

Oct. 23, 1923.

1,471,388

E. DIETZE

SIGNALING CIRCUIT

Filed Jan. 26, 1921

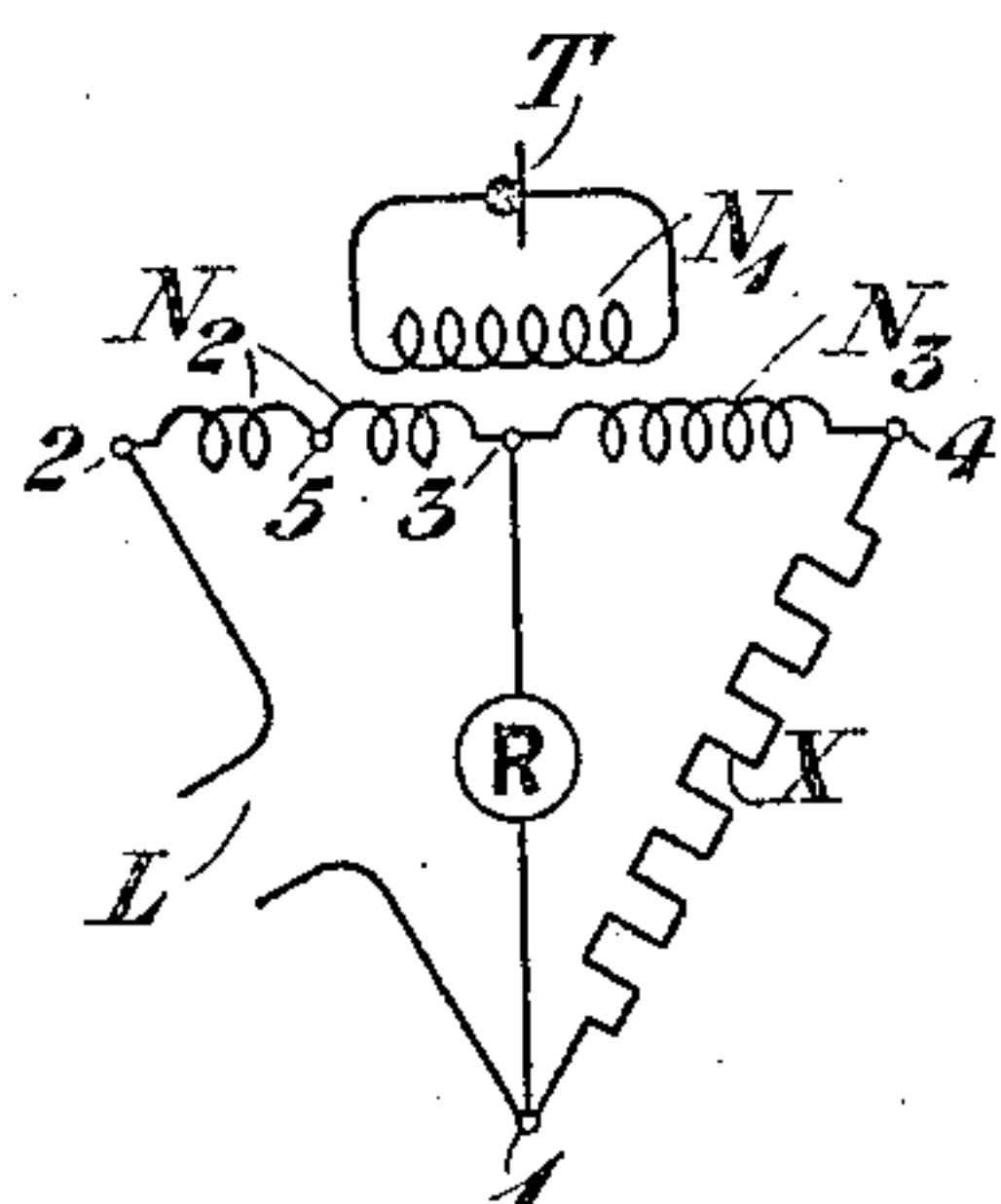


Fig. 1

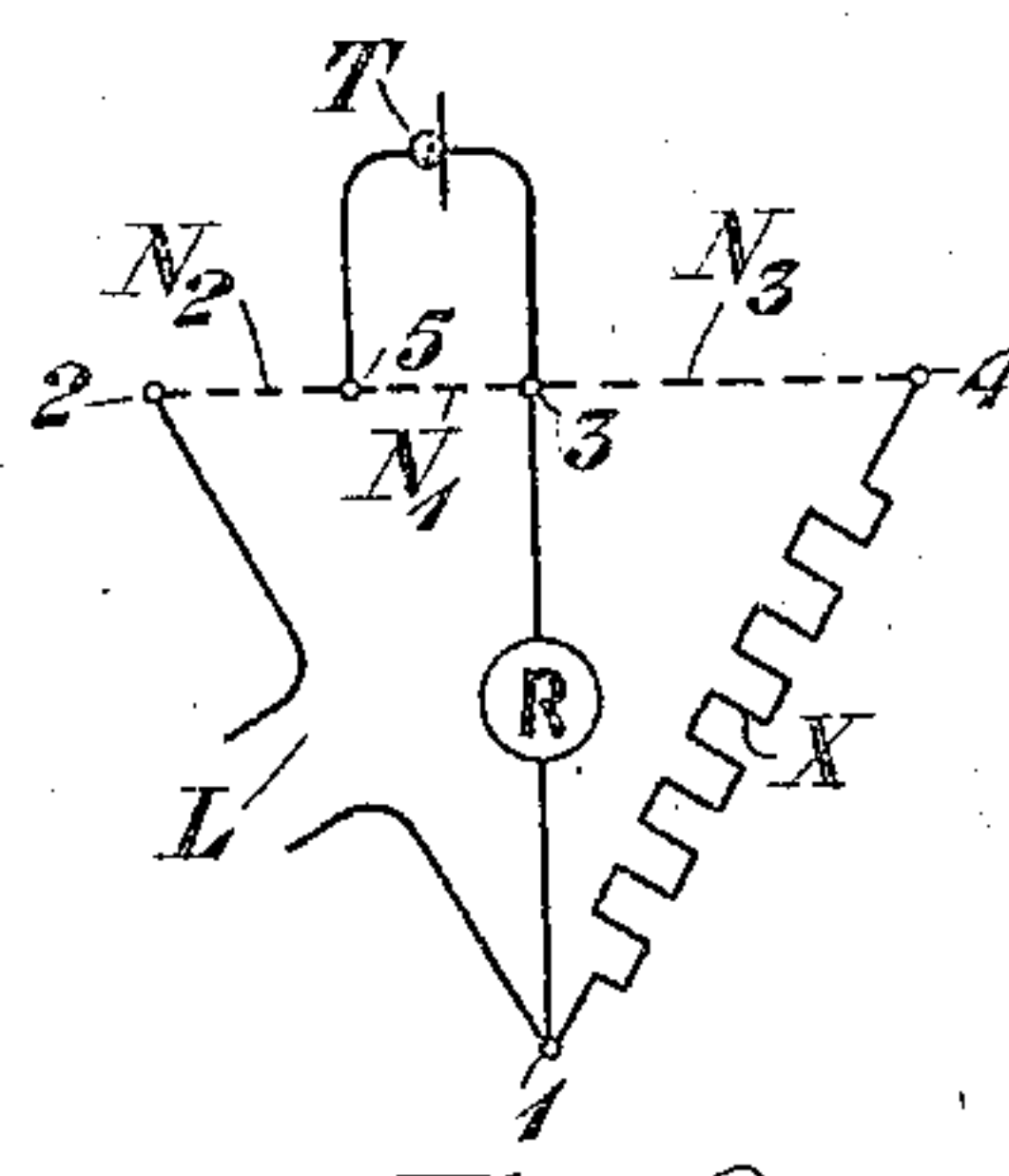


Fig. 2

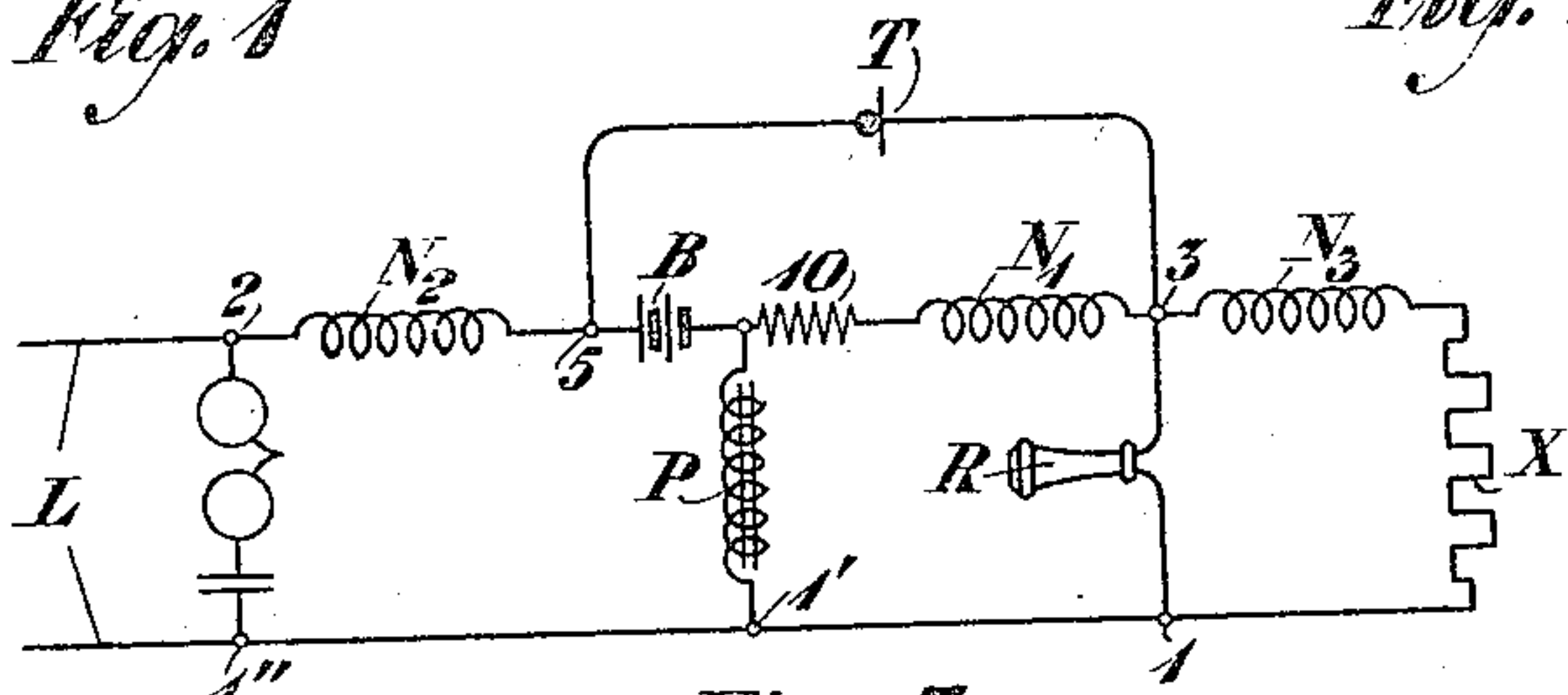


Fig. 3

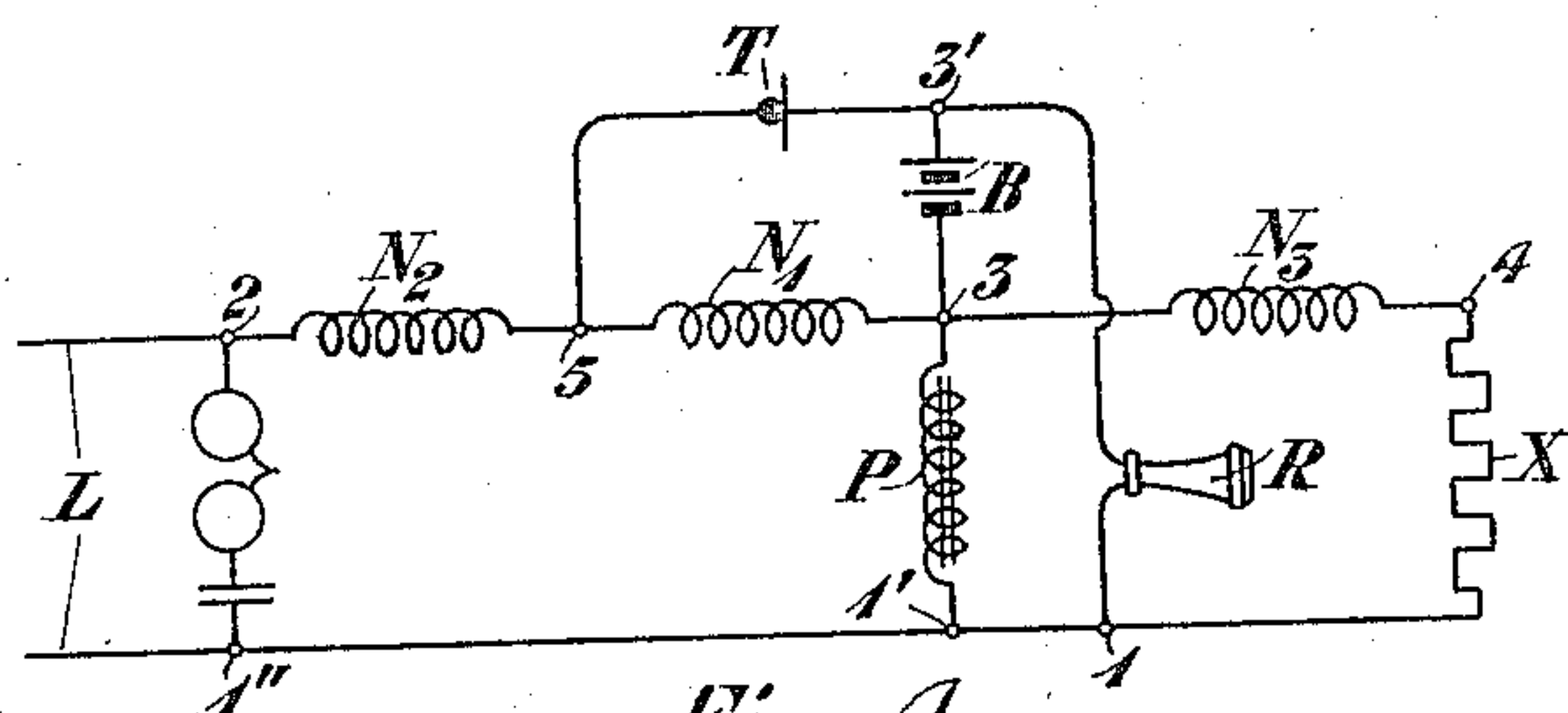


Fig. 4

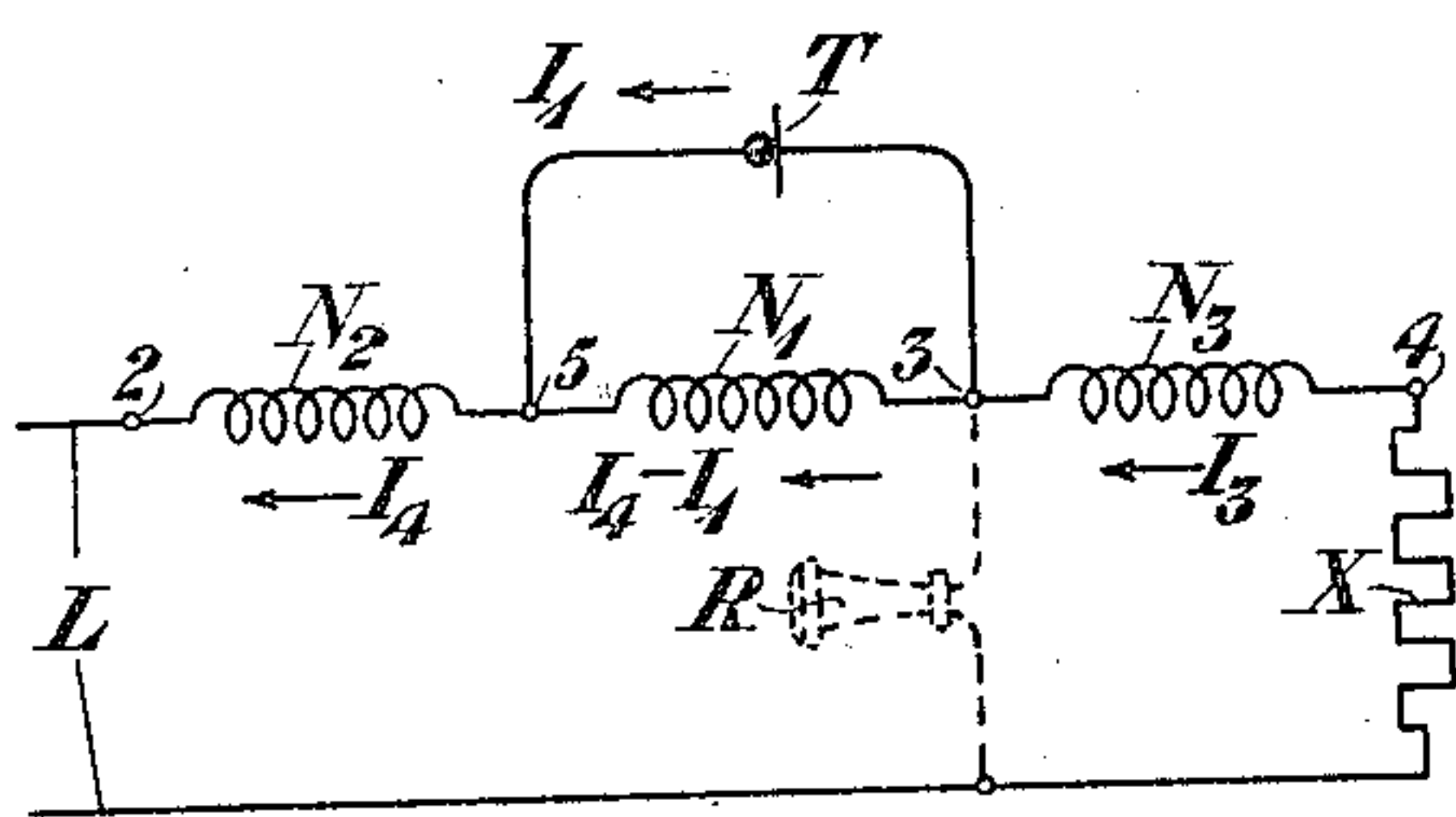


Fig. 5

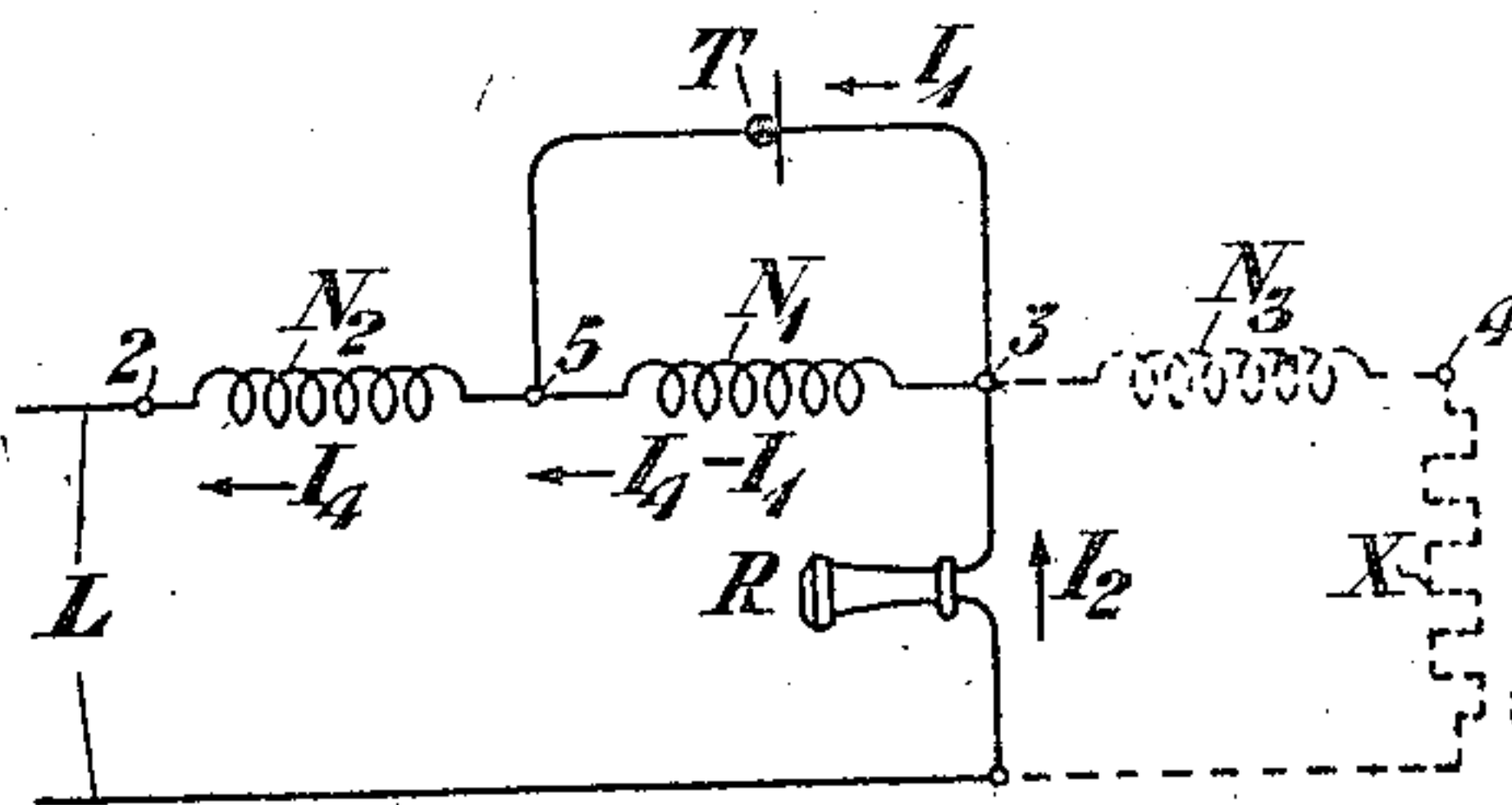


Fig. 6

Inventor
E. Dietze

By his Attorney *gaylor*

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1,471,388

UNITED STATES PATENT OFFICE.

