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TELEPHONE SYSTEM

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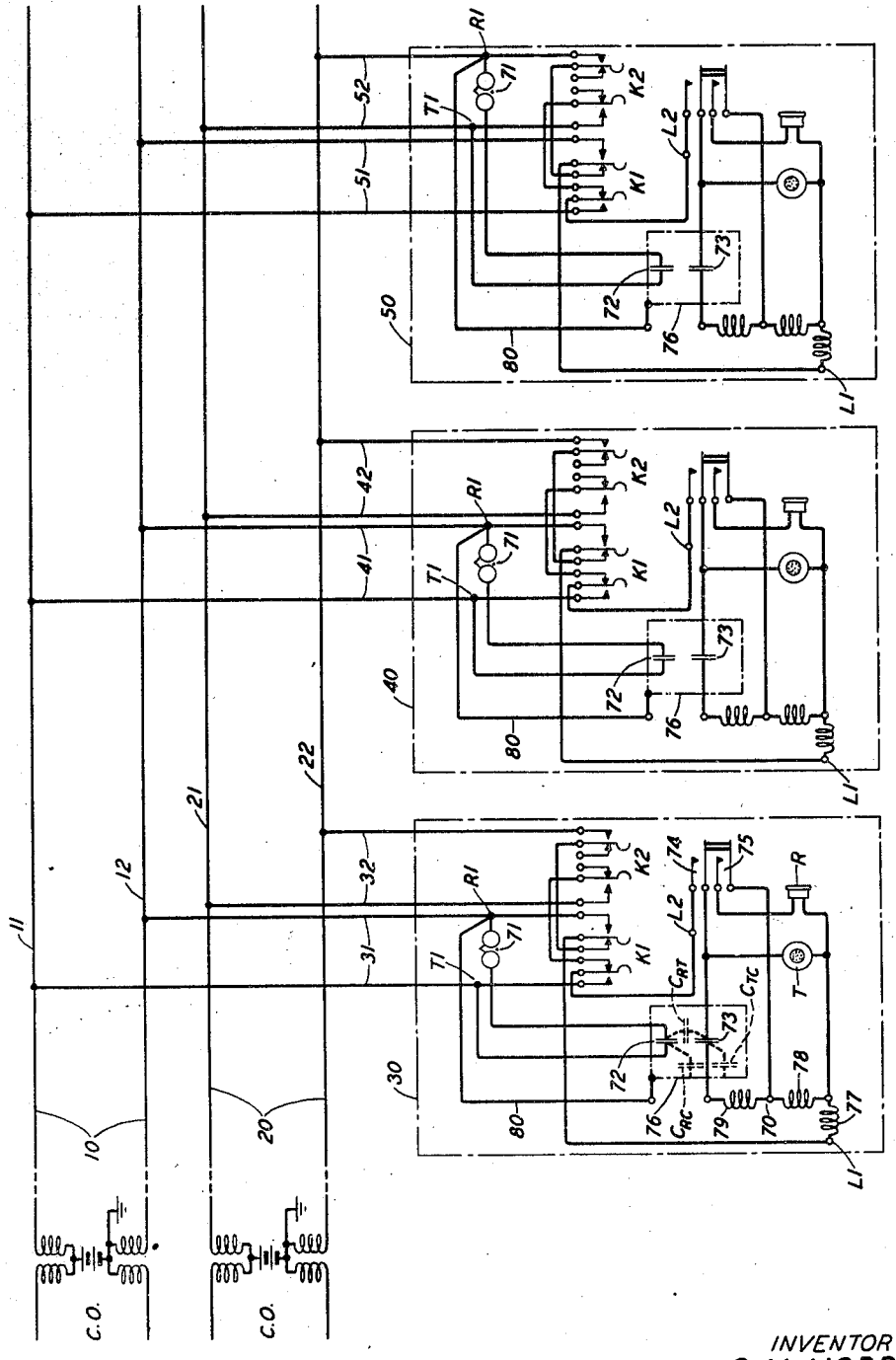

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TELEPHONE SYSTEM

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This invention relates to telephone transmission circuits and, more particularly, to a circuit arrangement for minimizing interfering disturbances, such as crosstalk, in the operation of telephone communication circuits, for example, of the type in which three or more key telephone sets or equipments are associated with a plurality of telephone lines.

