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W. H. EDWARDS ET AL

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MEANS TO REDUCE THE EFFECT OF INTERFERING CURRENTS ON TELEPHONE CIRCUITS

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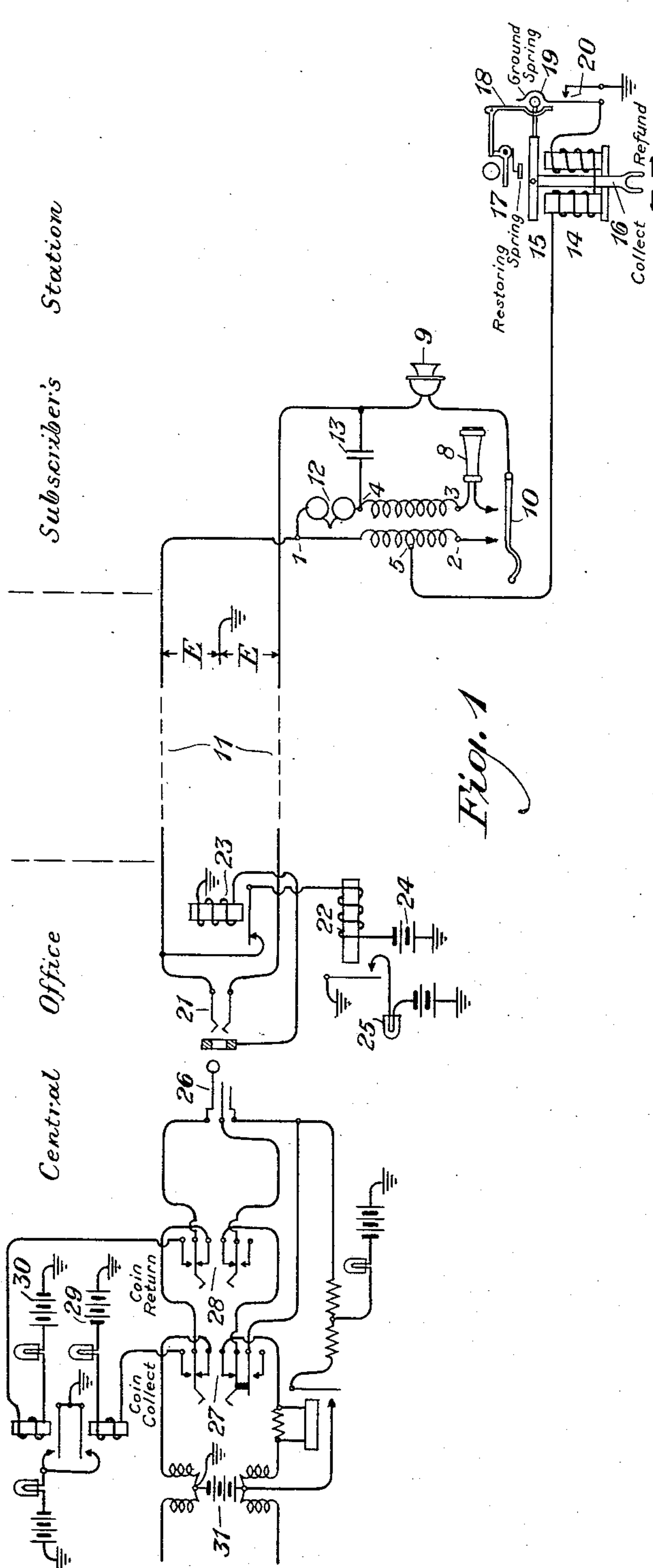