EGINHARD DIETZE, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

SIGNALING CIRCUIT.

Application filed January 26, 1921. Serial No. 440,087.

To all whom it may concern:

Be it known that I, EGINHARD DIETZE, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Signaling Circuits, of which the following is a specification.

This invention relates to circuit arrangements for signaling systems wherein signals may be either transmitted from or received at the same station. In its more specific aspects, this invention is embodied in a subscriber's telephone station hereinafter termed, in accordance with the common usage, a substation, and, more particularly, in the combination of a substation and a telephone line, the substation circuit arrangement being of the general type proposed by George A. Campbell and described in a number of U. S. patents issued to him under date of January 22, 1918, and numbered as follows: 1,254,116; 1,254,117; 1,254,118; 1,254,471; 1,254,472; 1,254,473; 1,254,474; 1,254,475 and 1,254,476.

As fully set forth in the patents above referred to, telephone substations of the Campbell type comprise a transmitter, receiver, auxiliary resistance and a transformer having a plurality of windings, and these elements, in combination with a telephone line, are so designed that: (1) the transmitter and receiver are conjugate, that is, there is negligible side tone in the receiver in consequence of the actuation of the transmitter by sound waves; (2) the line and auxiliary resistance are conjugate, in order that none of the energy absorbed by the substation from the line shall be wasted in said auxiliary resistance; (3) for a given line having a definite impedance, telephonic energy delivered by the transmitter is a maximum; (4) the amount of energy delivered by the line to the substation is a maximum—in other words, the impedance of the substation as seen from the line is equal to the impedance of the line; (5) at a small sacrifice of efficiency, it is possible to discriminate effectively against disturbing line noise, as distinguished from the telephonic signals from the communicating station.