It is an object of the invention to reduce crosstalk between communication circuits or lines of the type in which the ringing circuit and talking circuit capacitors of each telephone set or station associated with a plurality of telephone lines are housed in a single container, and in which operating conditions may necessitate the electrical association of a capacitor of one line with a capacitor of another line.

A more particular object of this invention is to reduce such crosstalk in a circuit arrangement comprising a pair of telephone lines each connecting with a central office or exchange, at least three or more key telephone sets being associated with such lines for selective connection with either, each set including the above-mentioned ringing circuit condenser and speech currents circuit condenser arrangement.

In what are known as combined hand telephone sets, it is the practice to enclose and to support all of the subscriber's station equipment, such as the speech currents induction coil and condenser, and the ringer and its associated condenser, in the base of the telephone set. To conserve space further, it has been found desirable to enclose the two condensers in a single metallic container. The latter construction results in certain natural internal capacitances, resulting from the direct capacity between the two condensers, and the capacities between each condenser and the common container. These internal capacities must be considered in the provision of certain telephone facilities such as those furnished by key telephone sets.

A key telephone set includes facilities that enable a subscriber to use the telephone equipment at his station in answering and in initiating calls on a telephone line or lines other than the telephone line to which his set or equipment is normally connected. In order that the subscriber's line from which the station equipment has been transferred while a call on a second line is being handled, be made available for use by another subscriber or subscribers having the same facilities, it has been found practicable to interpose the switching equipment, or keys between the ringer bridge and the speech receiving and transmitting equipment of each line so that when the keys are operated, the ringer circuit at each set is undisturbed in so far as its connection to a particular line is concerned, and only the speech receiving and transmitting circuits are switched to the other line or lines. It follows, therefore, that under such conditions wherein subscribers are using lines other than the ones to which their speech circuit equipment is normally connected, the ringing condenser of one line is electrically associated with a speech circuit capacitor of a second line. Because of the capacitive coupling between capacitors housed in the same container but electrically associated with different lines, the possibility of crosstalk between the two lines is present.

M. A. Logan Patent 2,230,357 of February 4, 1941 treated of this general problem in so far as it was presented by a circuit arrangement comprising two telephone lines each connecting with a central office or exchange and two key telephone sets, each set normally associated with one line but adapted through its key or keys to be transferred to the second line. With one set idle and the other set in use and connected with either of the two lines, the matter of crosstalk is not a concern. With each set in use and connected to the line with which its associated ringer circuit is not connected, crosstalk may exceed the permissible maximum level. By appropriate proportioning of the capacitances and by connecting the condenser container to a particular line terminal of the induction coil of each key telephone set, the patentee attained a balanced circuit that minimized or balanced out crosstalk.

It has been found, however, that when one or more additional key telephone sets are associated with such a pair of telephone lines, each additional set being adapted to be connected for responding to or initiating a call over either of the two lines, a crosstalk condition may be presented that is not effectively protected against by the patented arrangement. This condition is one that exists when two sets are in use, one on each of the two lines, the idle set or sets providing a capacitive coupling between the two active sets.

In accordance with this invention, crosstalk in such a circuit arrangement involving two telephone lines and three or more key telephone sets, is minimized or reduced by conductively connecting the common condenser container in each set to the ring conductor terminal of the ringer circuit of the set, that is, to the line ring conductor on the line side of the key or keys in the set.

A more complete understanding of the invention will be obtained from the detailed description that follows, taken in conjunction with the single figure of the appended drawing.