Fig. 1

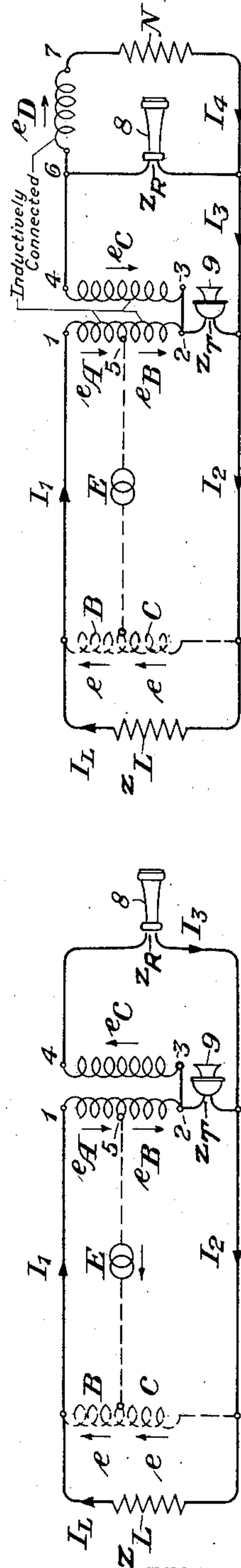


Fig. 3

Fig. 2

INVENTORS
W. H. Edwards and E. Dietze
BY *John*
ATTORNEY

UNITED STATES PATENT OFFICE

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MEANS TO REDUCE THE EFFECT OF INTERFERING CURRENTS ON TELEPHONE CIRCUITS

William Hopple Edwards, Great Neck, N. Y., and
Eginhard Dietze, Westfield, N. J., assignors to
American Telephone and Telegraph Company,
a corporation of New York

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5 Claims. (Cl. 179—6.3)

This invention relates to telephone station circuits and more particularly to station circuits in which a grounded signaling circuit is employed.

5 The object of this invention is to prevent inductive disturbances on a telephone line from causing noise in the receiver of a telephone circuit which employs a grounded signaling circuit, such as a coin collector circuit in which the
10 coin collect magnet is bridged from the set to ground, whenever a coin is deposited. The grounding of the circuit operates a signal which informs an operator at the central office that somebody wishes to make a call from the station; or operates switching devices in a dial telephone system. That grounded circuit is later
15 used to effect the collection or return of the coin.

In the coin collect systems heretofore employed, the coin collect magnet was connected
20 to the subscriber station circuit in such manner as to create an unbalanced condition between the sides of the line and ground. If an interfering voltage to ground were present in such a line it would cause a noise in the receiver
25 at the subscriber's station which would impair the quality of the received speech currents.

Our invention broadly resides in a circuit having a branch thereof arranged to be connected
30 to ground, but designed so as not to unbalance the said circuit to ground. Specifically the invention resides in a subscriber's coin collect circuit in which the coin collect magnet is connected to the induction coil in such manner
35 as not to unbalance to ground the windings of the said coil, thereby eliminating or substantially reducing the noise effect that was present in the arrangements of the prior art. The invention is applicable also to station message registers which are electrically similar to
40 coin collect circuits.

This invention will be clearly understood from the following description, when read in connection with the accompanying drawing, of
45 which Figure 1 is a line having a sub-station circuit of the sidetone type, embodying the invention; Fig. 2 is a schematic diagram of the circuit of Fig. 1; and Fig. 3 is a schematic arrangement of an anti-sidetone circuit embodying this invention.
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In Fig. 1, 11 represents a telephone subscriber's line by means of which the station, represented by the circuit at the right-hand side of the figure, is connected to a central office represented by the apparatus at the left-hand side of the figure. The subscriber's circuit comprises an induction coil including the windings 1—2 and 3—4, a receiver 8 and a transmitter 9. The terminal 2 is connected to one contact of the hook switch 10. Terminal 3
10 is connected to the receiver 8, which in turn is connected to another contact of the said hook switch. The arm of that switch is connected to one side of the transmitter 9, the other side of which is connected to the ring side of the line 11. The tip side of that line is effectively
15 connected to terminal 1 of the winding 1—2. The ringer 12 is connected across the terminals 1 and 4 and the condenser 13 is connected between terminal 4 and the other side of the line
20 to prevent current from the central office battery from flowing through the receiver 8. The coin collect magnet 14 is connected to the winding 1—2 at a point between the terminals thereof. That magnet has an armature 15
25 which is pivoted at its center. Connected to the armature is an operating arm 16 which controls the direction in which the coin is dropped whereby the collection or the return thereof is effected. The details of that are not
30 shown since they form no part of this invention. 17 represents a coin trigger which is normally in the position shown but is capable of being depressed by the weight of the coin which is deposited to make a call and is represented by
35 the circle above the said trigger. The right-hand end of the trigger normally coacts with the trigger arm 18 to keep it in the position shown. The right-hand end of the armature 15 carries a member 19 which coacts with the
40 trigger arm 18 to restore it to its normal position when the coin is collected or returned. The line 11 is exposed to sources of voltage extraneous thereto by which interfering voltages may be set up between each side of the line 11 and
45 ground, which voltages are represented by E.

