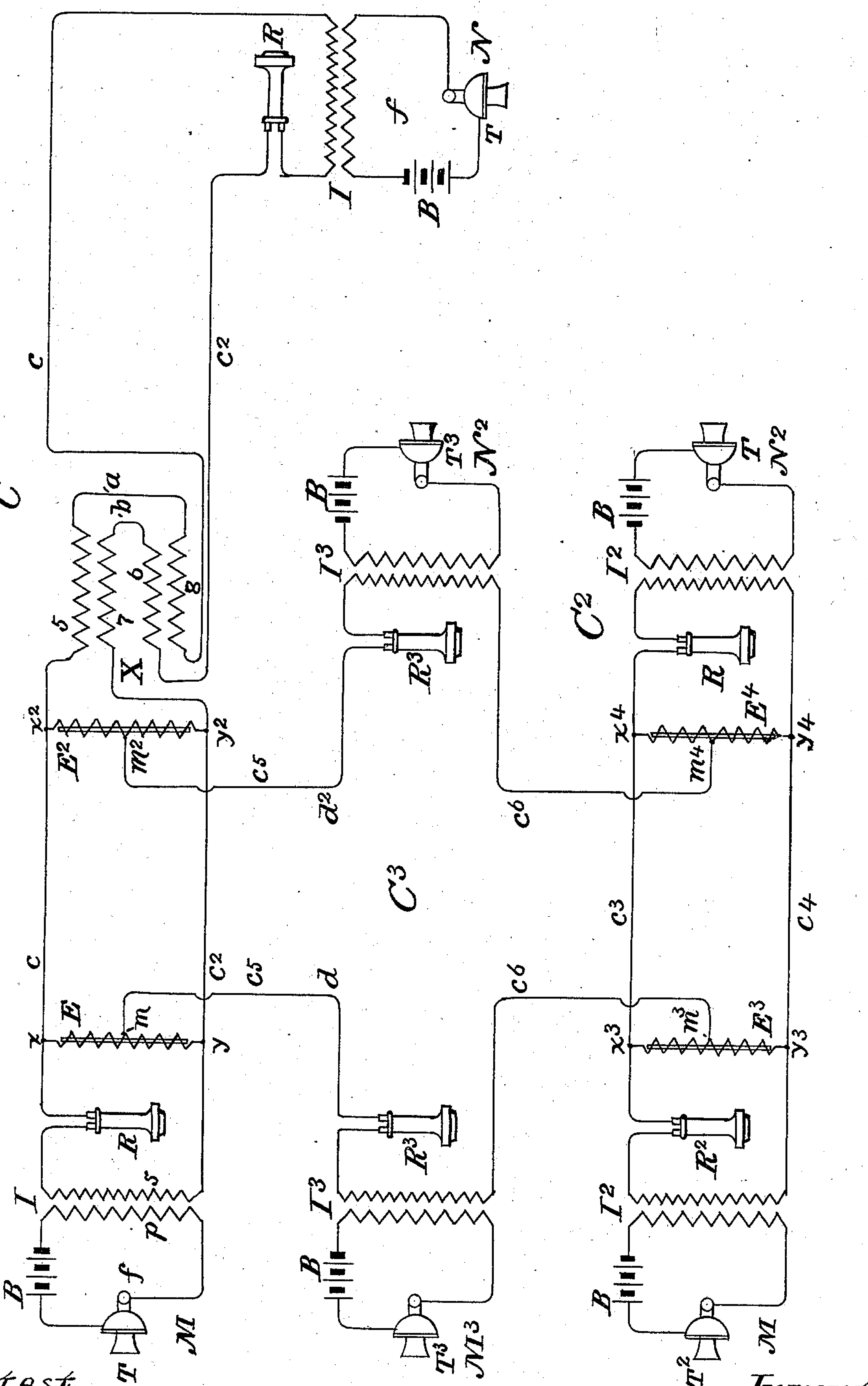
(No Model.) 2 Sheets—Sheet 1.

F. A. PICKERNELL & F. S. PERRIN.

MULTIPLE TELEPHONY.

No. 560,861. Patented May 26, 1896.

Fig. 1.