The drawing shows a key equipment telephone circuit comprising a pair of telephone lines or signaling and communication paths 10, 20, each comprising a so-called tip conductor or wire 11, 21 and a so-called ring conductor or wire 12, 22. A plurality, specifically, three, key telephone sets 30, 40, 50 are associated with the lines 10, 20, each set being adapted to be connected to the lines 10, 20 over the connecting wire pairs 31, 41, 51 and 32, 42, 52. The three sets may be identical and comprise a transmitter T, a receiver R, a three-winding induction coil 70, a ringer 71, a ringing circuit condenser 72, a speech currents circuit condenser 73, two pairs 74, 75 of speech currents circuit contact springs, and two keys K1, K2 for selectively connecting the speech currents circuit of the set with either telephone line. The transmitter and receiver may be included in a handset or hand telephone set. The condensers 72, 73 are housed in a single metallic container 76. All of the components of the set may be mounted on and/or in a single support or enclosure, that is, it may be of the so-called combined set type. Each set is shown in its idle condition, that is, with the handset on its support and spring pairs 74, 75 open. When the handset is removed from its support, spring pairs 74, 75 close; the transmitter T in series with one winding 77 of the induction coil, is connected through spring pair 74 between terminals L1, L2; induction coil windings 78, 79 are connected in series with the condenser 73 and in bridge of the transmitter; and the receiver is connected through spring pair 75 in bridge of induction coil winding 78. In the idle condition of the set, the keys K1, K2 may be as shown, or either key K1 or K2 may have been actuated so that its inner pair of contacts are open and its outer pair of contacts are closed, the terminals L1, L2 in the latter event being connected through either key K1 and wires 31 with line 10, or key K2 and wires 32 with line 11. In the case of sets 30, 40, the ringer 71 and condenser 72 are connected in series permanently between terminals R1, T1 in wire pairs 31, 41, and in the case of set 50, the ringer and ringer condenser are connected in series permanently between terminals R1, T1 in wire pair 52. In the showing of set 30 are indicated the natural capacitances C_{RC}, C_{TC}, C_{RT}, where C_{RC} is the capacitance between the condenser 72 and the container 76, C_{TC} is the capacitance between the condenser 73 and the container 76, and C_{RT} is the capacitance between the two condensers.

Since the ringing circuits of sets 30, 40 are connected with line 10, these sets are normally adapted and intended to receive any call incoming on that line, and since the ringing circuit of set 50 is connected with line 20, the latter set is normally adapted and intended to receive any call incoming on the latter line. On outgoing calls to the central office, sets 30, 40 would normally use line 10, and set 50, line 20. The keys K2 at sets 30, 40 enable these sets to be connected with line 20 so as to answer an incoming call or to make an outgoing call on that line, and the key K1 at set 50 enables the latter to answer an incoming call or to make an outgoing call on line 10. It is assumed that the set 50 would be so located with respect to the sets 30 so that the user or attendant at each set could hear the ringer at the others. If it is assumed that a call is incoming on line 20 and the set 50 does not respond, either because engaged on a call on line 10 or because the attendant is not at the set, either set 30 or 40, by operation of key K2 could take the call. If, on the other hand, either set 30 or 40 is using line 10 or line 20, and there is an incoming call on the line not in use, set 50 and either set 40 or 30, as the case might be, could answer the call by operating the appropriate key K1 or K2. In any event, there might and would be occasions when two of the three sets are connected with the lines 10, 20 and in use for telephonic purposes. In such a situation, it is desirable that crosstalk between the two sets in use, because of the coupling between them effected by the idle third station, be prevented or be maintained below the permissible maximum.

In the above-noted Logan Patent 2,230,357, there is disclosed a telephone system comprising two telephone lines with which are associated two key telephone sets, each set adapted to be selectively connected with either line. Each set includes a ringing circuit condenser and a talking circuit condenser in a common metallic container, the metallic container being conductively connected to that terminal of the set's induction coil that is connected to the ring conductor of the line. With this arrangement and appropriate proportioning of the condensers and their capacitances with respect to one another and their metallic container, crosstalk between the sets through the ringing circuit condensers permanently connected across the lines, is minimized or balanced out.

Where three or more key telephone sets are associated with two lines and two of the, say, three sets are in use, it has been found that if the Logan practice were followed, crosstalk between the two sets in use may be of undesirable or objectionable level, because the two sets may be capacitively coupled through the ringing circuit condenser of the third, or more, and idle, sets.

In accordance with the present invention, the conductive connection 80 from the metallic container 76 for the condensers in each set is brought out to the ring conductor terminal R1 of the ringer in each set, rather than to the terminal L1.