The line 11 terminates at the central office upon the tip and ring contacts of the jack 21. The line relay 22 is connected effectively between the tip side of the line and ground, the connection in-
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cluding a contact of the cut-off relay 23 and the battery 24. 25 is the line lamp controlled by relay 22. The cut-off relay 23 is connected to the sleeve of the said jack and is operated by the insertion of the plug 26 connected to one end of the cord at the switchboard. The cord circuit has associated therewith the keys 27 and 28, the former of which, when operated, effects the collection of the coin at the subscriber's station and the latter causes the return of the coin to the calling party. The current required by those operations is furnished by the batteries 29 and 30, and the current for talking and operating the cut-off relay is supplied by battery 31. Further description of the cord circuit is unnecessary since it forms no part of this invention.

When it is desired to make a call from the station connected to the line 11, a coin is inserted in the slot at the said station and the weight of the coin upon the trigger 17 causes it to rotate in a counterclockwise direction, thereby releasing the trigger arm 18 which locks down the trigger and also closes contact of the ground spring 20. This establishes a circuit that extends from ground through the winding of the magnet 14, through the portion 1-5 of the winding 1-2, and thence over the tip side of the line 11 to the central office, thence through relay 22 and battery 24 to ground. This effects the lighting of the lamp 25. The calling party then removes the receiver 8 from the hook switch 10, thereby closing the contacts of that switch, thus establishing the talking connection with the operator who will

have inserted the plug 26 in the jack 21 associated with the said lamp.

If the line 11 is exposed to inductive interference, the voltage E to ground will cause current to flow over the conductors of the said line, thence through the parts of the windings 1-5 and 2-5 and through the contact 20 of the magnet 14 to ground. By proper selection of the point 5, the effect of the interference currents upon the winding 3-4 and, thereby, upon the receiver 8 may be substantially prevented.

The determination of the proper location of tap 5 on winding 1-2 will be understood by considering Fig. 2 in connection with the following description of that figure which is a schematic representation of the circuit shown in Fig. 1. For the purpose of analysis, it is convenient to represent the induced voltages by a voltage E and a unity ratio transformer (windings B and C) which distributes this voltage equally to both sides of the line. As shown schematically in Fig. 2 the induced voltage E is directly applied to tap 5 on the induction coil. The coin collect magnet 14 of Fig. 1 is omitted from Fig. 2, but the voltage drop through the impedance represented by the said magnet is included in the voltage E . Likewise the condenser 13 in the station circuit of Fig. 1 has been omitted in Fig. 2, since it does not enter into the theoretical analysis of the circuit. The station receiver and transmitter are represented by 8 and 9, respectively. The terminals of the induction coil windings are denoted by the same numerals as used in Fig. 1 and the impedance of the line has been designated as z_L .

e_A , e_B , and e_C are voltages, induced in the induction coil windings under the influence of the induced voltage E on the line represented by the impedance z_L of Fig. 2, and have the directions shown. e represents the induced voltage in each winding B and C of the fictitious transformer.

I_L , I_1 , I_2 , and I_3 are currents in the different network branches having the directions shown. The impedance of the receiver and the transmitter is represented by z_R and z_T , respectively, and that of the line by z_L .

By means of Kirchhoff's laws, a system of equations can now be set up, giving the relation between the voltages and currents in the different branches of the network of Fig. 2, as follows:

$$\begin{aligned} E &= e + e_A \\ -E &= e + e_B + (I_2 - I_3)z_T \\ 0 &= I_3(z_T + z_R) - I_2z_T + e_C \\ 0 &= I_Lz_L - 2e \end{aligned} \quad (1)$$

By means of the well-known transformer theory, the following further equations can be set up:

$$\begin{aligned} I_1e_A + I_2e_B + I_3e_C &= 0 \\ (I_1 - I_L)e + (I_2 - I_L)e &= 0 \end{aligned} \quad (2)$$

Furthermore, in accordance with this same theory the voltages in each winding of a transformer are proportional to the turns ratios between the windings, so that the turns ratio between windings 5-2 and 1-5 $n_1 = e_B/e_A$ and the turns ratio between windings 3-4 and 1-5 $n_2 = e_C/e_A$ and in addition the turns ratio between windings 1-2 and 3-4 $n = (e_A + e_B)/e_C$.