In common battery telephone exchanges, special conditions often arise in which it is desirable to connect to the switchboard subscribers who are further away from the office than can be reached with the gauges

of cable usually employed for substation loops without exceeding the standard of transmission maintained for such exchanges. In such cases, in order to reduce the transmission loss between the substations and the switchboard, it is desirable that local battery sets be installed, so that these stations employ local battery for talking and common battery for signaling. It is also desirable that, if local battery sets are to be employed, high efficiency transmitters and receivers should be used, since the use of these instruments in a local battery set would not only give a gain in transmitting efficiency but in receiving efficiency. If, therefore, a set be employed, using a high efficiency transmitter and a receiver of the well-known electromagnet or direct current type, the circuit will not only have the advantages just stated, but it will also be an improvement from a maintenance standpoint, since the local battery set used on extraordinarily long common battery lines will then employ the same transmitter and receiver which are used in the ordinary common battery sets.

It is, therefore, one of the objects of this invention to produce a substation circuit having the characteristics of the Campbell type and which is so arranged that a local battery may be employed to energize both the transmitter and receiver, said local battery being adapted to energize these instruments either alone or in conjunction with common battery energy supplied from a central station, common battery energy being also employed for purposes of signaling and supervision.

Other and further objects of the invention will be clear from the following description when read in connection with the accompanying drawing, Figure 1 of which is a schematic diagram of the general type of Campbell substation circuit, from which the circuit of the present invention is derived; Fig. 2 of which is a similar diagram of the circuit of the present invention; Figs. 3 and 4 of which are diagrams showing two circuit arrangements of the invention in more detail; and Figs. 5 and 6 of which are diagrams illustrating the flow of alternating current during the operations of transmitting and receiving, respectively.

The general theory of substations of the type to which the present invention belongs, is fully set forth in the above men-

tioned patents to George A. Campbell, so that it is unnecessary to present any theoretical considerations in the present instance, a simple description of the circuit arrangement being sufficient for a full understanding of the invention.

Referring to Figs. 2 and 3, L designates a transmission line terminating in a telephone substation arrangement comprising a transmitter T, a receiver R, an auxiliary resistance X and a transformer comprising windings N_1 , N_2 and N_3 . One side of the line L and one terminal of the receiver R and the auxiliary resistance X are joined together at a common point 1. The winding N_3 is joined between the other terminal of the auxiliary resistance X and the other terminal of the receiver R, the windings N_2 and N_1 being connected in series between the terminals 2 and 3 of the line L and the receiver R, respectively. The transmitter T is connected between the common point 5 of the windings N_1 and N_2 and the terminal 3 of the winding N_2 , so as to be in shunt with the winding N_1 . A local battery B is inserted in circuit with the winding N_1 for supplying the current for the transmitter T. This battery would also supply an energizing current for the electromagnet receiver R through the winding N_2 over the line L, through the receiver R and back to battery through the winding N_1 . The resistance of this circuit, however, is quite high and, in order to provide a path of low resistance for the battery supply of the electromagnet receiver R, an impedance coil P is connected between the right-hand terminal of the battery B and the terminal 1'. The impedance coil P is of low resistance, so that a large current supply is furnished to the electromagnet receiver R over a circuit from the battery through the coil P, through the receiver R and through the transmitter T, to the other terminal of the battery. The impedance of the coil P is made very high, however, so that, as regards the flow of alternating current in the substation circuit, the path through the impedance coil is practically an open circuit. The resistance of coil P is so proportioned as to supply optimum direct current to the electromagnet receiver. It will be noted that the coil N_1 , which, as ordinarily constructed in the Campbell type of substation, is of low resistance, would normally constitute a low resistance shunt across the circuit including the receiver R, thereby diverting current away from the receiver. In order to prevent this a resistance 10 is included in the path of the winding N_1 , so that the resistance of this path becomes sufficiently large to cause a large current to flow over the circuit previously traced, including the transmitter T and the receiver R in series. It will be understood that in practice this resistance may be incorporated in the winding N_1 .

A slight modification of the circuit is illustrated in Fig. 4. This modification differs from that of Fig. 3 in that the battery B is included between the junction point 3 of the windings N_1 and N_3 and the junction point 3' of the transmitter T and electromagnet receiver R. The impedance coil P, instead of being connected as in Fig. 3, is connected between the terminal 3 and the point 1' which is strapped to the terminal 1 of the receiver. In accordance with this form of the invention, the receiver R and transmitter T are in effect strapped together to the terminal 3 through the battery B which, (so far as the flow of alternating current is concerned) may be considered of negligible impedance. From this standpoint, therefore, the circuit is identical with that of Fig. 3. This form of circuit arrangement also has the advantage that it is unnecessary to provide a resistance corresponding to the resistance 10 of Fig. 3, as there is no circuit of low impedance in shunt with the receiver R. With the battery B connected as shown, direct current for energizing the transmitter flows through the winding N_1 and the transmitter T back to battery, while the direct current for energizing the receiver R flows from the battery B through the impedance coil P and through the receiver R back to battery.

