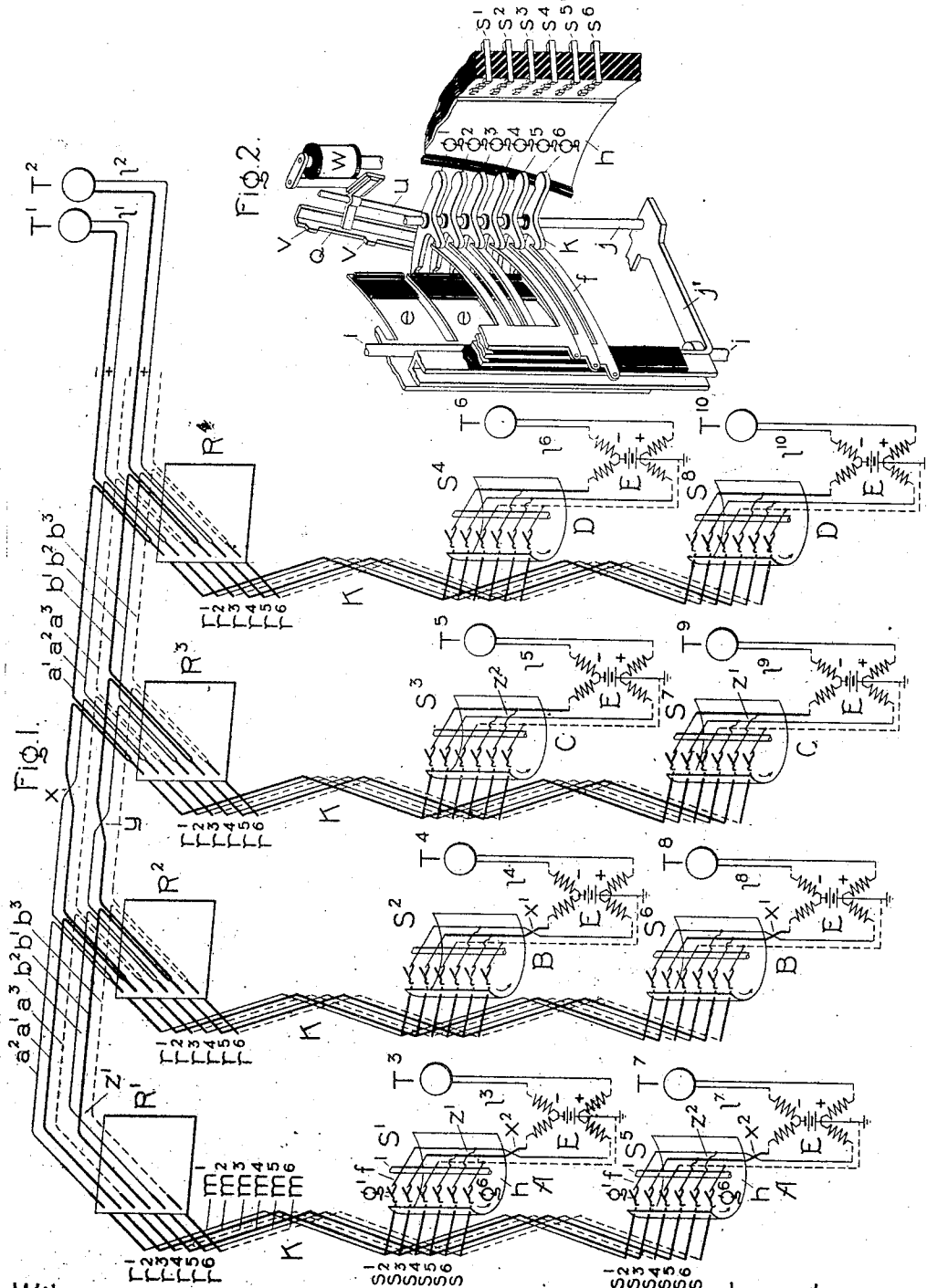


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WIRING SYSTEM FOR AUTOMATIC TELEPHONE EXCHANGES.
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UNITED STATES PATENT OFFICE.