The system of simultaneous Equations (1) and (2), in combination with the above relations between the turns ratios and the voltages on the induction coil, can be solved to obtain the current in the receiver induced by the line noise voltage E , as follows:

$$I_3 = 2E \frac{(1 - n_1)[4z_T - z_Ln_2(n_1 - 1)] - n_2[-4z_T - z_L(n_1 - 1)^2]}{D} \quad (3)$$

In this Equation (3) the denominator D has not been evaluated since it is not used in the determination of the balanced position of the tap 5 on winding 1-2. Equating Equation (3) to zero, and solving for the turns ratio n_1 , gives the value of n_1 , which makes the induced current in the receiver zero, i. e., determines the location of tap 5 on winding 1-2 to which the coin collect magnet should be connected so that no line noise will be heard in the receiver. This value of n_1 is:

$$n_1 = 1 + \frac{2z_T}{z_L}(1 + n) \quad (4)$$

Fig. 3 shows schematically another form of coin collect circuit distinguished from that shown in Figs. 1 and 2 by the use of anti-sidetone circuit described in the U. S. patent to Campbell, No. 1,254,471. In Fig. 3, the tap or branch circuit to which the coin collect magnet is connected is taken from the winding 1-2 at the point 5. The induction coil of this figure has three windings, designated 1-2, 3-4 and 6-7, with turns ratios n_1 , n_2 , n_3 between windings 1-5 and 1-2, windings 3-4 and 1-2, and windings 6-7 and 1-2, respectively. N is a balancing network which balances the sidetone in receiver 8 when the transmitter 9 is spoken into. In accordance with the said U. S. Patent No. 1,254,471, and particularly from Equation (8) thereof, it may be shown that the impedance of this network N is related to the impedance of line L , and the turns ratios on the induction coil, by the expression:

$$z_N = \frac{z_Ln_3(n_2 - n_3)}{(1 - n_2)} \quad (5)$$

B and C are the windings of the fictitious transformer, and e is the voltage in each of these windings produced by the line noise voltage E . I_L , I_1 , I_2 , I_3 , I_4 are currents in the different network branches having directions as shown. e_A , e_B , e_C are voltages, induced in the induction coil windings under the influence of the induced voltage E on the line represented by the impedance z_L of Fig. 2, and have the directions shown. e represents the induced voltage in each winding B and C of the fictitious transformer.

e_B , e_C , e_D are the voltages induced in the anti-sidetone induction coil. These have the directions shown and are proportional to turns ratios n_1 , n_2 , n_3 of the induction coil.

It will be readily understood by any one skilled in the art that it is possible to set up a system of simultaneous equations relating the voltages and currents in the different branches of the circuit of Fig. 3 in the same manner as has been done for the circuit of Fig. 2. Substituting the value for z_N given by Equation (5), in these simultaneous equations, solving for $I_R = I_4 - I_3$, and equating this current I_R to zero, gives as the condition for no induced noise current in the receiver:

$$n_1 = 1/2 \quad (6)$$

Comparing the Equations (4) and (6) which determine the position of the tap 5 on winding 1—2 of the sidetone circuit and anti-sidetone circuit, respectively, that balances the noise currents in the substation receiver R of these circuits, it will be noted that Equation (4) (which applies to the sidetone circuit) includes the resistance z_T of the station transmitter 9, whereas Equation (6) (which applies to the anti-sidetone circuit) is independent of the resistance of the station transmitter. This shows that for a sidetone station circuit the induced noise in the receiver can be balanced only for a fixed value of resistance of the station transmitter; whereas in the anti-sidetone circuit this balance is independent of the transmitter resistance. By means of the foregoing equations the position of the tap upon the winding 1—2 may be determined.

