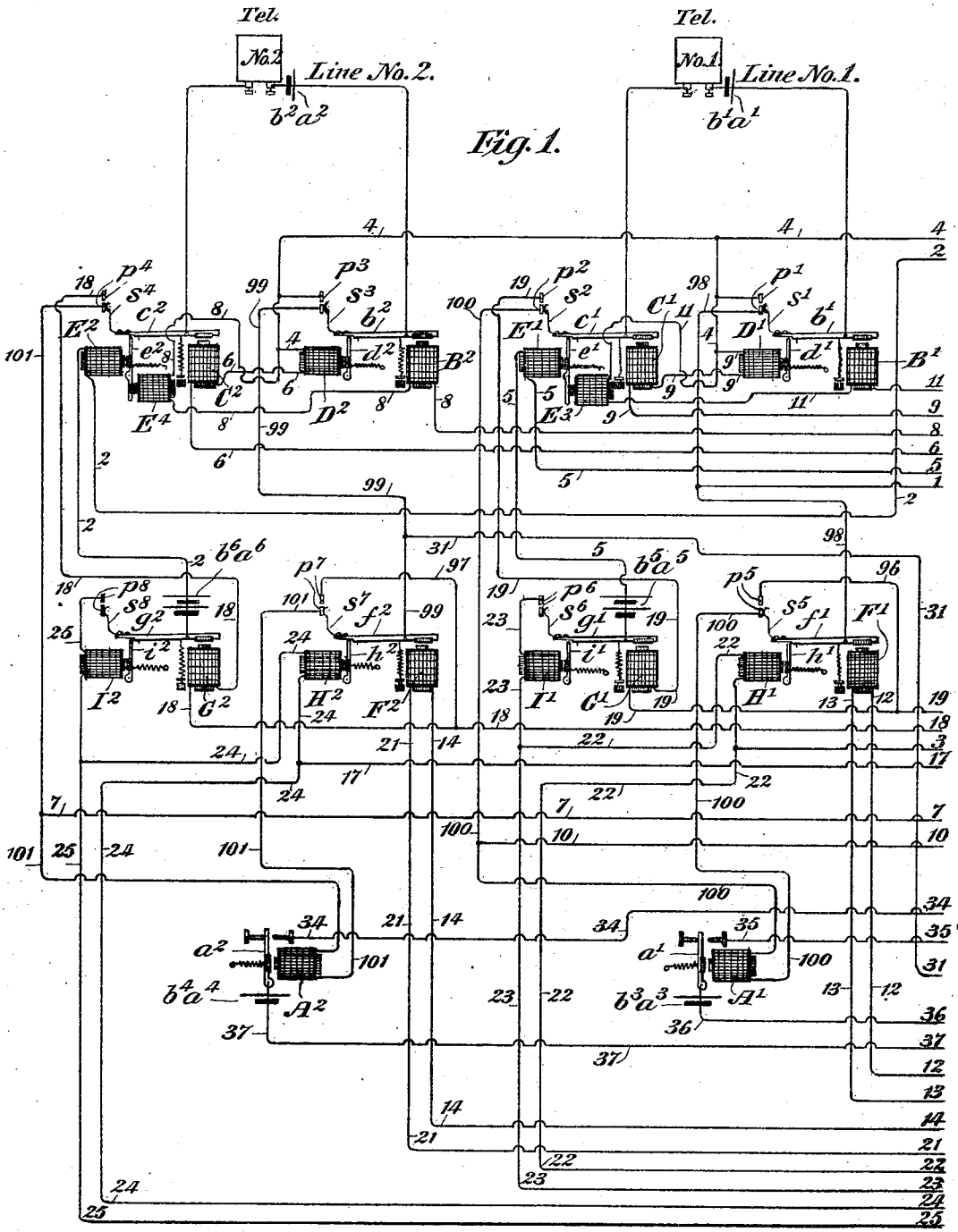
(No Model.) 14 Sheets—Sheet 1.

R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,874. Patented Jan. 2, 1894.

Fig. 1.



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14 Sheets—Sheet 2.

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TELEPHONE EXCHANGE SYSTEM.

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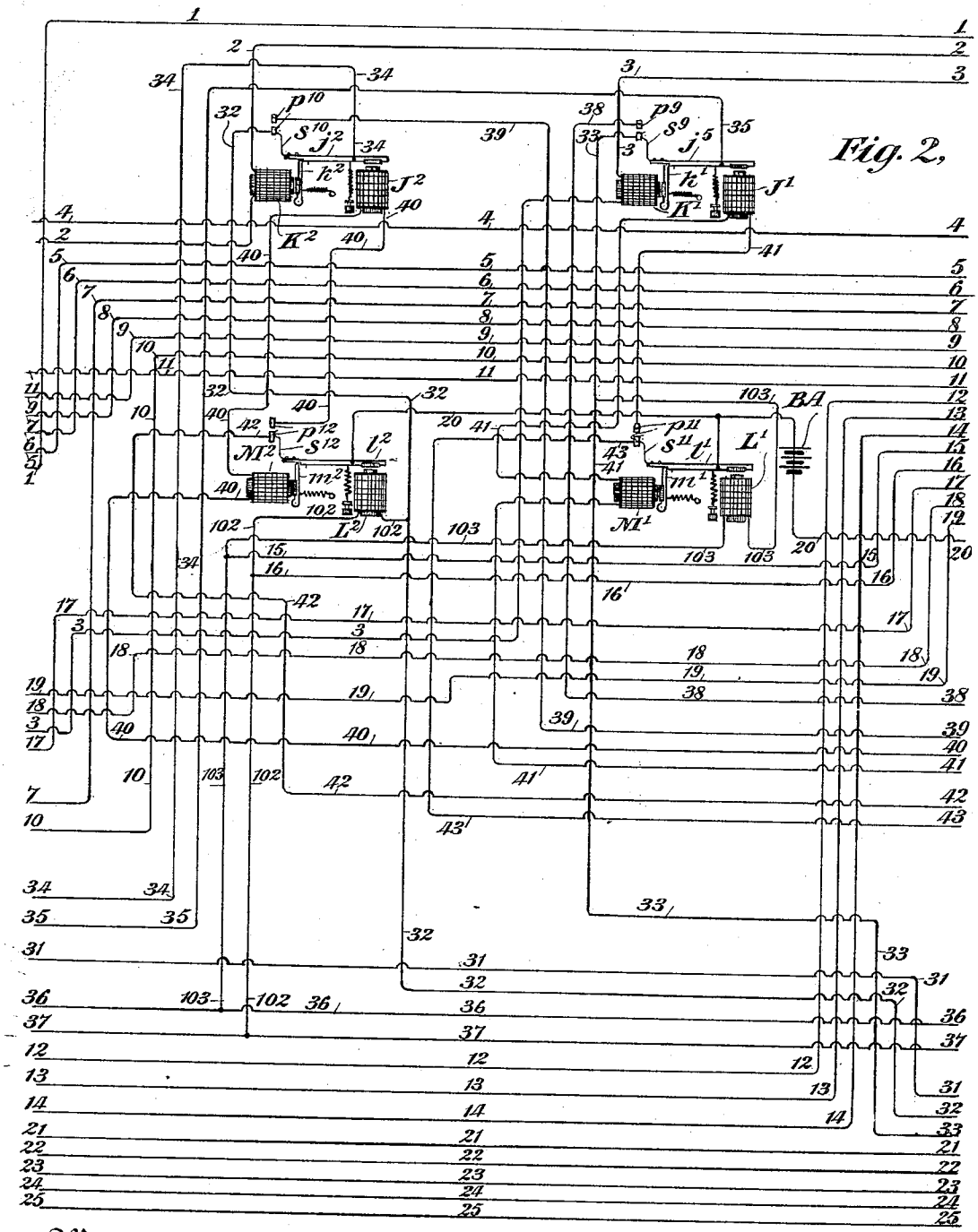

Fig. 2.