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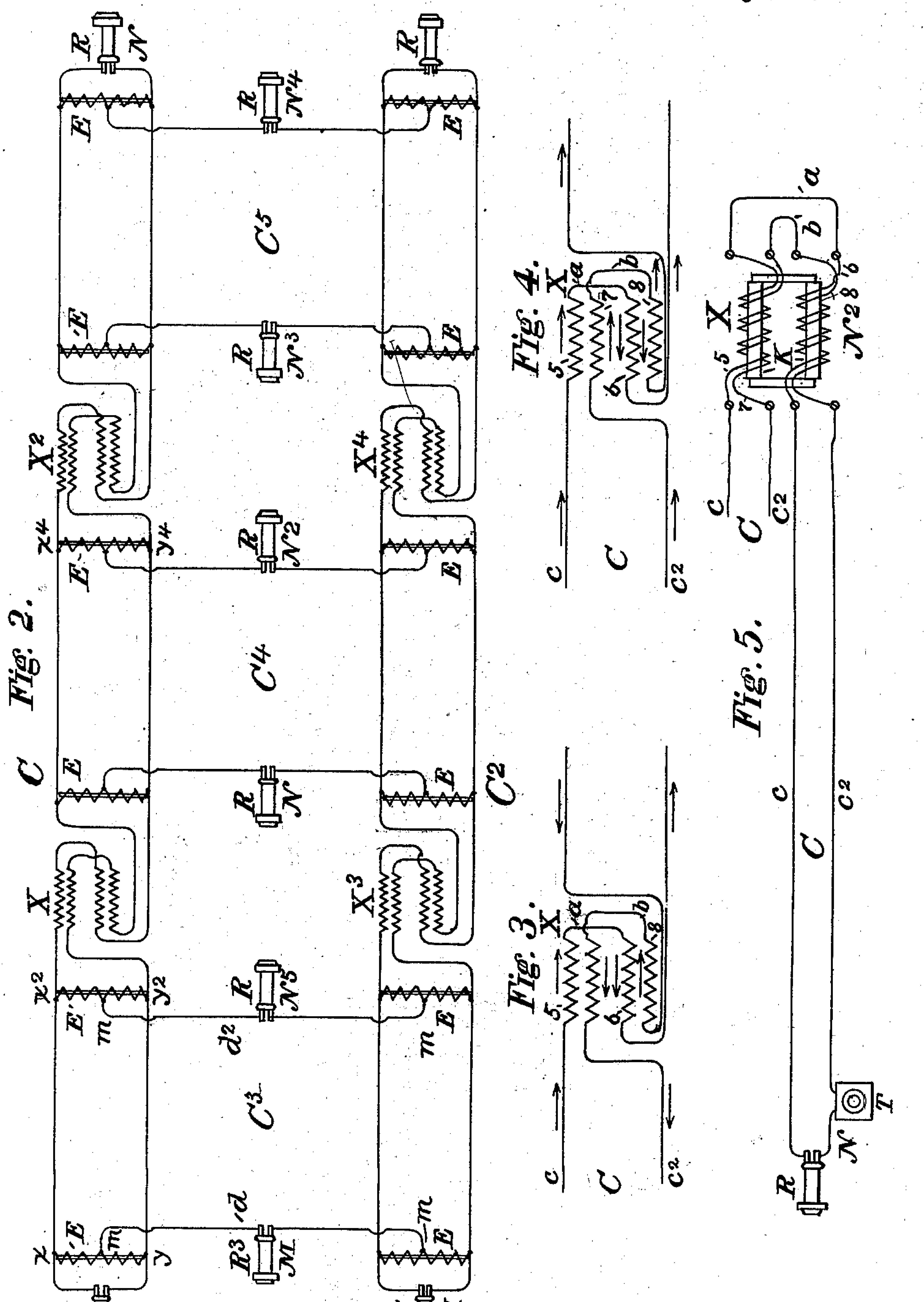

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UNITED STATES PATENT OFFICE.

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MULTIPLE TELEPHONY.

SPECIFICATION forming part of Letters Patent No. 560,861, dated May 26, 1896.

Application filed March 21, 1896. Serial No. 584,310. (No model.)

To all whom it may concern:

Be it known that we, FRANK A. PICKERNELL, residing at Newark, in the county of Essex and State of New Jersey, and FREDERIC S. PERRIN, residing at New York, in the county and State of New York, have invented certain improvements in Multiple Telephony, of which the following is a specification.