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WIRING SYSTEM FOR AUTOMATIC TELEPHONE-EXCHANGES.

1,000,614.

Specification of Letters Patent. Patented Aug. 15, 1911.

Application filed August 16, 1909. Serial No. 513,079.

To all whom it may concern:

Be it known that I, FRANK R. McBERTY, citizen of the United States, residing at New Rochelle, in the county of Westchester and State of New York, have invented a certain new and useful Improvement in Wiring Systems for Automatic Telephone-Exchanges, of which the following is a full, clear, concise, and exact description.

My invention relates to telephone exchange systems, and has for its object to prevent disturbances of telephonic communication by induction between the parallel conductors employed in the wiring of the switching apparatus thereof.

In an application for patent filed by me February 27, 1908, Serial No. 418,121, there is described a cable in the form of a flat ribbon, the conductors of which are not twisted in pairs or triplets, as in ordinary telephone switchboard cables, but lie parallel to one another and therefore in approximately the same plane. Such flat ribbon cables are used to wire in multiple the corresponding terminals of a group of automatic selectors, the cables being folded along diagonal lines and the conductors thereof soldered to the selector terminals at alternate folds.

Ordinarily there are three terminals in each selector and three conductors of the cable associated with each metallic circuit telephone or trunk line. Two of these terminals and two of these conductors form parts of the two sides, respectively, of one line circuit. The third terminal and third conductor form a part of a local or test circuit for the line, which circuit is usually grounded either directly or through a battery. Each such flat ribbon cable contains the conductors for a plurality of lines and every three successive wires, counting from one edge of the cable to the other, comprise two line wires and one local or test wire, the first and second, fourth and fifth, etc., comprising pairs of main circuit conductors, and the third, sixth, etc., comprising local or test circuit conductors. It will be readily understood by those skilled in the art that a cable constructed of parallel conductors, such as this flat ribbon cable, when used as a part of, or when connected to telephone circuits, would be particularly liable to inductive disturbances, causing cross talk between the telephone circuits and noisy telephone lines. The reason of this liability

of inductive disturbances may be briefly explained as follows: In any two adjacent pairs of wires, say those comprising wires Nos. 1, 2 and 4, 5, respectively, of a set of six wires of such a cable, two of them, wires 2 and 4, are nearer to each other than are the other two, 1 and 5. The static induction between wires 2 and 4 is therefore greater than that between 1 and 5, and the result is cross talk, unless some means to equalize the induction is provided. Also at or near the edges of the cable, one wire of a pair, say wire 2, is closer to test wire 3 than is the other wire 1 of the pair, and the pair is unsymmetrically located with respect to the mass of other wires in the cable which are usually connected to ground. The static induction to ground therefore is unequal as between the two wires of this pair, and fluctuating currents, which are frequently induced in the exposed portion of a telephone line outside of the switching station would be stronger through one side of the line to ground than through the other, the result being a noisy telephone line unless some means to equalize the induction is provided.

A type of selector adapted to be wired with flat ribbon cables is one having a plurality of curved rows of terminals traversed by a plurality of brushes, one brush for each row. Preferably these selectors are arranged in vertical rows and the brushes are mounted on vertical spindles. The flat ribbon cables run vertically along straight rows of terminals on each selector formed by corresponding terminals in successive curved rows, and the successive conductors of each such cable respectively connect successive terminals in a straight row on one selector with the corresponding terminals of other selectors in vertical alinement therewith. A number of vertical rows of selectors making up a group are wired in this manner, and each row preferably has a connecting rack at the top thereof, having terminals arranged in horizontal and vertical rows corresponding to the rows on a selector. The flat ribbon cables terminate at vertical rows on these racks, and the wires forming extensions of telephone lines and local circuits therefor extend horizontally along the horizontal rows of terminals on the racks and connect in multiple the corresponding terminals of the several racks associated with a group of selectors.

Each selector of the type referred to has a number of sets of three brushes each and the brushes of one set on any selector are connected in multiple with the corresponding brushes of the other sets thereon. All the brushes are normally held by latches so as to traverse the rows of terminals without making contact therewith, means being provided, however, to release any set to make contact with the terminals in the rows traversed thereby. Thus by the selection of a certain set of brushes and by a definite movement thereof about the axis, connection may be made through the selector to any line having terminals thereon.