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14 Sheets—Sheet 3.

R. CALLENDER.

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No. 511,874. Patented Jan. 2, 1894.

Fig. 3,

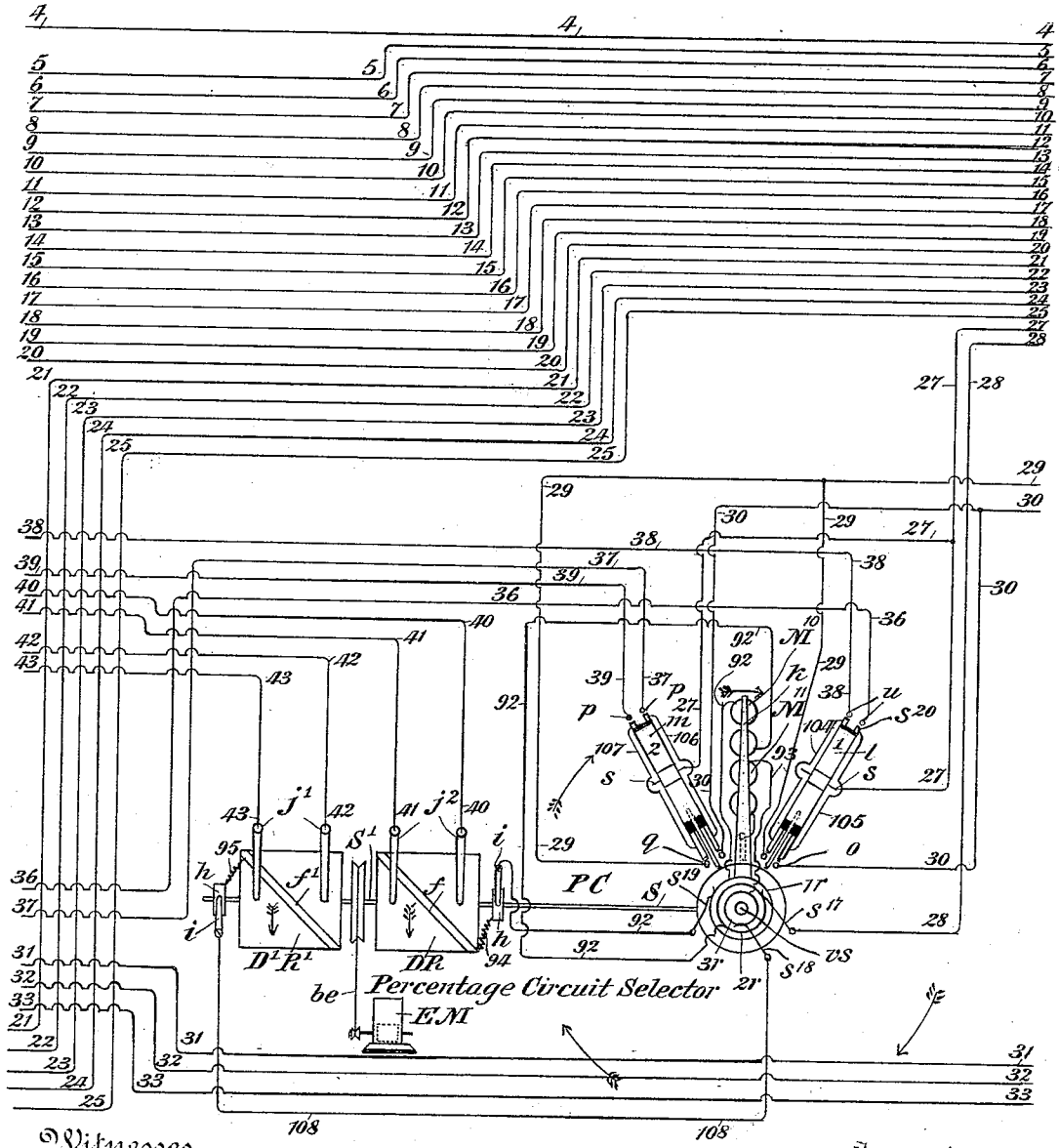

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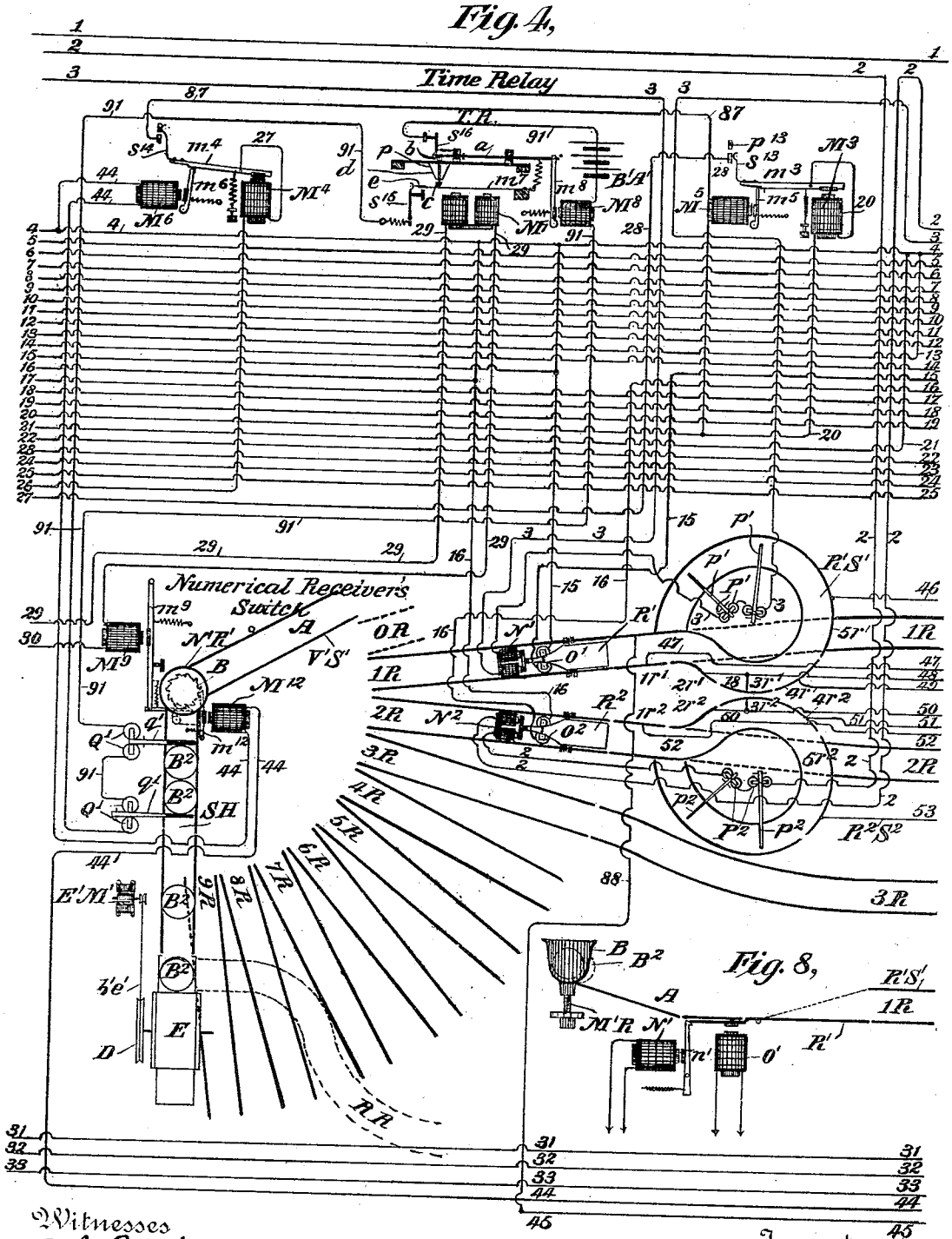
Fig. 4,