This invention relates to telephonic circuits and apparatus, and especially concerns systems of multiple telephony wherein two metallic line-circuits each have their outgoing or direct and return conductors connected or bunched in parallel with one another to collectively form the two sides or the direct and return conductors, respectively, of a third metallic line-circuit. In such a system any two wires forming in series a complete single telephone-circuit may also be employed in parallel as a single wire of larger size to constitute one of the conductors of another metallic circuit, and thus each pair of wires may be made to bear a part in the formation of a number of distinct circuits, the telephones of all of which can be operated simultaneously without interfering with one another. In constructing such a system it is frequently desirable and convenient that a third circuit formed of any two shall be shorter than one or both of its constituents, as would be the case if the two original circuits were extended between Boston and New York, while the third or superimposed circuit is required to extend from Boston to New Haven only, or one only of the original circuits might extend the greater distance, while the other constituent circuit might, together with the third or superimposed circuit, extend for only a portion of the said greater distance. It has also been found convenient to make the principles underlying the above-mentioned constructions available in other ways. For instance, a pair of metallic telephone-circuits extending between terminal stations may serve as a foundation on which a number of shorter, extra, or superimposed circuits uniting any two way-stations or a way-station and a terminal station may be formed, each of the said superimposed circuits in this instance having its two sides formed of portions of the two conductors in parallel of the two principal or constituent circuits. In systems of this kind it is evident that such portion or portions of either or both constituent circuits as extend beyond either end of the third or constituted circuit must be regarded as extensions or prolongations of the said constituent circuit or circuits and also of the superimposed circuit, which, though in conductive relation to the said third circuit, have no part in its structure and add nothing to its efficiency. It has, however, been found in practice that when two pairs of conductors of different lengths are associated to form a third circuit the latter circuit is subject to stray and induced currents and to variations and redistributions of electrostatic charge, which act upon its station-telephones and manifest themselves therein as loud and confused noises and disturbances, which interfere seriously with the proper operation of the said telephones. These disturbances obviously arise from the presence of the conductive extensions already mentioned, which project from certain points on the constituted circuit into inductive proximity to the conductors of other circuits, besides acting as electrostatic projections of large surface tending to accumulate considerable electrostatic charges, which distribute themselves over the several conductors of the system. In other words, the constituted circuit is by reason of these attached extensions in an unbalanced condition and is extremely subject to disturbance, because the disturbing currents flowing in one of its sides are not—and owing to the presence of such prolongations cannot be—neutralized by equal and oppositely-directed currents in its other side.

Our invention has for its object the establishment of a practical working balance in such superimposed circuits, whereby they shall be freed from the above-mentioned disturbances.

In our invention where one of the two constituent circuits is longer than the other we compensate for the unbalancing effect of said additional length or prolongation by associating with the longer constituent circuit an electromagnetic device interposed in circuit with the conductors thereof at a point adjacent to, but outside of or beyond, the end of the new or superimposed circuit, the said device by construction, connection, or adaptation being organized to oppose a minimum impedance—in fact, practically nothing more than simple resistance—to currents traversing the conductors of the constituent circuit in series—such, for instance, as the voice-currents passing between the terminal stations of the said circuit—but to oppose a maximum and high impedance to any currents traversing the conductors of the said constituent circuit and particularly the conductors in parallel of the prolongation thereof. The importance of this will be manifest when it is considered that the currents which disturb the superimposed circuit must necessarily reach the same by traversing a portion of the two conductors in parallel of some one of its constituents.

The electromagnetic device we employ is a double-wound electromagnetic resistance or choking-coil, and we connect its two windings in the circuit of the two prolongation-conductors in such a way that any current passing through the two windings one after the other (a condition which is complied with by the legitimate working currents of the constituent circuit itself) shall, in each, set up magnetizing effects equal and opposite to the magnetizing effects of the other upon their common iron core, so that as far as these currents are concerned the reactance of the device due to self-induction is eliminated, the core maintaining a magnetic zero and the coil-windings therefor offer an opposition due to their resistance only; but it is obvious that any current passing through the two windings in parallel or side by side (a condition of currents or waves, which pass to or from the superimposed circuit through the conductors of the prolongation) will necessarily circulate in each round the iron core in the same direction, so that the current flowing in each winding will assist the magnetizing effect of that flowing in the other. The self-inductive reactance of the device will in such case be present to the fullest extent, and the coil-windings will offer an impedance to the passage of these currents corresponding to the vector sum of the said reactance and coil-winding resistance.