Let it be assumed for purposes of discussion that the conductive connection 80 were made from the container 76 to the terminal L1 in each set instead of to the R1 terminal as shown. Consider, then, the condition existing when station 30 is in its idle condition, that is, with contact pairs 74, 75 open, and with its key K2 operated so that the set 30 is connected to line 20; and with sets 40 and 50 in use, with key K1 of set 40 operated so that its speech circuit is connected with line 10, and with key K2 of set 50 operated so that the speech current circuit of the latter is connected with 20. Under such conditions, the capacitance C_{RC} would be a source of coupling between the conductor 11 of line 10 and the conductor 22 of line 20, the path being from conductor 11 over one wire 31 to terminal T1 to one terminal of condenser 72, capacitance C_{RC}, connection to terminal L1, right inner contact of key K1, right outer contact of key K2, over one wire 32 to conductor 22. Since the contact pairs 74, 75 would be open, the terminal L2 would have substantially the same potential as the terminal L1, and capacitance C_{RT} would be in parallel with capacitance C_{RC} thereby increasing the coupling between the conductors 11 and 22. Capacitance C_{TC} would appear as a shunt

across the induction coil and would have a negligible effect on the amount of crosstalk. The unbalanced capacitance between lines 10, 20 on which sets 40, 50 are talking would be

$$C_{RC}+C_{RT}=C_{XT}$$

and for N such idle stations associated with lines of, say, 600 ohms impedance, the crosstalk at 1000 C. P. S. would be of the order of .48 NC_{XT} crosstalk units. Assume, now, that set 30 is one of the two sets in use, of which the other is set 40, set 30 being connected to line 20 through key K2 and set 40 to line 10 through key K1. Capacitance C_{RT} is now a source of coupling between conductor 11 of line 10 and conductor 21 of line 20, capacitance C_{RC} is again a source of coupling between conductor 11 of line 10 and conductor 22 of line 20, the unbalanced capacitance being $C_{RT}-C_{RC}=C'_{XT}$. As before, capacitance C_{TC} appears as a shunt across the induction coil with only a negligible effect on crosstalk. In crosstalk units, therefore, the crosstalk will be .48 NC'_{XT}.

Mimimum crosstalk coupling will result if in the idle and the talking conditions of the sets, the intercapacitances between lines 10, 20 are arranged so that approximately balanced capacitance coupling is provided. This is achieved with the arrangement shown in the drawing in which the conductive connection 80 from the condenser container is to the terminal R1 of the ringer and by proportioning the condenser separations from each other and the container such that capacitance C_{RT} is approximately equal to capacitance C_{TC}. Capacitance C_{RC} appears as a shunt of negligible effect across line 10. Capacitances C_{RT} and C_{TC} are effective in coupling lines 10, 20 but in opposite phase. There are four arrangements of two capacitances which will result, in a circuit arrangement as shown in the drawing, in balanced capacitance coupling: (1) conductor 11 to conductor 21 and conductor 11 to conductor 22; (2) conductor 12 to conductor 21 and conductor 12 to conductor 22; (3) conductor 11 to conductor 21 and conductor 12 to conductor 21; (4) conductor 11 to conductor 22 and conductor 12 to conductor 22.

With connection 80 made to terminal R1, arrangement (3) obtains under the talking condition of the set, and arrangement (4) under the idle condition of the set. Since capacitances C_{RT} and C_{TC} couple the conductors 11, 12 to terminal L2, the potential to ground at the latter point, with respect to the metallic voltage on line 10, is proportional to $C_{RT}-C_{TC}$, and it is immaterial from a crosstalk standpoint whether the current from terminal L2 enters the line 20 on either conductor 21, as in the talking condition of the set, or on conductor 22, as in the idle condition of the set. In either event, no crosstalk current can flow in line 20 if $C_{RT}=C_{TC}$.

As already explained, if the container 76 is connected to terminal L, arrangement (1) would exist for the talking condition of the set with an unbalanced coupling obtaining under the idle condition. If the container 76 were connected to L2, instead of to L1 or R1, C_{TC} would be short-circuited, $C_{RT}+C_{RC}$ would couple T1 to L2, and none of the four arrangements are obtained under either the idle or the talking condition of the set. A result similar to the latter follows if the container is connected to T1.

Although this invention has been described with reference to a specific embodiment, it is not limited thereto but is of a scope evidenced by the appended claims.