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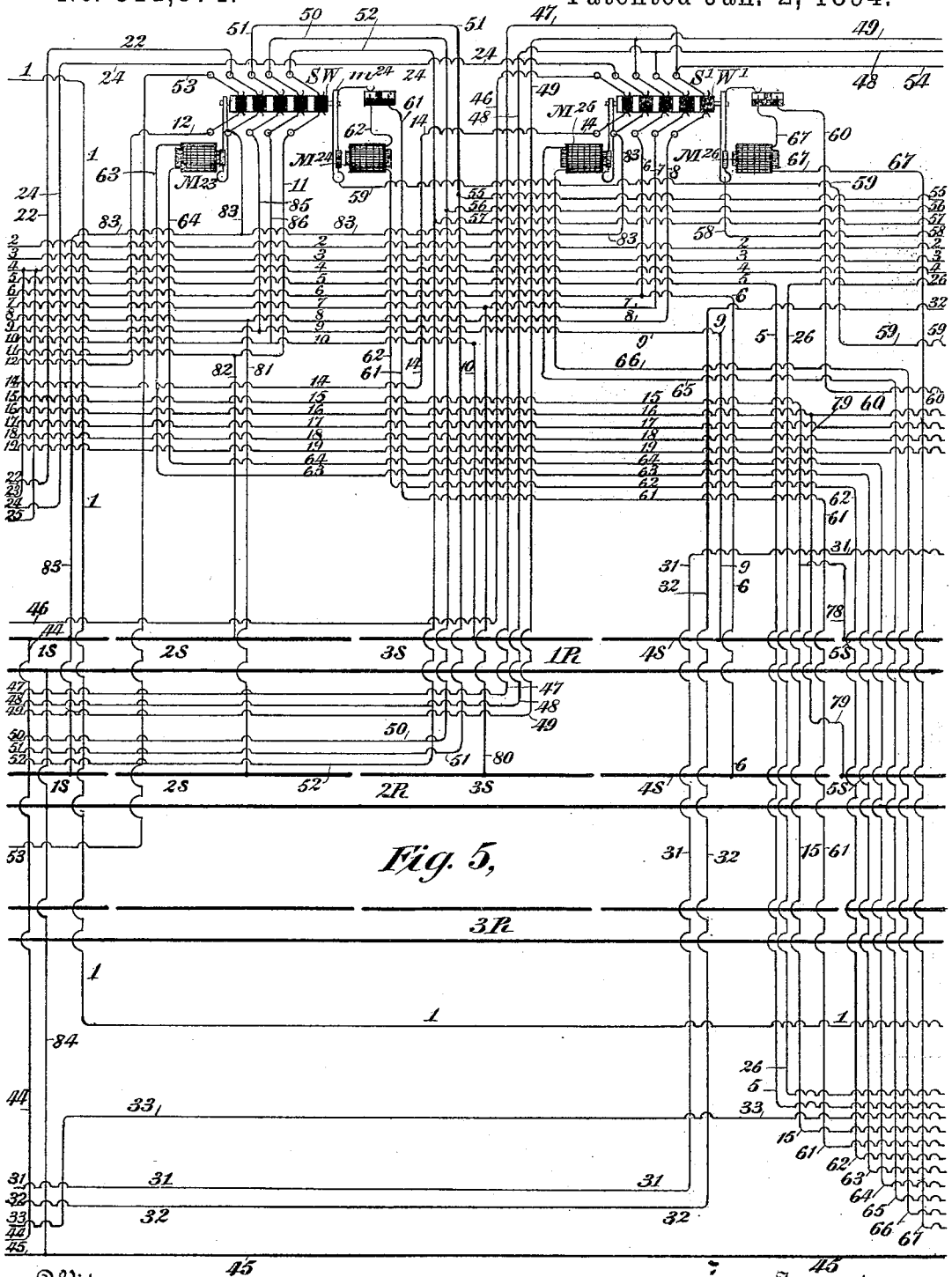

Fig. 5,

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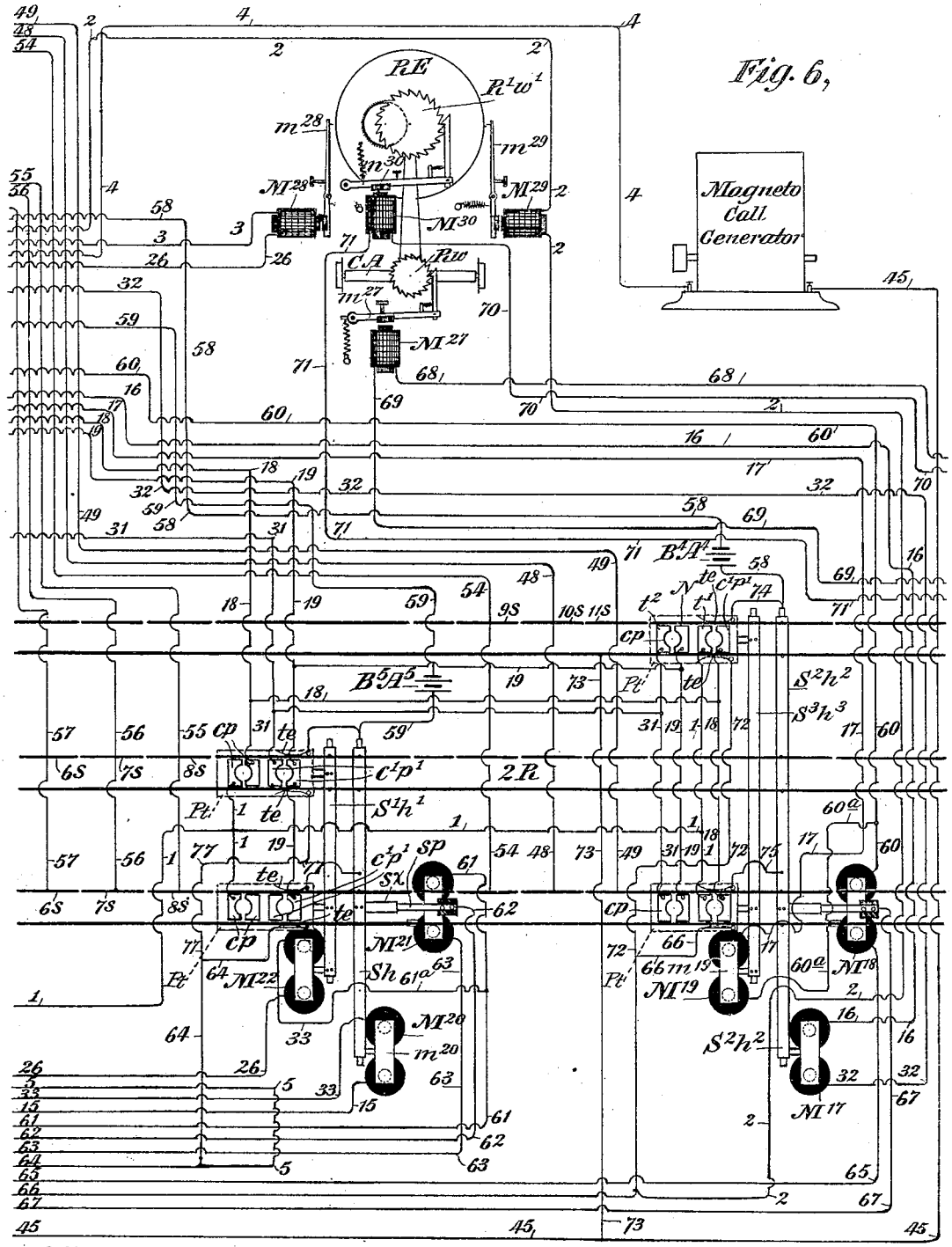
Fig. 6,