When used in an automatic telephone exchange system, the brushes of such a selector preferably form terminals of a connecting circuit adapted to be associated with a calling telephone line or a trunk line, and such connecting circuit usually includes a central source of current, which, when the lines are connected through the selector, supplies current to the telephone transmitters at the substations or to other apparatus associated with the connected lines.

This invention may be applied to any telephone exchange system having sets of conductors lying parallel to one another in approximately the same plane and connecting the pairs of line wires of metallic telephone circuits to the switching apparatus. It is, however, especially applicable to an automatic telephone exchange system having groups of selectors arranged in rows, the terminals of which are wired by means of the parallel conductors in flat ribbon cables.

In general, therefore, my invention provides that, in a telephone exchange system, where two pairs of line wires are connected to the switching apparatus thereof, each pair of wires by a pair of conductors in each of two sets of parallel conductors, the connection to the line wires of one of said pairs of conductors in one of the sets shall be in reverse order to that of the other pairs in said sets. It provides further that, where each set of parallel conductors has more than two pairs of line conductors, as it would ordinarily in practice, the connections of each alternate pair in each alternate set or in one half of the sets shall be reversed in the same manner. The several line circuits are thus inductively balanced with respect to one another in the parallel conductors, and cross talk is prevented.

The sets of parallel conductors may be and preferably are arranged in the form of flat ribbon cables, and the switching mechanism may comprise the selectors of an automatic telephone exchange system. These selectors preferably have sets of brushes traversing rows of terminals and are themselves arranged in rows, there being at least one set of parallel conductors or cables for each row

of selectors. Where four such rows of selectors make up a group, my invention provides that a general reversal or transposition be made preferably in all of the pairs of line wires between two of the sets of conductors and the other two, and it is desirable that these last mentioned reversals be so made as not to interfere with the balance between adjacent pairs secured by the first mentioned reversals. A static balance is thus secured in each metallic telephone circuit with respect to all other circuits connected to the cables of parallel conductors as well as between adjacent pairs thereof.

My invention also provides for reversing or transposing the connections of certain of the brushes of the selectors, these reversals or transpositions corresponding to those of the cable conductors to the lines. This is in order that the flow of current by way of the brushes through the cable conductors to the lines shall in all cases be in the same direction.

I will describe my invention more particularly by reference to the accompanying drawings, in which—

Figure 1 represents diagrammatically and in an isometric view the wiring of a group of selector switches in an automatic telephone exchange system; and Fig. 2 represents in some detail, and in a similar view with parts broken away, the construction of a selector of the type which I prefer to use.

In the drawings S' to S^8 inclusive are selectors arranged in four vertical rows A, B, C and D, and R' to R^4 inclusive are connecting racks, one at the top of each row of selectors. This apparatus may be located at the central office of a telephone exchange system.

T' and T^2 represent two telephone substations connected by pairs of line wires $1'$ and 1^2 to the apparatus at the central office. T^3 to T^{10} inclusive represent other telephone substations connected by pairs of line wires 1^3 to 1^{10} inclusive to the central office.

Each selector has a plurality of horizontal curved rows of terminals as shown in Fig. 2, fixed upon a cylindrical frame h and a row of brushes g' to g^6 inclusive adapted to traverse the curved rows of terminals respectively. Corresponding terminals in the successive curved rows form straight rows running vertically, and I have represented one such vertical row on each selector by the terminals s' to s^6 inclusive. The brushes of each selector are mounted upon a central spindle i , about which they are adapted to rotate together. Any suitable mechanism may be provided for that purpose. These brushes are also rotatably held upon a rod j about which they are capable of slight movement independently of one another. The rod j is held in a frame j' . Normally these brushes are held by a

series of spring latches e , one for each set of three brushes; in such a position that the brushes may rotate about the spindle i without coming in contact with the terminals.

5 Springs f , one for each brush, bear against offsets k of the brushes and tend to throw the brushes outwardly into position to make contact with the terminals. An arm g pivoted on the spindle u and having offsets v , v ,
10 is controlled by an electromagnet w in such a manner that during the preliminary stage of movement of the brushes about the spindle i , one or the other of the offsets v is brought into position to engage one of the
15 spring latches e and thus to release a set of three of the brushes.