What is claimed is:

1. A subscriber's telephone set comprising, in combination, a speech transmitting and receiving circuit and a signal circuit, a metal container, a condenser included in said speech circuit and housed in said container, a condenser included in said signal circuit and housed in said container, said condensers being so separated from each other and from the container that the capacity between said first condenser and said container equals the direct capacity between the condensers, and a connection from said container to a terminal of said signal circuit whereby the internal capacity between said second condenser and said container is effectively connected across the terminals of the signaling circuit.

2. A telephone system comprising a telephone line, and a subscriber's telephone set connected to said line; said telephone set including a signal circuit permanently connected to said line, a speech currents circuit normally disconnected from said line but adapted to be connected thereto through circuit opening and closing means, a condenser included in said signal circuit, a condenser included in said speech circuit, a metallic container constituting a single enclosure for said condensers, said condensers being so separated from each other and said container that the capacity between the speech circuit condenser and the container and the capacity between the two condensers are substantially equal, and a connection from said container to a terminal of said signal circuit whereby the capacity between said signal circuit condenser and said container is effectively connected across the line.

3. A telephone system comprising a first telephone line, a second telephone line, and at least three telephone sets, each set including a speech transmitting and receiving circuit and a signaling circuit and each of said circuits including a separate condenser, the two condensers of a set being housed in a common metallic container, the signaling circuit of one set being permanently connected to said first line, the signaling circuit of a second set being permanently connected to said second line, and the signaling circuit of the third set being permanently connected to either of said lines, means for connecting the speech circuit of any set to either of said lines whereby the condensers in the same container are electrically included in different lines and the lines are thus electrostatically coupled, and means for reducing crosstalk resulting from such coupling, such latter means comprising a conductive connection between each of the containers and a line conductor of the line to which the associated signaling circuit is connected, said conductive connection being independent of the means for connecting the associated speech circuit to the lines.

4. A telephone system comprising a first telephone line, a second telephone line, and at least three telephone sets, each set including a speech transmitting and receiving circuit and a signaling circuit and each of said circuits including a separate condenser, the two condensers of a set being housed in a common container, the signaling circuit of one set being permanently connected to said first line, the signaling circuit of a second set being permanently connected to said second line, and the signaling circuit of said third set being permanently connected to said first line, means for connecting the speech circuit of a set,

independently of its associated signaling circuit, with either the first line or the second line whereby the condensers in the same container are electrically included in different lines and the lines are thus electrostatically coupled, and means for reducing crosstalk resulting from said coupling, such latter means comprising a conductive connection between each of said containers and a line conductor of the line to which the associated signaling circuit is permanently connected, said conductive connection being independent of the means for connecting the associated speech circuit with said lines.

5. A telephone system comprising a first telephone line, a second telephone line, and at least three telephone sets, each set including a speech transmitting and receiving circuit and a signaling circuit, and each of said circuits including a separate condenser, the two condensers of a set being housed in a single metallic container, the signaling circuit of one set being permanently connected to said first line, the signaling circuit of a second set being permanently connected to said second line, and the signaling circuit of the third set being permanently connected to said first line, means for connecting the speech circuit of a set with either of said lines, the speech circuits of said first and second sets when in use for telephonic communication and connected to the lines to which their associated signaling circuits are permanently connected, being electrostatically coupled through the signaling circuit of the third set in the event the speech circuit of the idle third set is connected with said second line, and means for reducing crosstalk resulting from said coupling, such latter means comprising a direct conductive connection between each of the condenser containers and a line conductor of the line to which the associated signaling circuit is connected.

6. A telephone system comprising a speech transmitting and receiving circuit, a telephone line for connecting said circuit with an exchange, a second telephone line leading to an exchange, circuit opening and closing contacts for interconnecting said speech circuit and either of said lines, a second and a third speech transmitting and receiving circuit having individual circuit opening and closing contacts for interconnecting said second and third speech circuits with either of said lines, a signal circuit individual to each speech circuit and connected on the line side of the circuit opening and closing contacts, each speech circuit including a condenser and each signal circuit including a condenser, the condensers of each speech circuit and its associated signal circuit being included in a unitary structure comprising a metallic container, and a conductive connection from the container to one line conductor on the line side of the contacts individual to the speech circuit.

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