When in our invention it is desired to form two or more way-circuits from the metallic through-circuits, we prefer to unite the station terminal portions of our superimposed or constituted circuits, including the station-telephones, to their main-line sections (each such section being formed of a portion of the two constituent circuits) by means of singly-wound impedance-coils, which are bridged between the two wires of each of the said two original circuits at appropriate points, the two such coils of each way-station having the middle point of their respective windings connected with the ends, respectively, of the telephone-containing-station portions of the way-circuit terminating at such way-station.

In the drawings which accompany and illustrate this specification, Figure 1 is a diagram representing a system of three metallic circuits formed of four line conductors in which the inequality in length of the two pairs of line conductors is compensated for and balanced in accordance with the principles of our invention. Fig. 2 is a diagrammatic representation of an application of the same principles to a system of multiple telephony wherein a number of way telephone-circuits are superimposed upon a pair of through metallic telephone-circuits, the same four main conductors being employed for both classes of circuit, whereby each way-circuit is balanced notwithstanding the prolongation of its sides. Figs. 3 and 4 are detail diagrams illustrating the windings of our double-wound segregating device and the direction through the said windings of currents passing them in series and in parallel, respectively; and Fig. 5 is a diagram indicating more clearly the construction of the said device.

In the drawings, as far as possible, like appliances and circuit connections are indicated by similar reference letters and numerals, and where similar devices occur more than once in the same figure, but require to be distinguished, the first bears the letter alone and the other ones are supplied with exponents of successively-increasing magnitude.

In Figs. 1 and 2 the original or constituent telephone-circuits are marked C and C^2, and the constituted or superimposed circuits in the first case C^3 and in the second case C^3, C^4, and C^5.

T represents the telephone-transmitters; R, the receivers; I, the ordinary transmitter induction-coils; B, the transmitter-batteries, and E the single-wire electromagnetic resistances or choking-coils bridged between the two conductors of any constituent circuit at the points where they are joined to the terminal conductors of a superimposed circuit.

X represents the double-wound electromagnetic resistance, which is the characteristic feature of our invention and which forms the electromagnetic segregating device interposed in the conductors of each constituent main circuit at points where the said conductors extend beyond the end of any extra main circuit, having one of its line conductors composed of the two conductors in parallel of the said prolonged line. The principle underlying the said segregating device is well indicated by Fig. 5, where such a device X is represented as being placed at a station N^2 of a telephone-circuit C, whose direct and return conductors c and c^2 extend to a terminal station N, where are placed a telephone transmitter T and receiver R. In this instance the device X is provided with an iron core K, having a closed magnetic circuit, over which the two windings are wound in two sections 5, 6, 7, and 8, respectively.

The circuit starting from the entering-point of the main conductor c may be traced through the coil X as follows: conductor c, winding-section 5, connection a, winding-section 6, wire c, receiver R and transmitter T at station N, wire c^2, winding-section 8, connecting-wire b, winding-section 7, and main conductor c^2. In such a compound coil, so connected, it is evident that the magnetic polarity or tendency thereto developed at any or all points of the core by the action at any given moment on said core of a current of given direction traversing the winding-sections in series and acting through the winding-sections 5 and 6 will be opposed and neutralized by the action of the same current in winding-sections 7 and 8; but it is also evident that if a current instead of going through the windings in series be sent through the sections 5 and 6 in parallel with the sections 7 and 8 the currents in the two windings will be in the same direction as regards the core, and instead of exerting each a neutralizing effect on the other they will exercise a mutually reinforcing effect each at all points tending to set up like polarity or magnetization. The result of this is of course that little self-induction will occur in the transit through the complete coil of currents passing the windings in series, and that a high development of self-induction will occur in the transit of currents through the windings of the coil in parallel; and since rapidly-varying currents are strongly opposed by self-inductive reactance it follows that we may say that the coil X will offer a maximum impedance to currents traversing its windings in parallel and a minimum impedance to currents traversing its windings in series. These facts are more clearly illustrated by Figs. 3 and 4, which indicate by arrows the different effects of the passage through the windings of series and parallel currents, for in Fig. 3, which illustrates the route of the series currents, we see that the magnetizing action of the current flowing through the sections 5 and 6 of the winding in conductor c is necessarily neutralized by the same current flowing in the opposite direction through the winding-sections 7 associated with 5, and 8 associated with 6, and in Fig. 4, which illustrates the route of currents sent through the coil-conductors in parallel, we see that the windings 5 and 6 each wind round their respective core-sections in the same direction as their respective associated windings 7 and 8, and since the currents are also in the same direction the magnetization induced by 5 and 6 is reinforced and exalted by that of 7 and 8. It is of course not necessary that the form of choking-coil indicated in Fig. 5 shall be followed. Instead of a ring or closed core we may employ one in the form of a cylinder and have one section of each winding wound over each end of the said cylinder. In short the essence of the device consists in the electrical relation of the windings and not in form in any sense whatsoever.

