We have illustrated graphically in Fig. 13 the magnitude and nature of the attenuation characteristics produced by the cooperative elements in the balanced circuit arrangement of our composite set.

Curves A and B represent the transmission-frequency characteristics from the terminal sets to line through the composite set for the physical and voice frequency circuits respectively. These two curves if added together would produce the dotted curve C_1 , which for conventional types of composites would represent the attenuation to disturbing currents flowing from the physical to the voice frequency branches. In the arrangement which we have herein described however, this attenuation actually is given by curve C; the shaded area between curves C and C_1 representing the loss imposed upon disturbing currents due to the balanced connection. This loss it is seen is quite appreciable in magnitude, and is distributed over a wide range, but produces no appreciable added loss in the paths of the two working circuits.

The curve C'' indicates the added noise reduction which can be achieved by means of the resistances R_1 . This reduction however is at the expense of a slight increase in attenuation, illustrated at B' . In practical designs a compromise value of R_1 would probably be adopted.

It will be evident to engineers that various modifications of our invention may be made embodying the essential features thereof. We have illustrated in Figs. 3 to 10 certain of the modifications which may be employed. In Fig. 3, an autotransformer L_2' is substituted for the inductance L_2 to improve the impedance relations and in the low pass filter, tuned circuits tc to ground are substituted for the condensers. These circuits may be tuned to a frequency where added noise suppression is desired. In Fig. 4, a network N containing a symmetrical ground, but also resonant at a point slightly below the cutoff frequency is substituted for the inductance L_2 . This particular arrangement is effective in suppressing noise in the neighborhood of the cut-off frequency. In Fig. 6, at transformer T_L is substituted for the inductance L_2 . Figures 5 and 7 to 10 represent other modifications of this general form of composite set. In Fig. 10, the two inductances L_1 are comprised of transformers T_1 . They could be used separately with the secondaries closed through individual inductances of appropriate value. However, it has been found that these two secondaries may be connected in series through a single inductance L_3 . A further reduction in noise from the physical circuits into the voice frequency branch may be accomplished by connecting the secondary circuit to the coil L_2 as shown. The coils of the two transformers T_1 may be placed upon a single core. While it might appear that severe coupling between the two lines might result, this coupling is in fact negligible.

In the circuits of the preceding figures, particularly Fig. 2, a high degree of noise suppression was attained but this efficiency varied somewhat with lines of different character inasmuch as an approximate balance of the lines was involved. The efficacy of the noise suppression of the arrangement of Fig. 10, however, is substantially independent of the character of the lines to which it is connected. At the same time, the attenuation in the pass ranges of both the physical and

voice frequency circuits is very satisfactory. The curve B' of Fig. 13 does not apply to Fig. 10.

While our composite set has been described with particular reference to grounded physical circuits, it is also applicable for use with metallic circuits. It should be understood also that the composite set is not limited to the separation of the frequency ranges normally employed for direct current telegraph and the voice frequency range, but it may also be used for separating any two frequency ranges. While in this specification numerous references have been made to telephone transmission and to telephone instruments, it is to be understood that the composite set herein described is equally applicable for carrier telegraph, facsimile, or other transmission systems involving the transmission of two or more frequency ranges which are to be separated.

If it is desired to use two sets of composited lines as the sides respectively of a phantom circuit, each inductance L_2 may be comprised of two equal inductances in series with their junction points grounded; or an inductance may be inserted in series with the composite set ground. The connections to the phantom circuit may then be made in the usual way.

We claim:—

1. In a communication system having a pair of transmission lines, means for simultaneously transmitting voice frequency currents over said pair of lines and currents of telegraph frequency separately over each of said lines, comprising a composite set including a bridge across said lines having a pair of condensers and an intermediate inductance coil connected in series, voice frequency apparatus connected to said coil, means for connecting telegraph legs in conjugate relation to said apparatus, and means grounding the central point of said intermediate coil, whereby the balanced currents traversing the coil in opposite directions toward said ground nullify the inductance and the cross-fire between the lines is rendered negligible.

2. In a communication system as set forth in claim 1, said means for connecting the telegraph legs embodying a variable impedance element serving to reduce disturbance into the voice frequency circuit over a wide range of frequencies while increasing voice frequency attenuation only over the low frequency end of the range.

3. In a communication system having a pair of lines for the simultaneous transmission of currents respectively within the telegraph frequency range and the voice frequency range, a composite set including a telegraph bridge across the lines, voice frequency terminal apparatus connected to said lines, telegraph legs connected in conjugate relation to said terminal apparatus through said bridge, an inductance element grounded at its center and connected in shunt to said apparatus, and balancing circuits connecting each telegraph leg to the side of said element opposite to that to which the respective leg is connected through said bridge.

4. In a communication system having a pair of lines composited for the transmission of voice frequency currents thereover and the transmission of telegraph frequency currents separately over each line, a composite set having a shunt circuit across said lines including a pair of condensers and an intermediate centrally grounded inductance coil to which the voice frequency apparatus is connected, auxiliary balancing circuits, each including an inductance coil and a condenser, said circuits being connected respectively to the line and to said intermediate coil on the side opposite to its corresponding line connection and telegraph legs connected to said balancing circuit coils in conjugate relation to said apparatus.

5. In a communication system as defined in claim 4, said balancing sets including a resistance in series with the inductance coil and condenser.

6. In a communication system as defined in claim 4, each of said telegraph legs being constructed for duplex operation.

7. In a communication system as defined in claim 4, portions of said intermediate inductance coil being connected at points symmetrical to its central ground in a closed circuit containing inductance.

8. In a communication system as defined in claim 4, said telegraph legs including inductance coils adjustably connected to the inductance coils in the respective balancing circuits.

9. In a communication system as defined in claim 4, secondary coils in inductive relation to said balancing circuit coils connected in series and to said intermediate inductance coil in symmetrical relation to its grounded point.

10. In a communication system as defined in claim 4, portions of said intermediate inductance coil being connected at points symmetrical to its central ground in a circuit embodying a plurality of coils, certain of the latter being wound on a core with the inductance coils of said balancing circuits and forming transformers therewith.

11. In a communication system having a pair of lines, a balanced high pass network connected to the terminals of said lines, said network comprising two tuned circuits in series with an intermediate third inductance, condensers connected between each terminal and the distant terminal of the third inductance, and conductors including condensers connecting the terminals of said inductance to a translating device.

12. In a communication system having a pair of lines composited for the transmission of both voice frequency currents and telegraph currents thereover, a composite set comprising the four arms of a Wheatstone bridge and an inductance connected between opposite terminals of the bridge to form the diagonal circuit element of the bridge.

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