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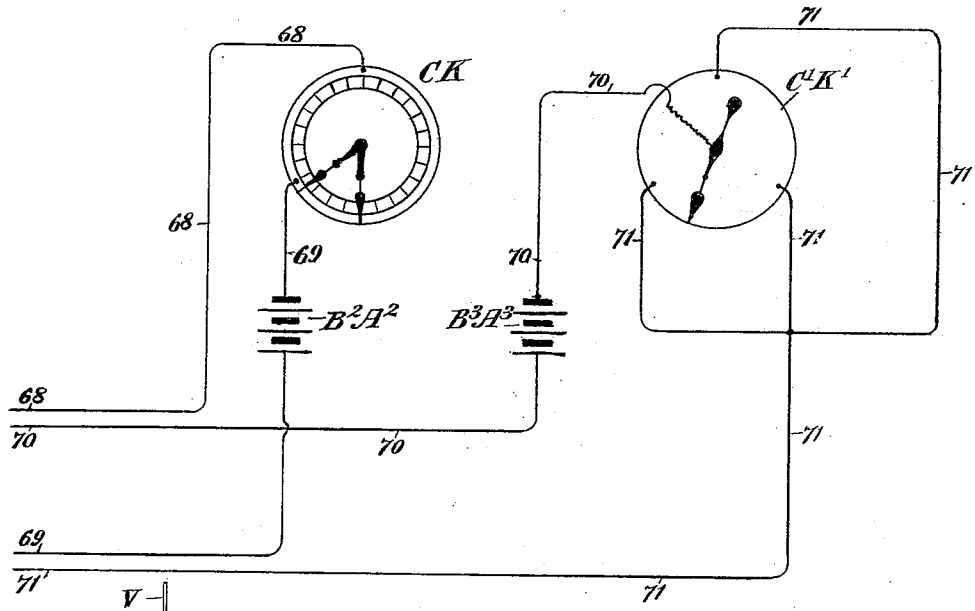
24 hour clock **Fig. 7,** *60 seconds clock*



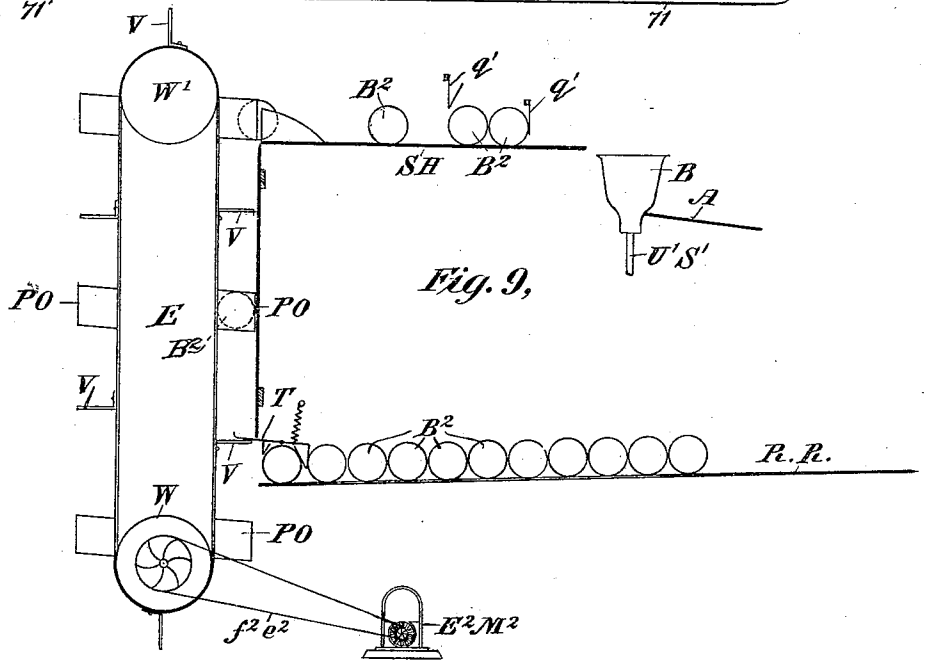


Fig. 9,

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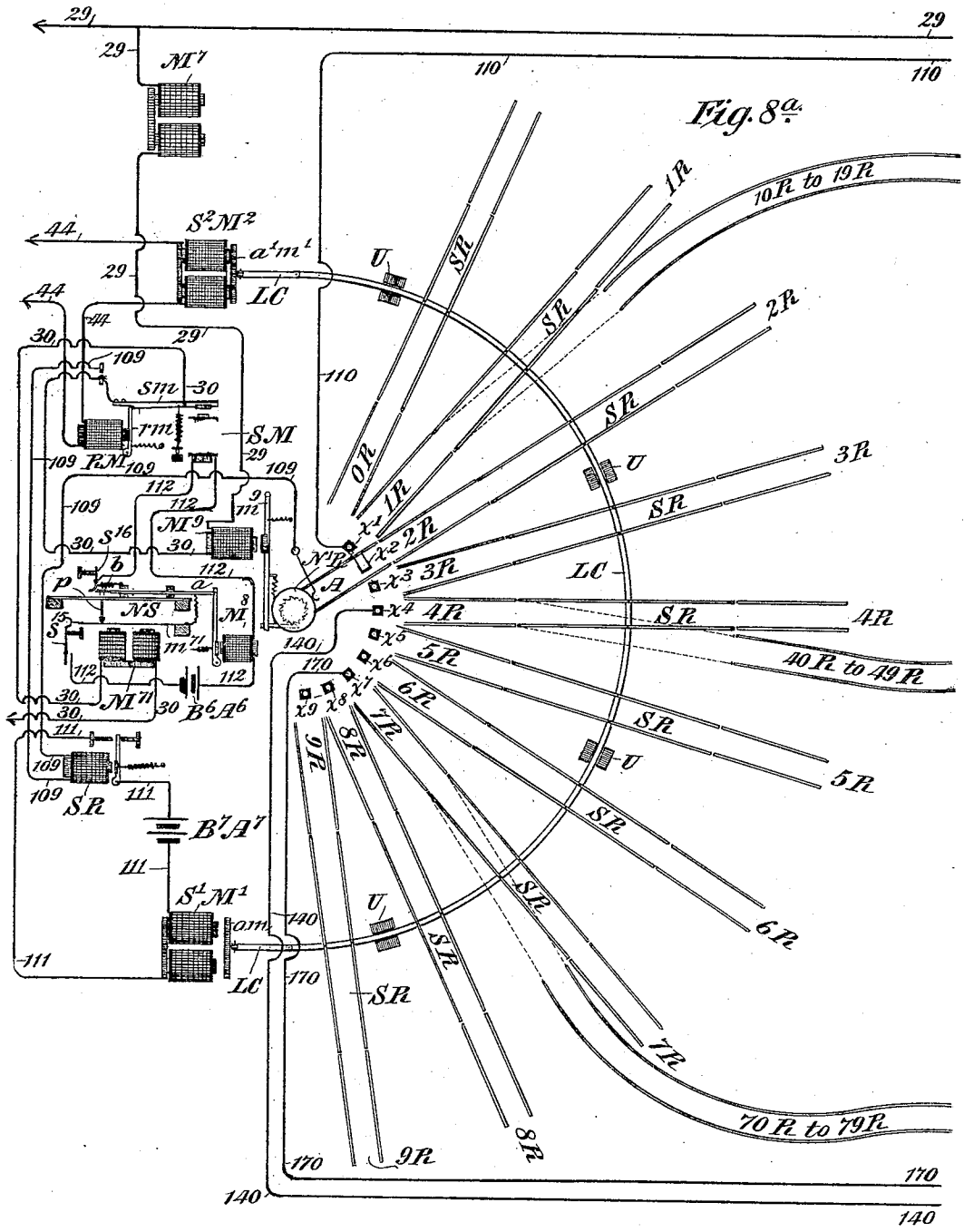

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14 Sheets—Sheet 9.