Recurring to Fig. 1, c and c^2 are the two main conductors of a metallic telephone-circuit extending between two terminal stations M and N and fitted at each with the ordinary telephones T and R, the former shown as being associated with a battery B, a local circuit f therefor, and an induction-coil I, whose primary p is in the local circuit f with the transmitter, and whose secondary s is in the main circuit C with the receiver.

C^2 is a second metallic telephone-circuit extended in a direction substantially parallel with the first. It is not, however, as long as the first, and though one of its ends also is at station M its other end reaches only as far as station N^2, which may be a way-station—possibly of circuit C. We may consider that circuit C^2 is about half as long as circuit C. A third circuit, C^3, may now be formed between the stations M and N^2 without employing any additional main conductors by arranging on circuits C and C^2 at the two desired stations singly-wound electromagnetic resistance or impedance coils E, bridged between the two conductors c c^2 and c^3 c^4 at points x and y, and uniting the central or middle points m and m^3 of the winding of the coils E and E^3, associated with the circuits C and C^2 at station M, and the central points m^2 and m^4 of coils E^2 and E^4 at station N^2 by means of terminal conductors d and d^2, including the telephones T^3 and R^3 of the new and extra circuit. Since this new and extra circuit has no main conductors of its own, but employs the two wires c c^2 of circuit C in parallel as one and the two wires c^3 c^4 of circuit C^2 in parallel as the other of its sides, it is a superimposed circuit having the two original circuits as its constituents, and it may in conformity with usage be termed a "phantom-circuit." From the point m it may be traced by way of c^5, receiver R^3, induction-coil I^3, and wire c^6 to m^3, thence in split conductor to the two ends x^3 y^3 of coil E^3 and over the two conductors c^3 c^4 of circuit C^2 in parallel to x^4 and y^4 and to the central point m^4 of coil E^4, then through wire c^6, induction-coil I^3, receiver R^3, and wire c^5 at station N^2 to the central point m^2 of coil E^2 and back over the conductors c and c^2 of circuit C in parallel to the coil-terminals x and y at station M, and from the said terminals to the starting-point m at the center of the coil E. The currents of circuit C will find so much impedance in the bridged electromagnetic coils E that they will have little tendency to leak through the bridges, but the currents of circuit C^3, passing as they do between the middle of each of the said bridges and its ends, will be subjected to very little impedance. Such a system, as far as described, is unbalanced by reason of the prolongation of circuit C beyond the end of the phantom-circuit and beyond the end of circuit C^2, for although the phantom-circuit C^3 is indeed a metallic telephone-circuit with its two sides substantially equidistant from parallel sources of inductive disturbance it is not balanced as is necessary to secure immunity from such disturbances, because from the end of one of its constituents an electrostatic extension or prolongation projects in the form of that portion of circuit C which continues to station N. We find that a practical balance may be attained by connecting our double-wound electromagnetic segregating or differentiating device in the circuit of the two conductors c c^2, in the manner shown, at a point beyond the connection of the terminal d^2 of the phantom-circuit C^3 and its associated choking-coil E^2. The windings 5 and 6 are connected one after another in the conductor c, and the windings 7 and 8 are connected one after another in the conductor c^2. When so connected, the windings, though all in circuit C, offer merely the opposition of resistance to the currents of the said circuit and being half in one of its sides and half in the other do not in any way unbalance the same, while they present a maximum impedance to stray or disturbing currents or waves, or charge distributions which may be accumulated by the extension toward N of the conductors of circuit C, and which tend to surge through the phantom-circuit C^3. In other words, they form such an effective bar to the passage of such currents over c and c^2 in parallel that such portion of C as constitutes one side of C^3 is substantially segregated from the prolongation of C toward N, and as a consequence two sides of C^3 are no longer unbalanced.