Inasmuch as this invention does not involve the circuits by which the brush selection is secured, nor the details of the selector mechanism, I have not shown in the
20 drawings these circuits nor the complete selector. It will be apparent, however, that the construction shown in Fig. 2 is one in which any one of two or more sets of three
25 brushes each may be selectively brought into position to engage the corresponding rows of terminals of the selector, the other sets of brushes remaining out of contact with the terminals, although moving about
30 the spindle with the first mentioned set of brushes.

The pairs of line wires l^3 to l^{10} are represented as being connected inductively by way of repeating coil windings to the
35 brushes of the several selectors; a battery E being connected in each repeating coil circuit in a manner well understood by those skilled in the art. This battery is adapted to supply current to line circuits which may
40 be extended as shown to the various telephone substations.

Associated with each row of selectors is a set of parallel conductors. These are preferably in the form of flat ribbon cables k .
45 In fact, there would be as many such cables for each row of selectors as there are vertical rows of terminals on one selector. Having shown in Fig. 1 but a single row of terminals on each selector, my drawing also
50 shows but a single cable for each row. Each of these cables has as many conductors lying parallel to one another as there are terminals in a vertical row on one selector, and therefore six conductors in the arrangement shown in the drawing. Conductors
55 m^1 , m^2 and m^3 are associated with one telephone line and conductors m^4 , m^5 and m^6 with another line. m^1 and m^2 form a pair of line circuit conductors, m^3 a local circuit conductor, m^4 and m^5 another pair of
60 line conductors, and m^6 another local circuit conductor. These six conductors in each cable respectively unite in multiple corresponding terminals of the selectors in
65 one vertical row and connect them with ter-

minals r^1 to r^6 , of the associated connecting rack. The pairs of line wires l^1 and l^2 are extended to the terminals of the connecting racks, the extensions of line l^1 being represented by a pair of wires a^1 , a^2 and
70 the extension of line l^2 being represented by a pair b^1 , b^2 . A local circuit wire a^3 is associated with line l^1 and a local circuit wire b^3 is likewise associated with line l^2 .
75 Terminals r^1 to r^6 inclusive of the several connecting racks are united in multiple by these wires a^1 , a^2 , a^3 , b^1 , b^2 , b^3 , which are preferably made up in twisted triples for each telephone line; thus a^1 , a^2 and a^3 would
80 comprise one twisted triple and b^1 , b^2 and b^3 another.

The method of making the connections of the line wires to the terminals of the connecting racks in accordance with my invention is as follows: At terminals r^4 , r^5 of
85 connecting rack R^3 , line wires b^1 and b^2 of line l^2 are connected in reverse order to that of the same wires to terminals r^4 and r^5 of connecting rack R^4 ; that is, wire b^1 is connected to terminal r^4 of rack R^4 and to terminal
90 r^5 of rack R^3 , and in like manner wire b^2 is connected to terminal r^5 of rack R^4 and to terminal r^4 of rack R^3 . A like reversal in the order of connections of the pair b^1 , b^2 occurs at connecting rack R^1 .
95 Line wires a^1 and a^2 of line l^1 , however, are connected without a reversal as between connecting racks R^3 and R^4 , and as between racks R^1 and R^2 . By means of these reversals
100 the adjacent pairs of conductors in the flat ribbon cables are transposed in relative positions to one another in the different cables with the result that induction causing cross talk between the telephone
105 lines connected therewith is prevented.

In order to insure a static balance in all of the conductors of the flat ribbon cables with respect to the grounded local circuit wires and with respect to the mass of other
110 wires in the cable a general transposition or reversal may be made in the order of connections of all of the line wires to the pairs in the cable conductors. Such reversals are indicated at x and y in the pairs of wires a^1 ,
115 a^2 and b^1 , b^2 , midway between connecting racks R^3 and R^4 on one side and R^1 and R^2 on the other. It will be noted that these reversals do not disturb the balance between
120 lines l^1 and l^2 secured by the reversals at terminals r^4 and r^5 of connecting racks R^3 and R^1 .