Upon the completion of the call, the subscriber hangs up the receiver and the collection or return of the coin is effected by sending a direct current impulse over the tip side of the line 11 and through the circuit of the magnet 14 to ground. The transmitted impulse, which comes from the battery 29 or 30, by operation of key 27 or 28, will cause the movement of the armature, the direction of motion depending upon the polarity of the impulse. The right-hand member 19 of arm 15 will press against the trigger arm 18, causing it to rotate in a clockwise direction and permitting the coin trigger 17 to be restored to its normal position by the action of the spring. This opens the contact 20 and puts the system in condition for the making of another call from the subscriber station. The operating arm 16, which controls the collection or the return of the coin, functions in a manner that is well understood and need not be described herein since it forms no part of this invention.

Since a station message register is electrically similar to a coin collect device, the invention is equally applicable to both. This will be apparent if we assume that in the circuit of the coin collect device, represented by elements 14 to 20 of Fig. 1, the coin is replaced by a push button and the arm 16 is connected to a counting device so as to rotate the number wheel only when the arm is moved in one direction. To make a call from a station equipped with such register, the calling party pushes the button which grounds the tip side of the line just as was done by depositing a coin in the coin collect system. If the call is properly completed the operator presses one of the keys, say 27, which will move the arm 16 in the direction that will cause the register to indicate the next higher number, and will also restore the elements 17 and 18 to their normal positions. If it is not desired to register the call,

the other key, viz. 28, will be operated which will restore elements 17 and 18 to normal but will not affect the counting device.

While this invention has been described in certain embodiments, it is to be understood that it is capable of being employed in ways other than those shown without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a telephone system, the combination with a line in which voltages to ground may be set up by sources extraneous thereto capable of interfering with the signal voltages transmitted thereover, of a substation connected thereto including an induction coil having a plurality of windings inductively related, one of said windings being effectively bridged across said line and another winding being in series with a receiver, the said bridged winding having a tap taken therefrom at a point between the terminals thereof, the said tap including the winding of a magnet and means to connect said tap to ground and to disconnect it therefrom.

2. In a telephone system, the combination with a line in which voltages to ground may be set up by sources extraneous thereto capable of interfering with the signal voltages transmitted thereover, of a substation connected thereto including a transmitting element having a variable impedance, an induction coil having a plurality of windings inductively related, one of said windings in series with said transmitting element being effectively bridged across said line and another being in series with a receiver, means controllable at will to ground a point upon said bridged winding, the said point being so chosen that the currents flowing from said line through the parts of said bridge winding on either side of said point will produce substantially no effect in said receiver.

3. A telephone substation set comprising an induction coil having two windings inductively related, one of said windings being connected across said line in series with a transmitter, and the other winding being in series with a receiver and the said transmitter, the said first mentioned winding having a tap extending therefrom to ground, the point of connection of said tap being such that the said receiver is balanced against the effects of currents caused by voltages to ground applied across the terminals of the first mentioned windings.

4. In a telephone system, the combination with a line of impedance z_L in which voltages to ground may be set up by sources extraneous thereto capable of interfering with signal voltages upon said line, a telephone substation connected to said line and including an induction coil having two windings the turns of which have the ratio n , one winding being effectively connected in series with said line and a transmitter of impedance z_T , and the other winding being in series with a receiver and the said transmitter, and means to connect to ground a point upon the said first mentioned winding so that the ratio of turns of the parts shall equal n_1 , the values being so chosen as to satisfy the equation

$$n_1 = 1 + \frac{2z_T}{z_L}(1 + n). \quad 70$$

5. A telephone substation set comprising an induction coil having three windings each inductively related to the others, a transmitter having a variable impedance, a receiver, and a net-

work, one of said windings in series with said transmitter being arranged for connection across the line with which said substation set is intended to function, another winding of said induction coil being connected in series with the said transmitter and the said receiver and the third winding of said coil in series with the said network being bridged across the said receiver, the said first mentioned winding having a tap extending therefrom to ground, the point of con-

nection of said tap to said first winding being such that the said receiver is rendered substantially free from the effects of currents in said first winding arising from voltages to ground set up in said line by extraneous sources, the freedom from the said effects being independent of impedance variations occurring in the said transmitter.

WILLIAM H. EDWARDS.
EGINHARD DIETZE.