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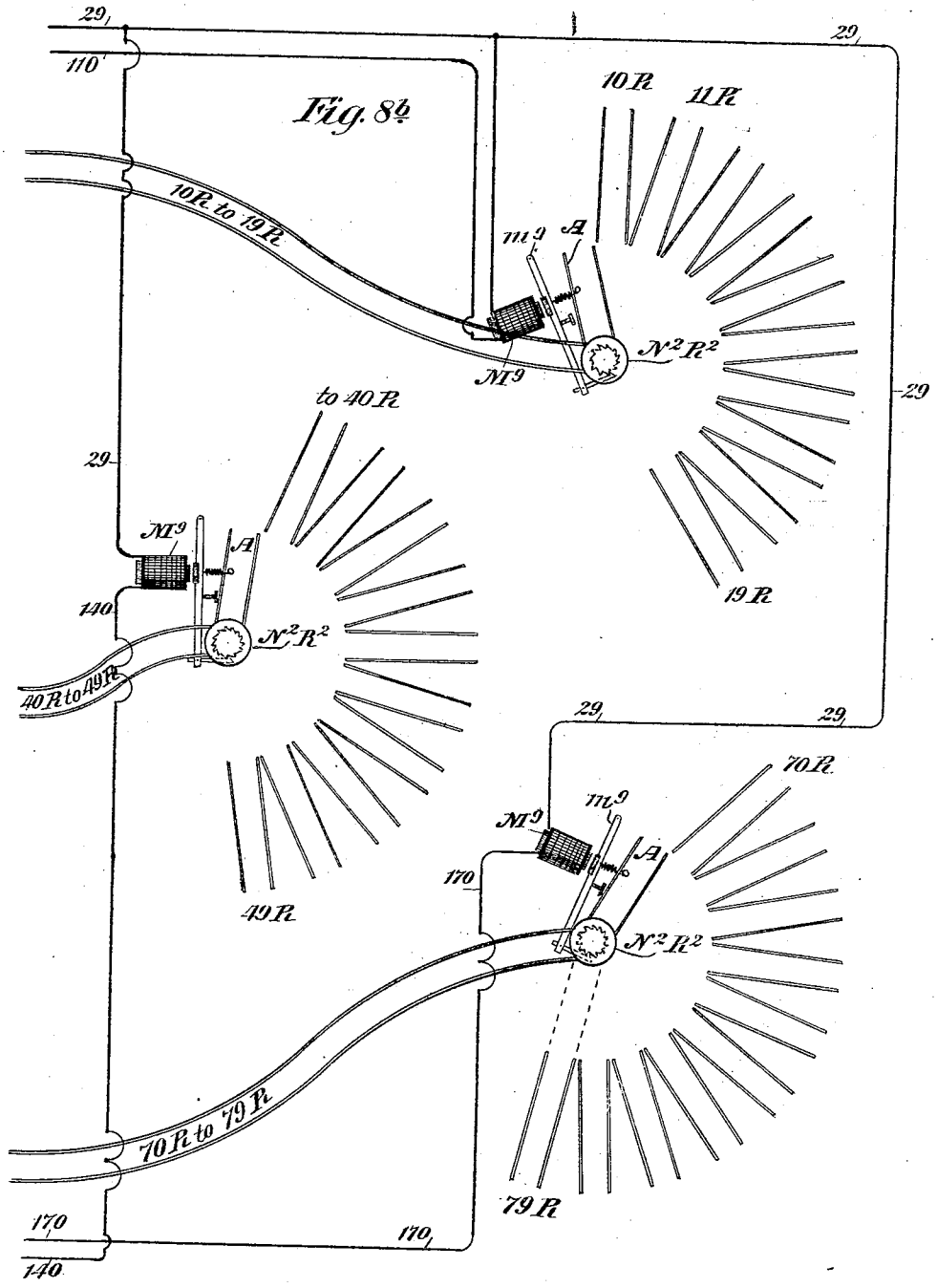

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14 Sheets—Sheet 10.

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TELEPHONE EXCHANGE SYSTEM.

No. 511,874. Patented Jan. 2, 1894.

Fig. 10,

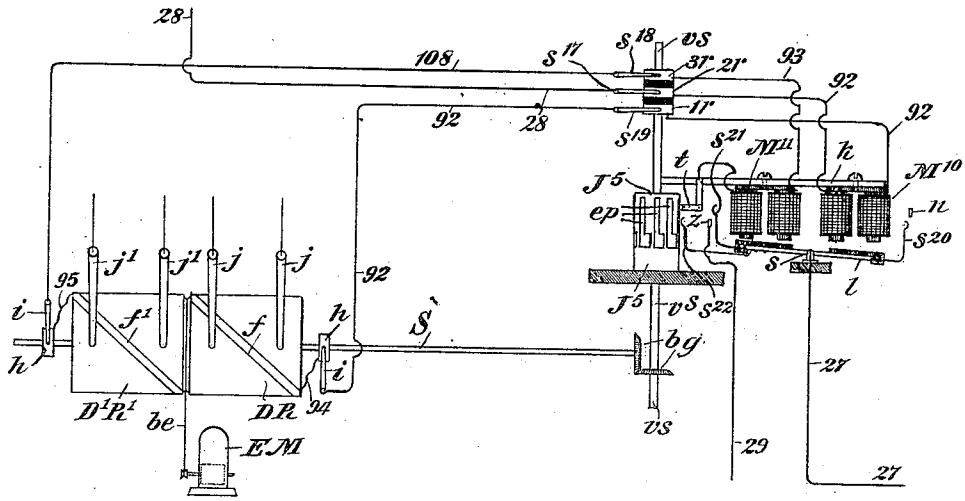
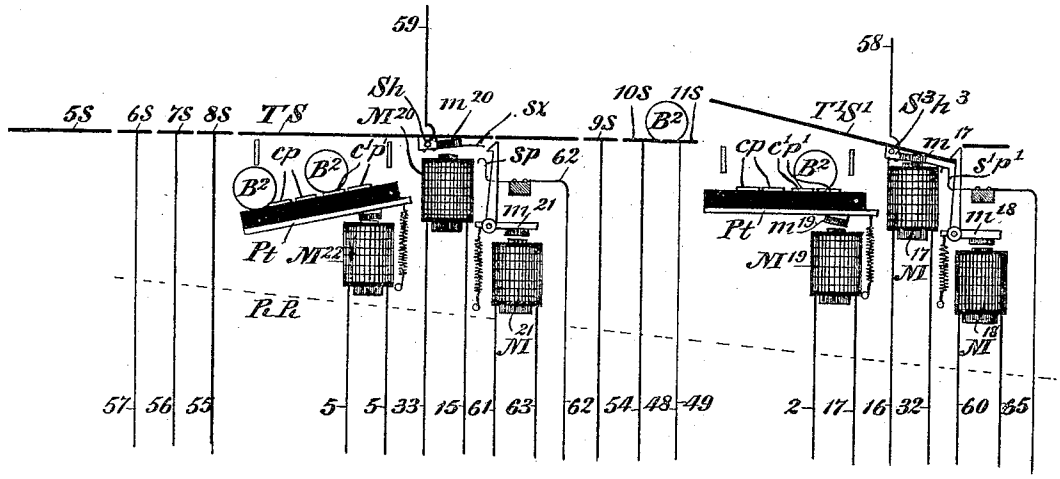


Fig. 11,



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14 Sheets—Sheet 11.