As it is desirable to have the flow of current in the several lines of the exchange
125 always in the same direction regardless of which selector is used to make the connection thereto, a reversal in the order of connection or transposition is made in the conductors or wires leading from certain pairs
130 of brushes to the battery in the connecting circuit and such reversals or transpositions

are made wherever the corresponding terminals of the selectors are transposed by reason of their connection to the transposed conductors in the flat ribbon cables. It will be noted that no transposition is required in the selectors in row D; that in row B the same relation between the different pairs of brushes to each other is maintained but that a general reversal of the battery connections at x' is made to correspond to the transpositions at x and y ; that, in the selectors of rows C and A the lower pairs of brushes g^4 , g^5 are transposed at z' and z^2 with respect to the upper pairs g' , g^2 , these transpositions corresponding to the reversal of connections at terminals r^4 and r^5 of connecting racks R' and R²; while at the selectors in row A a general reversal of the battery connections at x^2 is also made to correspond to the transpositions at x and y .

A brief summary may be made of the several reversals or transpositions in the cabling system shown in the drawing made in accordance with my invention and the advantageous results thereof. The reversals at terminals r^4 and r^5 of connecting racks R' and R² prevent cross talk between the telephone lines (l' and l^2) which have adjacent pairs of conductors in the flat ribbon cables; those at x and y prevent the lines from being noisy and those at x' , x^2 , z' and z^2 insure a uni-directional flow of current in the telephone lines.

Although I have shown for the sake of clearness a separate battery E in each connecting circuit, it is to be understood that one battery may be used and would ordinarily be preferred in place of the several shown. It is also to be understood that any suitable number of selectors may be placed in a row connected in the same way as those shown by the flat ribbon cables k ; that any suitable number of rows of selectors may be provided in a group and that each selector may have as many terminals as practical requirements dictate. I have shown but two lines connected to terminals of the connecting racks and selectors, but it is to be understood that other telephone lines may be connected to other terminals in the same manner and that in the case of a large number of lines, the pairs of line wires that are connected to alternate pairs of terminals in vertical rows on the connecting racks and thus to alternate pairs of parallel conductors in the flat cables would be transposed at alternate connecting racks. Obviously the brushes of the several selectors may be connected to telephone lines either directly or indirectly through trunk or connecting circuits.

As this invention is not concerned with the details of circuit arrangements, only so much of the wiring is shown as seems necessary to fully describe the invention. For

clearness in tracing the circuits the wires or conductors forming part of line circuits are shown in heavy and light lines, respectively, and those forming parts of local circuits are shown in dotted lines. The polarity of the battery E is indicated by + and - signs and corresponding signs placed near the wires of the lines l' and l^2 indicate the direction of current in the lines when the battery is connected therewith through the selectors and cable conductors.

What I claim is:

1. In a telephone exchange system, the combination with two pairs of line wires forming in part two metallic telephone circuits respectively, and switching mechanism adapted to extend the circuit of said line wires to other lines, of two sets of parallel conductors each set comprising two pairs of conductors connecting said switching mechanism in circuit with said two pairs of line wires respectively, one of said pairs of conductors in one of the sets being connected in circuit in reverse order to that of the other pairs in said sets, whereby cross talk between said telephone lines is prevented.

2. In a telephone exchange system, the combination with two pairs of line wires forming in part two metallic telephone circuits respectively, and two sets of switches each adapted to extend the circuits of said two pairs of line wires to other lines, of two sets of parallel conductors one associated with each set of switches, each set of conductors comprising two pairs connecting one of said sets of switches in circuit with said two pairs of line wires respectively, one of the pairs of conductors in one of the sets being connected in circuit in reverse order to that of the other pairs in said sets, whereby cross talk between said telephone lines is prevented.