In so far as the flow of alternating current is concerned, the two arrangements of Figs. 3 and 4 are identical and differ only as regards the direct current connections. The operation of these circuits when transmitting will be as indicated in Fig. 5, in which the arrows designate the instantaneous flow of alternating current. The diagram of Fig. 5 is simplified by omitting the direct current apparatus and illustrating only the circuits for the flow of alternating current and may be considered as exemplifying either the arrangement shown in Fig. 3 or Fig. 4. When the transmitter T is actuated, its operation is equivalent to setting up an alternating electromotive force in the circuit of the transmitter T, so that a current I_1 will flow at a given instant in the direction indicated by the arrow to the left of the transmitter T. As the transmitter T and the receiver R are conjugate, no current flows through the receiver R in response to the actuation of the transmitter T, and, therefore, the current I_1 , which flows over the line L in response to the actuation of the transmitter T must be equal to the current I_2 flowing through the auxiliary resistance X. Consequently, a current equal to the difference between the transmitter current I_1 and the line current, or its equivalent, the current I_3 through the auxiliary resistance X, appears in the winding N_1 , so that a current $I_4 - I_1$ flows in the direction indicated by the arrow, just below the winding N_1 .

The operation during the reception of sig-

nals is indicated in Fig. 6. An electromotive force applied to the line L causes the line current I_4 to flow through the winding of the coil N_2 in the direction indicated. As the auxiliary resistance X is conjugate with respect to the line L under these conditions, no current flows through the auxiliary resistance and, consequently, no current flows through the winding N_3 . It follows, therefore, that the current I_2 through the receiver must be equal to the line current I_4 . A current I_1 will be caused to flow through the transmitter in the direction indicated by the arrow to the right of the transmitter T and a current will flow through the winding N_1 , in the direction indicated, this current having a value $I_4 - I_1$.

The circuit of the present invention is a development of the general type of circuit disclosed in Fig. 1 of Campbell Patent, 1,254,472, above referred to, and the circuit type of said patent can be represented schematically as shown in Fig. 1. The operation of such a circuit as an anti-side tone circuit requires that in all cases the voltages between terminals 2—3 and 3—4 be series-aiding and of the relative magnitude γ , where γ is the energy distribution ratio and may be defined as the ratio of the energy in the transmitter to the energy in the receiver on receiving.

The design formulæ for the general type of circuit as given in the Campbell patent are as follows:

$$\begin{aligned} \frac{N_2}{N_1} &= \pm \sqrt{\frac{R_4}{R_1} \frac{\gamma}{1+\gamma}} \\ \frac{N_3}{N_1} &= \pm \sqrt{\frac{R_4}{R_1} \frac{1}{\gamma(1+\gamma)}} \\ R_3 &= \frac{1}{\gamma} R_4 \\ R_2 &= \frac{1}{1+\gamma} R_4 \end{aligned} \quad (1)$$

The circuit of the present invention may be obtained from the type circuit illustrated in Fig. 1 by eliminating the winding N_1 of Fig. 1 and bridging the transmitter across the terminal 3 and some point 5 of the winding N_2 , thereby giving the general type of circuit schematically illustrated in Fig. 2. This leads to an auto-transformer arrangement between the windings N_1 and N_2 of Fig. 1, the part of the winding N_2 between the terminals 3 and 5 taking the place of the winding N_1 . Windings N_1 and N_3 in Fig. 2 correspond respectively to the windings N_1 and N_3 of Fig. 1, and the number of turns effectively in series between the terminals 2 and 3 of Fig. 2 represent the winding N_2 of the circuit of Fig. 1. These turns and the turns of the winding N_3 are always series-aiding as above pointed out.

There are in general a number of possible values for the winding N_2 of Fig. 2, cor-

responding to several possible arrangements of the windings on the core. For example, all three windings in Fig. 2 may be series-aiding, in which case the turns of winding N_2 of Fig. 2 are equal to the turns of winding N_2 of Fig. 1 minus the turns of winding N_1 of Fig. 1. Another method of winding is to make N_2 and N_3 of Fig. 2 aiding, and N_1 opposing, in which case the turns of winding N_2 of Fig. 2 will be equal to the turns of winding N_1 of Fig. 1 plus the turns of winding N_2 of Fig. 1. It is also possible to arrange the windings of Fig. 2 so that windings N_1 and N_3 of said figure will be aiding and N_2 opposing. In this case the turns of winding N_2 of Fig. 2 will be equal to the turns of winding N_1 of Fig. 1 minus the turns of the winding N_2 of Fig. 1.