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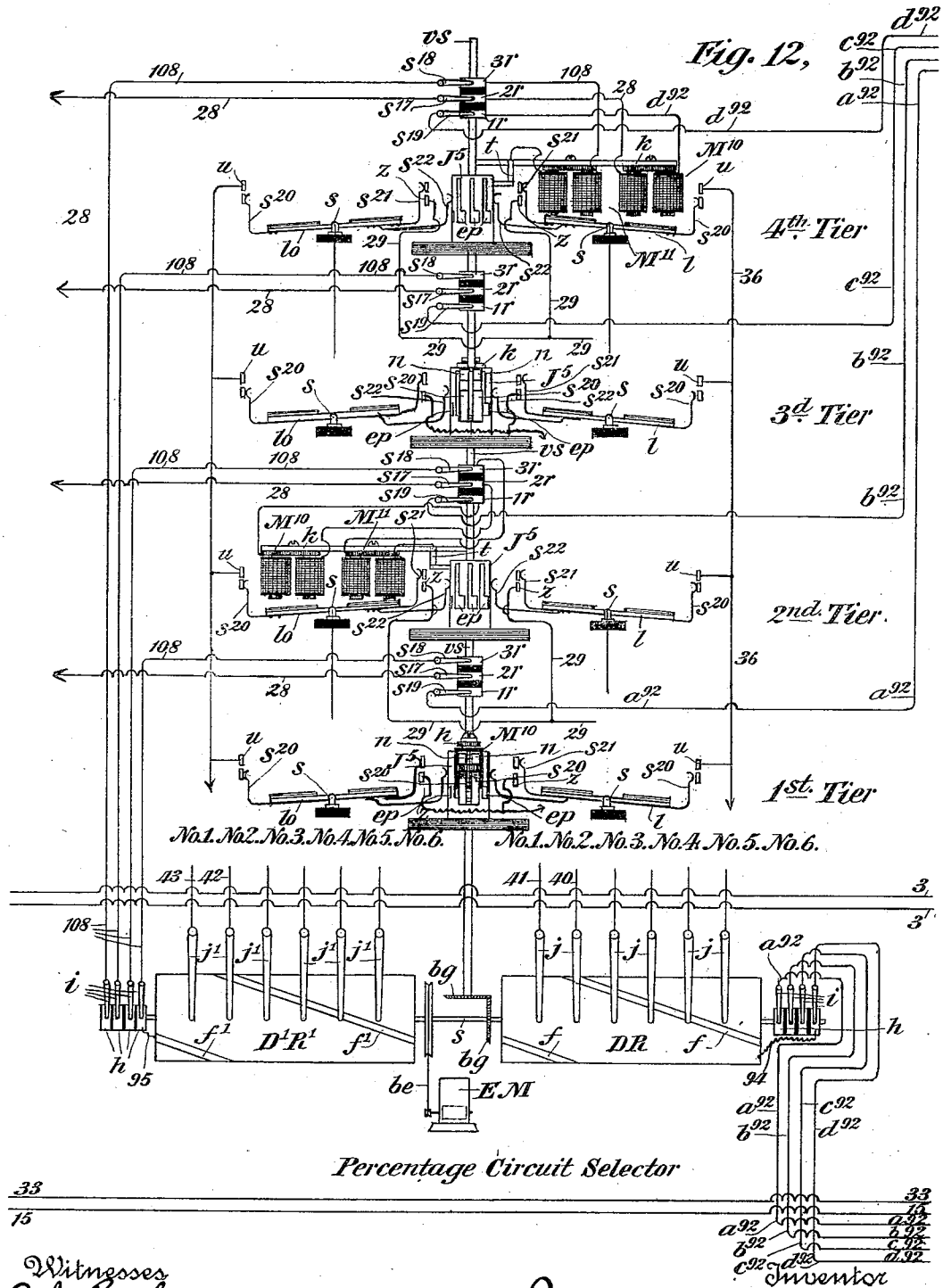

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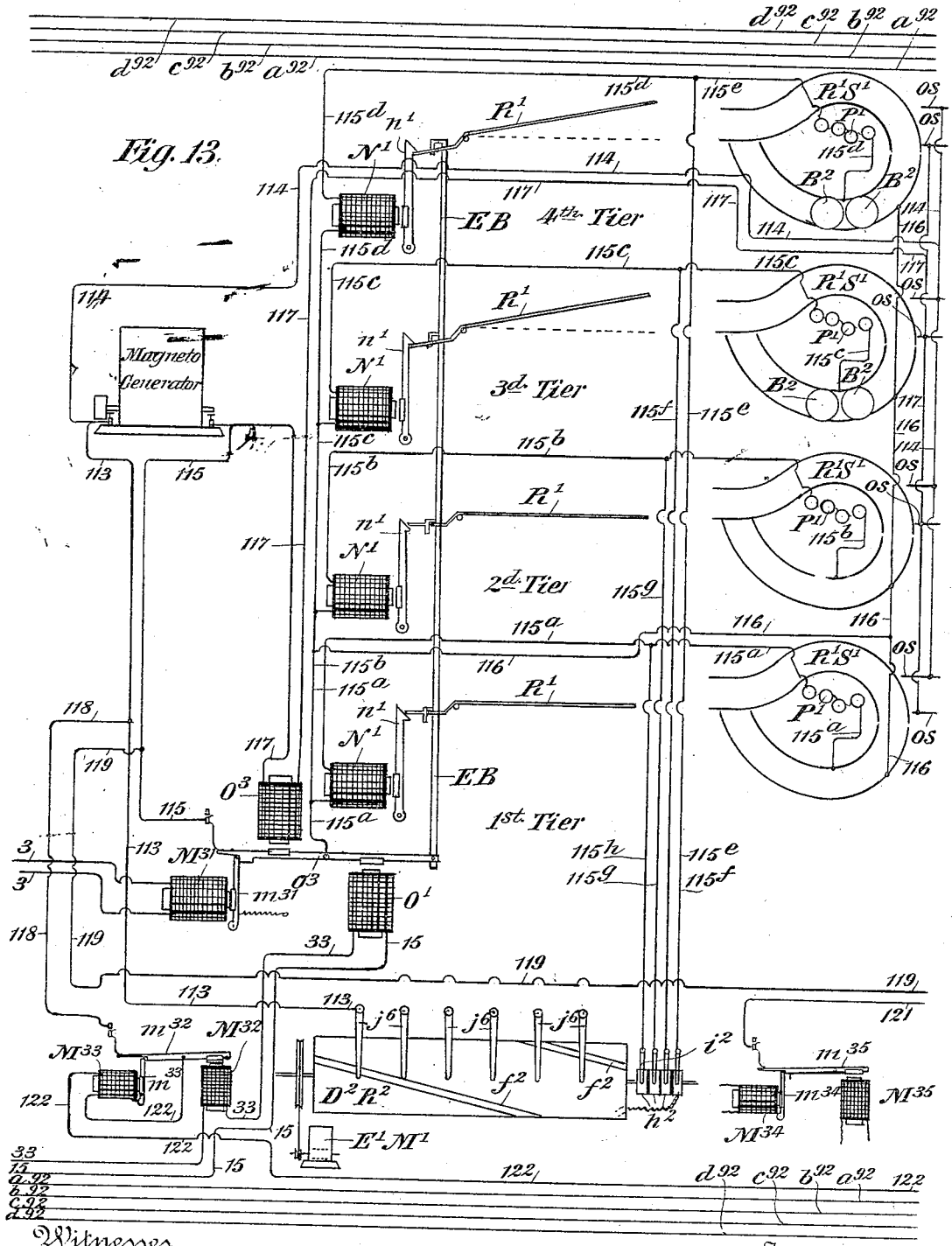
14 Sheets—Sheet 12.

R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,874. Patented Jan. 2, 1894.

Fig. 13.