3. In a telephone exchange system, the combination with two pairs of line wires forming in part two metallic telephone circuits respectively, two switching mechanisms and a source of current, each of said switching mechanisms being adapted to connect said source of current to either of said pairs of line wires, of two sets of parallel conductors, one associated with each switching mechanism, each set comprising two pairs of conductors connecting one of said switching mechanisms in circuit with said two pairs of line wires respectively, one of the pairs of conductors in one of the sets being connected in circuit in reverse order to that of the other pairs in said sets, and means adapted to secure a uni-directional flow of current in said telephone circuits when said source of current is connected to the line wires through said pairs of conductors.

4. In a telephone exchange system, the

combination with two pairs of line wires forming in part two metallic telephone circuits respectively and two selectors, each selector having a row of terminals for said

6 lines, of two sets of conductors one for each selector, each set having its conductors lying parallel to one another in approximately the same plane and comprising two pairs respectively connecting said two pairs of
10 line wires with the terminals of one of said selectors, one of the pairs of conductors in one of the sets being connected in circuit in reverse order to that of the other pairs in said sets, whereby cross talk between the
15 telephone lines is prevented.

5. In a telephone exchange system, the combination with two pairs of line wires forming in part two metallic telephone circuits respectively, and two selectors, each
20 selector having terminals for said lines arranged in a row and two pairs of current connecting brushes adapted, respectively, to make contact with said terminals, of two sets of conductors one for each selector, each
25 set having its conductors lying parallel to one another and comprising two pairs respectively uniting the terminals of one of the selectors with said two pairs of line wires, one of the pairs of conductors in one
30 of the sets being connected in circuit in reverse order to that of the other pairs in said sets, and the pair of said brushes of one selector which is adapted to make contact with the pair of terminals that are connected in
35 circuit through the reversely connected pair of conductors being connected in circuit likewise in reverse order to that of the other of said pairs of brushes of said selectors, whereby cross talk between the telephone
40 lines is prevented.

6. In a telephone exchange system, the combination with two pairs of line wires forming in part two metallic telephone circuits respectively and switching mechanism
45 therefor, of two ribbon cables each having its conductors lying parallel to one another and comprising two pairs, respectively, connecting said two pairs of line wires with said switching mechanism, one of said pairs
50 of conductors in one of the cables being connected in circuit in reverse order to that of the other pairs in said cables, whereby cross talk between the telephone lines is prevented.

7. In a telephone exchange system, the combination with two pairs of line wires forming in part two metallic telephone circuits and two selectors, each selector having a row of terminals for said lines, in combination with two ribbon cables one for each
60 selector, each cable having its conductors lying parallel to one another and comprising two pairs respectively uniting said two pairs of line wires with the terminals of one of
65 said selectors, one of the pairs of conduc-

tors in one of the cables being connected in circuit in reverse order to that of the other pairs in said cables, whereby cross talk between the telephone lines is prevented.

8. In a telephone exchange system, the
70 combination with two pairs of line wires forming in part two metallic telephone circuits, a source of current and two rows of selectors, each selector having terminals for
75 said lines and two pairs of current connecting brushes adapted to make contact with said terminals respectively and thereby connect said source of current in circuit with said pairs of line wires, of two ribbon cables
80 one for each row of selectors, each cable having its conductors lying parallel to one another and comprising two pairs uniting in multiple the corresponding terminals of the selectors in one row and being respectively
85 connected in circuit with said pairs of line wires, one of said pairs of conductors in one of the cables being connected in circuit in reverse order to that of the other pairs in said cables, and the pairs of brushes in one of the rows of selectors which
90 are adapted to connect said source of current in circuit through the reversely connected pair of conductors being connected to said source of current likewise in reverse order to that of the other pairs of brushes
95 of said selectors.

9. In a telephone exchange system, the combination with two pairs of line wires forming in part two metallic telephone
100 circuits respectively, two rows of selectors each selector having four terminals for said line wires and two pairs of current connecting brushes adapted to make contact with said terminals respectively, and two connecting
105 racks one for each row of selectors each connecting rack having four terminals corresponding to those of a selector, of two ribbon cables one for each row of selectors, each cable having four conductors lying
110 parallel to one another and comprising two pairs uniting in multiple the corresponding terminals of the selectors in one row and the connecting rack therefor, the corresponding terminals of said two connecting racks
115 being connected together by said pairs of line wires, the connections of one of said pairs of line wires to the terminals on one of the connecting racks being in reverse order to that of the other connections of
120 said pairs of line wires, and the pairs of brushes in one of the rows of selectors which are adapted to connect current in said circuits through the reversely connected pair of connecting rack terminals being
125 connected to the poles of a source of current likewise in reverse order to that of the other pairs of brushes of said selectors.