In Fig. 2 the same principles are applied to the utilization of the conductors of the two circuits C and C^2 in such a manner that out of them a number of way telephone-circuits may be formed, each employing a different longitudinal section of the said circuits C C^2. Three such way-circuits are in the drawings shown. These are C^3, extending between stations M and N^5; C^4, extending between N and N^2, and C^5 between stations N^3 and N^4. Each way-circuit is formed in a manner similar to the circuit C^3 of Fig. 1 of terminal conductors d d^2, and telephones R, connected therein, uniting at their respective stations the middle points m of the two singly-wound choking-coils E, which at such stations are bridged between the main-line conductors of the constituent circuits C and C^2, so that the portions of the two conductors of the said circuits located between the coils E of any two paired stations, as M and N^3, constitute in parallel the direct and return conductor, respectively, of the way-circuit concerned. In this arrangement we place one of our double-wound choking-coils X in the circuit of the two conductors of each of the constituent circuits C and C^2 between the approximate or adjacent ends of each two successive way-circuits, as shown in the figure, where X and X^3 are associated with the circuits C and C^2 between the conterminous ends of the way-circuits C^3 and C^4, while the choking-coils X^2 and X^4 are similarly placed with respect to the other end of way-circuit C^4 and the neighboring end of C^5. When our double-wound coils X are so placed, the current from the telephones R^3 at station M will not pass beyond station N^3, where it will operate the corresponding telephones R^3, and the other way-circuits C^4 and C^5 are in like manner completely isolated.

By means of our invention, therefore, we are enabled not only to restore a practical working balance to phantom telephone-circuits superimposed upon the conductors of metallic telephone-circuits, where the constituent circuits are unequal in length, but also to divide pairs of long metallic circuits into sections, using the two conductors of such sections of the said circuits as the two sides of shorter way-circuits available for local and intermediate intercommunication, while the said long circuits as a whole are being employed for through business.

We claim as our invention—

1. The combination of a metallic telephone line-circuit, a second main metallic telephone-circuit having for one of its sides or conductors a portion of both of the conductors in parallel of the first circuit, and a double-wound electromagnetic resistance or choking-coil having its two windings serially but opposingly connected in the conductors of the said first circuit at points beyond or outside the portion of them which forms one side of the second circuit, and adapted thereby to offer a minimum impedance to currents flowing through the conductors of the said first circuit in series, and a maximum impedance to currents flowing through the same conductors in parallel, substantially as specified.

2. The combination of two main telephone-circuits each having an outgoing and a return conductor, and a third telephone-circuit whose direct and return conductors are formed of the two conductors in parallel of the said two original circuits respectively, one or both of said original circuits being longer than the said third circuit, or having an extension or prolongation beyond an end thereof; with an electromagnetic device interposed in circuit with the two conductors of each extension, immediately beyond the end of the said third circuit, and adapted to oppose a maximum impedance to currents traversing the conductors of the said extension in parallel, and a minimum impedance or simple resistance to currents traversing the said conductors in series; whereby the said original circuit extensions may be segregated from the said third circuit, and prevented from disturbing the balance thereof, substantially as specified.

3. The combination in a system of multiple telephony, of two metallic telephone-circuits each extending between two terminal stations; electromagnetic resistance or single-wire choking-coils bridged between and connecting the two conductors of both of the said circuits at one or more pairs of stations located thereon; terminal conductors including station-telephones, uniting the central, points of the said electromagnetic resistances of the

two circuits at any pair or pairs of such stations; to form thereby one or more superimposed or phantom circuits, each having its two sides formed of portions of the two conductors in parallel, of the two original circuits; and a series of double-wound electromagnetic resistances or choking-coils, associated with each of the said original circuits, and having their two windings serially connected in the two conductors thereof, the said choking-coils being interposed in pairs in their respective constituent circuits, at points between any two of the said extra or superimposed circuits, and so connected as to offer a maximum impedance to currents passing in parallel and the minimum impedances to currents passing in series over the conductors of the said two original circuits.

In testimony whereof we have signed our names to this specification, in the presence of two subscribing witnesses, this 18th day of March, 1896.

FRANK A. PICKERNELL.
FREDERIC S. PERRIN.

Witnesses:
ALFRED E. HOLCOMB,
EDWARD W. BELL.