In practice, when the transmitter resistance is low, the first of these methods of winding, that is, the one in which windings N_1 , N_2 and N_3 are series-aiding, is preferable as it requires a minimum number of turns on the transformer. The design formulæ for this case may be readily obtained from the design formulæ of Fig. 1 by considering the relations between the windings of Fig. 1 and Fig. 2, as just given. These design formulæ are as follows:

$$\begin{aligned} \frac{N_2}{N_1} &= \sqrt{\frac{R_4}{R_1} \frac{\gamma}{1+\gamma} - 1} \\ \frac{N_3}{N_1} &= \sqrt{\frac{R_4}{R_1} \frac{1}{\gamma(1+\gamma)}} \\ R_3 &= \frac{1}{\gamma} R_4 \\ R_2 &= \frac{1}{1+\gamma} R_4 \end{aligned} \quad (2)$$

In formulæ (1) and (2) it will be understood that R_1 is the resistance of the transmitter, R_2 the resistance of the receiver, R_3 the resistance of the auxiliary element and R_4 the resistance of the line, while γ is the energy ratio previously defined. It will be seen from these formulæ that having given the line impedance and the resistance of the transmitter it is desired to use, the impedance of the receiver and auxiliary element and the number of turns of the winding of the transformer may be readily obtained by assigning any desired value to the ratio γ . As pointed out in the Campbell patent, a desirable value for γ is in the neighborhood of 1.4. It will of course be obvious that while the auxiliary element X is illustrated as a separate resistance element, in practice the resistance represented by this element may be obtained by properly designing the winding N_3 so that the elements N_3 and X may be merged.

It will be apparent that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing

from the invention, as defined in the following claims.

What is claimed is:

1. In a signaling system a transmission
5 circuit, a transmitting circuit, a receiving
circuit, a balancing circuit, and a trans-
former having three windings, one of said
windings being included in said transmis-
10 sion circuit, another of said windings being
included in said balancing circuit, and the
third winding being included between said
transmission and balancing circuits; a ter-
minal of each of said transmission, receiving,
15 and balancing circuits being joined together,
the other terminal of said receiving circuit
being connected to the junction point be-
tween said third winding and said balanc-
ing circuit; said transmitting circuit be-
20 ing connected in shunt with said third wind-
ing; a source of direct current so connected
as to supply current to both said transmit-
ting and receiving circuits, and a connection
having large impedance and low resistance
25 directly connected between one terminal of
said source and a terminal of said receiving
circuit.

2. In a signaling system a transmission
circuit, a transmitting circuit, a receiving
circuit, a balancing circuit, and a trans-
30 former having three windings, one of said
windings being included in said transmis-
sion circuit, another of said windings being
included in said balancing circuit, and the
third winding being included between said
35 transmission and balancing circuits; a ter-
minal of each of said transmission, receiv-
ing, and balancing circuits being joined to-
gether, the other terminal of said receiving
circuit being connected to the junction point
40 between said third winding and said balanc-
ing circuit; said transmitting circuit being
connected in shunt with said third winding;
a source of direct current included in series
with said third winding, and a connection
45 having large impedance and low resistance
directly connected between one terminal of
said source and a terminal of said receiv-
ing circuit.

3. In a signaling system a transmission
50 circuit, a transmitting circuit, a receiving

circuit, a balancing circuit, and a trans-
former having three windings, one of said
windings being included in said transmis-
55 sion circuit, another of said windings being
included in said balancing circuit, and the
third winding being included between said
transmission and balancing circuits; a ter-
minal of each of said transmission, receiv-
ing, and balancing circuits being joined to-
60 gether, the other terminal of said receiving
circuit being connected to the junction point
between said third winding and said balanc-
ing circuit; said transmitting circuit being
connected in shunt with said third winding;
65 a source of direct current so connected as
to supply current to both said transmitting
and receiving circuits, and a connection of
high impedance but low resistance directly
connected between one terminal of said
70 source and the terminal of said receiving cir-
cuit, which is joined to said transmission
and balancing circuits.

4. In a signaling system a transmission
circuit, a transmitting circuit, a receiving
circuit, a balancing circuit, and a trans-
75 former having three windings, one of said
windings being included in said transmis-
sion circuit, another of said windings being
included in said balancing circuit, and the
third winding being included between said
80 transmission and balancing circuits; a ter-
minal of each of said transmission, receiv-
ing, and balancing circuits being joined to-
gether, the other terminal of said receiving
circuit being connected to the junction point be-
85 tween said third winding and said balancing
circuit; said transmitting circuit being con-
nected in shunt with said third winding; a
source of direct current included in series
with said third winding, and a connection of
90 high impedance but low resistance directly
connected between one terminal of said
source and the terminal of said receiving
circuit which is joined to said transmission
and balancing circuits. 95

In testimony whereof, I have signed my
name to this specification this 22nd day of
January 1921.

EGINHARD DIETZE.