10. In a telephone exchange system, the combination with a plurality of selectors each having a row of terminals and a row
130

of brushes adapted to make contact therewith respectively, said selectors being arranged in rows, of a plurality of ribbon cables one for each row of selectors, each cable having conductors arranged in pairs and lying parallel to one another, and two pairs of line wires forming in part two metallic telephone circuits respectively, said line wires being connected to the terminals of each of said selectors by way of the conductors of said ribbon cables, alternate pairs of conductors in the cables of alternate rows of selectors being connected in circuit in reverse order to that of the other pairs of conductors in said cables, whereby cross talk between the telephone lines is prevented.

11. In a telephone exchange system, the combination with a pair of line wires forming in part a metallic telephone circuit and two switching mechanisms therefor each adapted to connect telephone lines with said pair of line wires, of two sets of conductors each set having its conductors lying parallel to one another in approximately the same plane, two corresponding pairs of said conductors, one in each set and unsymmetrically located with respect to other conductors in the sets, being arranged to unite terminals of said two switching mechanisms respectively with said telephone line, the connections of one of said pairs to the line being in reverse order to that of the other pair, whereby an inductive balance in the line circuit is secured.

12. In a telephone exchange system, the combination with a plurality of line wires forming in part the sides of metallic circuit telephone lines and a plurality of switching mechanisms therefor each adapted to connect other lines with said telephone lines and said mechanisms being arranged in rows, in combination with a plurality of sets of conductors one for each row of switch mechanisms each set comprising a pair of conductors for each telephone line and the conductors of each set being arranged parallel to one another in approximately the same plane and connecting in multiple corresponding terminals of the switch mechanisms in one row with said line wires, pairs of conductors in some of said sets being connected to said line wires in reverse order to that of the corresponding pairs in other sets, whereby an inductive balance in the circuits of the telephone lines is secured.

13. In a telephone exchange system, the combination with a plurality of pairs of line wires forming in part the sides of metallic circuit telephone lines and a plurality of switch mechanisms therefor, each adapted to connect other lines with said telephone lines and said mechanism being arranged in rows, in combination with a plurality of ribbon cables one for each row each cable compris-

ing a pair of conductors for each telephone line and the conductors of each cable being arranged parallel to one another and connecting in multiple corresponding terminals of the switch mechanisms of one row with said line wires, pairs of conductors in some of said cables being connected to said line wires in reverse order to that of the corresponding pairs in the other cables, whereby an inductive balance in the circuits of said telephone lines is secured.

14. In a telephone exchange system, the combination with two pairs of line wires each pair forming in part the metallic circuit of a telephone line, two local circuit wires, one associated with each telephone line and four switching mechanisms controlling said line and local circuits to connect other lines with said telephone lines, of four sets of six conductors each associated with said four switching mechanisms respectively, the conductors of each set lying parallel to one another in approximately the same plane and uniting successive terminals of the associated switching mechanism respectively with the pair of line wires and one local circuit wire of one line and the pair of line wires and one local circuit wire of the other of said lines, the connections of one of said pairs of line wires to the corresponding pairs of conductors in two of said sets and of the other of said pairs of line wires to the corresponding pairs of conductors in one of the same two sets and one of the other two sets being in reverse order to that of the connections of said pairs of line wires to the other pairs of conductors of said four sets, whereby cross talk between said telephone lines is prevented and an inductive balance in the circuits of said telephone lines is secured.

15. In a telephone exchange system, the combination with two pairs of line wires each pair forming in part the metallic circuit of a telephone line, two local circuit wires one associated with each telephone line, four selectors each having six terminals and six brushes corresponding to said line and local circuit wires of the two lines respectively, each of said selectors being adapted to connect a source of current with either of said lines, of four ribbon cables of six conductors each associated with said four selectors respectively, the conductors of each cable lying parallel to one another and uniting said terminals of the associated selector successively with the pair of line wires and one local circuit wire of one line and the pair of line wires and one local circuit wire of the other of said lines, the connections of one of said pairs of line wires to the corresponding pairs of conductors in two of said cables and of the other of said pairs of line wires to the corresponding pairs of conductors in one of the same two cables

and one of the other two cables being transposed with respect to the other connections of said pairs of line wires to pairs of conductors in said cables, corresponding transpositions being made in the connections of said brushes to maintain the same direction of current flow in the lines regardless of the path by which the source of current is connected therewith, whereby cross talk between the telephone lines is prevented.

16. In a telephone exchange system, the combination with conductors furnishing a plurality of metallic telephone circuits and switching mechanism therefor, of sets of parallel conductors connecting the telephone circuits and switching mechanism, each set comprising a plurality of pairs of conductors and a pair in one set being connected in reverse order to that of other pairs in the set, whereby cross talk between telephone circuits is prevented.

17. In a telephone exchange system, the combination with conductors furnishing a plurality of metallic telephone circuits and a plurality of sets of switches, of a plurality of sets of parallel conductors connecting the telephone circuits and the switches, one set of parallel conductors being associated with each set of switches and a pair of conductors in one set being connected in reverse order to that of other pairs in the sets, whereby cross talk between telephone circuits is prevented.

18. In a telephone exchange system, the combination with conductors furnishing a plurality of metallic telephone circuits and switching mechanism therefor, of sets of parallel conductors connecting the telephone circuits and switching mechanism, each set comprising a plurality of pairs of conductors and a pair in each alternate set being connected to one of the telephone circuits in reverse order to that of other pairs in the sets, whereby cross talk between telephone circuits is prevented.

19. In a telephone exchange system, the combination with conductors furnishing a plurality of metallic telephone circuits and switching mechanism therefor, of sets of parallel conductors connecting the telephone circuits and switching mechanism, each set comprising a plurality of pairs of conductors, a source of current adapted to be connected in circuit by said switching mechanism, a pair in one set being connected in reverse order to that of other pairs in the sets, and means adapted to secure a unidirectional flow of current in the telephone circuits when said source of current is connected to the line wires through said pairs of conductors, whereby cross talk between telephone circuits is prevented.

20. In a telephone exchange system, the combination with the conductors furnishing a plurality of metallic telephone circuits and automatic selector switches therefor, each selector having a row of terminals, of sets of parallel conductors connecting the telephone circuits and the selectors, each set having a plurality of conductors lying parallel to one another in approximately the same plane and a pair in one set being connected in reverse order to that of other pairs of the sets, whereby cross talk between telephone circuits is prevented.

21. In a telephone exchange system, the combination with conductors furnishing a plurality of metallic telephone circuits and a plurality of automatic selector switches therefor, each selector having terminals for each of said circuits arranged in a row, and pairs of current connecting brushes adapted, respectively, to make contact with said terminals, of a plurality of sets of parallel conductors, each set having its conductors lying parallel to one another and comprising a plurality of pairs connecting the telephone circuits and the terminals, some of the circuits in alternate sets being connected to their conductors in reverse order to that of the connections to other conductors in the sets, whereby cross talk between telephone circuits is prevented.

22. In a telephone exchange system, the combination with conductors furnishing a plurality of metallic telephone circuits and switching mechanism therefor, of a plurality of ribbon cables connecting the telephone circuits and switching mechanism, each cable comprising a plurality of pairs of parallel conductors and a pair in one cable being connected in reverse order to that of other pairs in the cable, whereby cross talk between telephone circuits is prevented.

23. In a telephone exchange system, the combination with conductors furnishing a plurality of metallic telephone circuits and switching mechanism therefor, sets of parallel conductors connecting the telephone circuits and switching mechanism, each set comprising a plurality of pairs of conductors and some of the pairs in some of the sets being connected in reverse order to that of the other pairs in the sets, whereby cross talk between telephone circuits is prevented.

In witness whereof, I hereunto subscribe my name this sixth day of August A. D., 1909.

FRANK R. McBERTY.

Witnesses:

F. T. WOODWARD,
F. P. McINTOSH.