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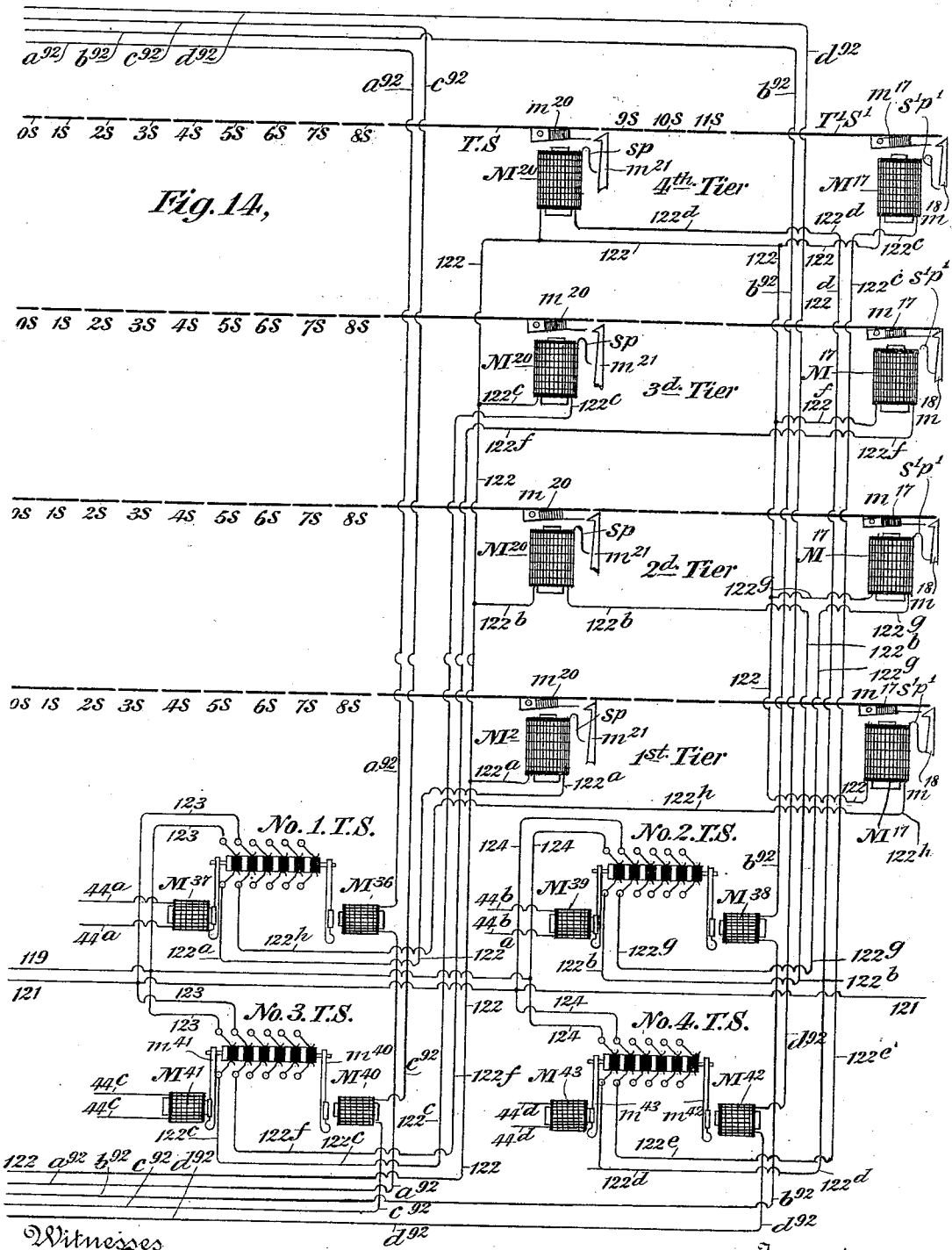
14 Sheets—Sheet 13.

R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,874. Patented Jan. 2, 1894.

Fig. 14.



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(No Model.)

14 Sheets—Sheet 14.

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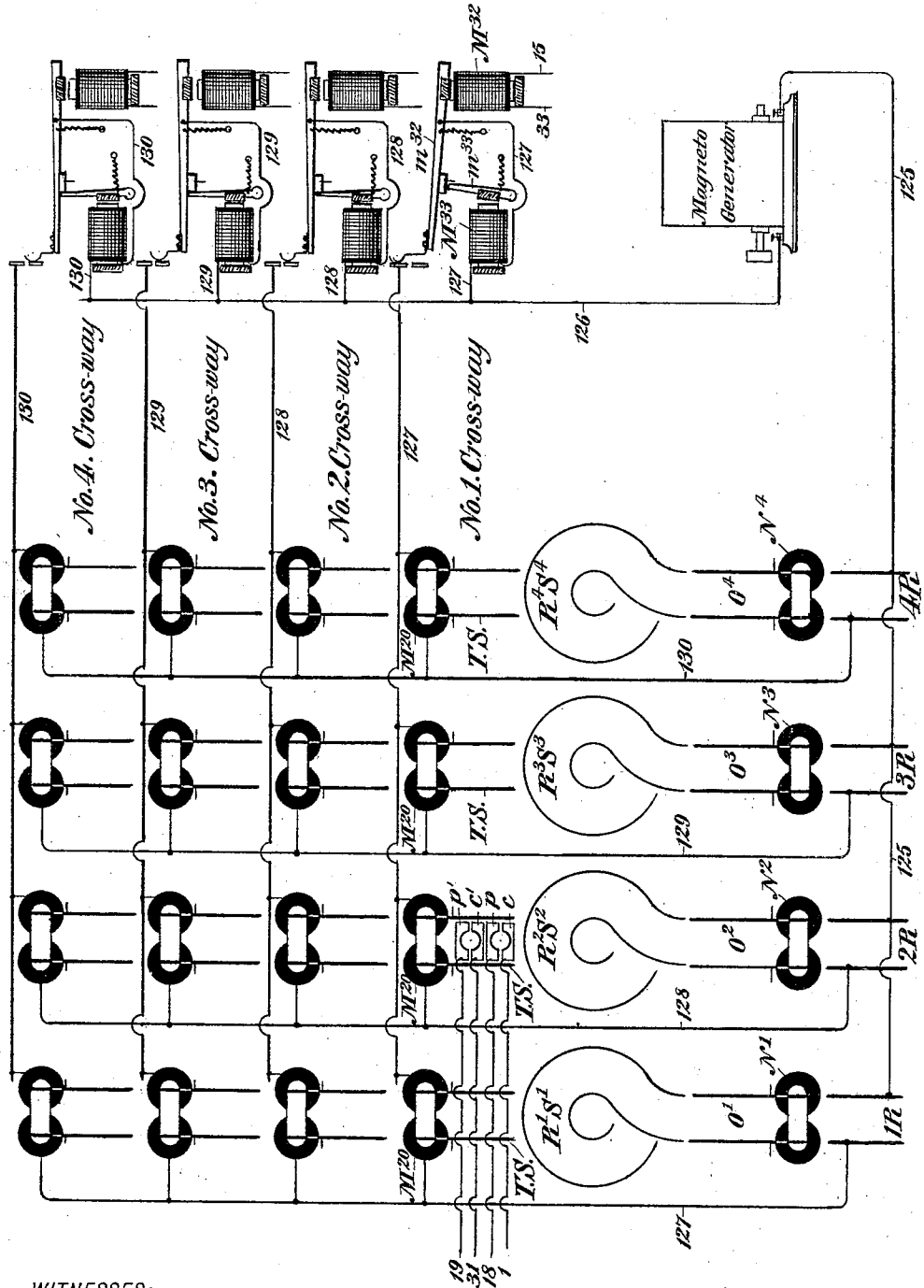

Fig. 15.

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UNITED STATES PATENT OFFICE.

ROMAINE CALLENDER, OF BRANTFORD, CANADA.

TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 511,874, dated January 2, 1894.

Application filed May 12, 1893. Serial No. 474,024. (No model.)

To all whom it may concern:

Be it known that I, ROMAINE CALLENDER, a subject of the Queen of Great Britain, residing at Brantford, in the Province of Ontario and Dominion of Canada, have made a new and useful Invention in Telephone-Exchange Systems, of which the following is a specification.

The present invention is directed to improvements in automatic telephone exchange systems and particularly to improvements upon a prior invention described in an application for a patent filed by me in the United States Patent Office on the 13th day of August, 1892, bearing Serial No. 442,948. In the aforesaid application I have described and claimed a system of automatic intercommunication in which all incoming signals over any line of the entire system are caused to rupture all of the line circuits except that over which the signal is being transmitted, and to then effect the necessary connections after which the several line connections are again restored and conversation between two subscribers effected, the remaining subscribers being however, during the interval, wholly deprived of any opportunity of using the system. It also comprehended a continuously actuated time mechanism which controlled the operation of the entire apparatus and regulated the length of conversation between subscribers, &c.

The present invention is intended to simplify in many respects, the method of intercommunication and apparatus referred to and to add features of novelty and utility both in methods and mechanism not found therein. These features are essentially as follows: first, an improved automatic exchange apparatus and method of operation whereby any subscriber may obtain control of one section of the switching apparatus instantaneously, and to the exclusion of all other subscribers from the use of that particular section for a brief space of time sufficient to effect the desired connection, and then through the mechanism thus actuated to automatically disconnect the section of switching mechanism used and leave it for the use of any other subscriber, while he (the first named subscriber) continues his conversation unmolested with the subscriber called, and at the end of that conversation restores his line and the line of the subscriber to whom he is talking, to normal condition, the arrangement being such that if need be, an indefinite number of the entire list of subscribers might call and talk simultaneously with a like number of outlying subscribers and in such manner that there would be no delay in signaling, nor interference of any kind whatever at any point; second, means whereby if a subscriber when called is using his line, any such calls are stored up one after another and then sent in to the first named subscriber automatically and in the order stored, the sequence of connections to the various lines being effected in the order in which they are stored; third, an automatic recorder which is located at the exchange and operatively connected with any subscriber and adapted to make a record of all calls made by all subscribers connected to it, thereby acting as a check on the actual number of calls made; fourth, in the details of construction of the entire apparatus as hereinafter fully described.

The features of novelty which I deem as of my invention are particularly pointed out in the claims at the end of this specification.

Referring to the drawings which constitute a part of this specification and in all of which like letters and figures represent like parts wherever used, Figures 1, 2, 3, 4, 5, 6, and 7 are diagrammatic views illustrating the complete and operative parts of a system by showing the circuit connections and mechanism entire for two independent telephone lines which are shown at the top of Fig. 1, additional parts of the apparatus being shown at the bottom of Fig. 4 as applicable to a complete system of nine lines. Fig. 8 is a side elevational view showing a main runway and an accumulator or storing track in their relation to an accumulator switch or gate. Figs. 8^a and 8^b are diagrammatic views illustrating the switching apparatus utilized by me in connecting up telephone subscribers' lines in a system of lines involving ninety-nine subscribers. Fig. 9 is a side elevational view of the elevator or hoisting apparatus which returns the circuit controlling balls of the system to their normal position after they have been used in making the necessary circuit connections at the switch board. Fig. 10 is a

part diagrammatic part side elevational view of my novel percentage circuit selecting apparatus which enables any subscriber to obtain control of the switching apparatus and effect his circuit connections with that of the subscriber called and without any fear of interruption. Fig. 11 is a diagrammatic view of the track sections which sustain the circuit controlling balls at the switch board and releasing apparatus therefor for releasing and allowing them to be returned to the elevator shown in Fig. 9. Fig. 12 is a diagrammatic view illustrating my novel percentage circuit selector as applicable to a large series of telephone lines. Fig. 13 is a diagrammatic view illustrating what I term a signal storing mechanism or call accumulator for storing up calls from outlying subscribers and for discharging them consecutively in such a way that only one stored call at a time can be sent to its proper destination, thus preventing more than one connection at a time for each wire even if calls are stored on every accumulator tier in the system. This figure also shows a portion of what I term the signal distributing mechanism for ultimately releasing and distributing the calls previously stored by the call accumulator just referred to; the remainder of the signal distributing mechanism being shown in Figs. 3, 4, 8 and 12. Fig. 14 is a diagrammatic view illustrating circuit connections and electro-magnetic controlling apparatus with switching devices for causing the circuit connecting balls to drop into their proper pockets at the switch board and on a tier thereof which shall correspond in number to that tier of the percentage selecting device shown in Fig. 12 through which the incoming signal was transmitted. Fig. 15 is a diagrammatic view of a modified form of apparatus for individually operating the hinged track sections over the switch board connections.

I preferably make use of an all wire circuit from each subscriber to the exchange system and each of such circuits includes a signaling battery and a relay which is adapted to control switching mechanism operatively connected to a cross connected switch board, and also a continuously operating switching device which in turn controls the operation of numerical receiver switches having a decimal order of relation as described in my prior application. The traveling arms of the numerical receivers described and claimed in my prior application were utilized directly as switching devices which made the actual circuit connections between any two subscribers' lines and remained intact whenever actuated for a given signal until the conversation has been completed. In the present invention the pivoted traveling arms of the numerical receiver switches are utilized to perform the function of acting as carriers or conveyers for the transference of metal balls or moving circuit closers which are set in motion and allowed to run over or through fixed runways, chutes or conveyers to their destination finally making the necessary connections (much as switch plug connections are made in an ordinary cross connected switch board) between any two subscribers' lines, while the pivoted conveyers or arms of the numerical receiver switches are automatically returned instantly to normal position for use by other subscribers as desired. I make use also of what I term a percentage circuit selector which acts to receive all incoming signals and to distribute them to those sections of the switching system not in use at the time of the arrival of said signals, thus allowing a limited number of short switching lines at the station to accommodate themselves to a large number of possible signals or calls. In other words I assume, upon a careful analysis of telephone statistics, that a given system of outlying telephone lines will, at the busiest time of the day, be called upon to carry a known maximum number of signals or calls in a definite period of time, and for security I multiply this number by a given number which will surely give a number of signals greater than any probable number estimated. I then adapt the mechanism to work always for all signals or calls within this fixed limit; so proportioning the several sections of the percentage selector that it will receive and distribute all signals or calls within the limit named and without failure.

I provide a cross connecting switch board with the usual cross connections and with automatic switching devices for adapting it for connections between any and all pairs of lines of the system. The usual plug connections in this switch board are effected, as I have above indicated, by metallic or other conducting balls which are allowed to roll down and drop into the plug holes or upon exposed contacts in pairs, finding their way to the proper plug holes over stationary runways or conveyers connected to the movable switch arms of the numerical receiver switches and controlled by electro-magnets as are the corresponding numerical receiver switching arms described and shown in my prior application. With a limited number of such conducting balls which are released and restored automatically by electro-magnetic mechanism and carried by mechanical runways and an elevator back to the starting point for re-use, I am enabled to quickly effect any cross connection desired and to maintain any two lines in undisturbed relation as long as the subscribers may wish, while additional calls for either of them are temporarily stored, the balls for effecting the connections for such additional calls being held in check by mechanism controlled by the subscribers themselves.

Referring now to the drawings in detail and first to Sheets 1 to 7 inclusive, which should be placed side by side in sequence, there are shown at the top of Fig. 1 two telephone lines, Nos. 1 and 2 each provided with a complete metallic circuit running from the individual

subscriber to the central station, the usual telephone transmitters, receivers and magneto call bells being located at the subscribers' telephone boxes and each provided with a circuit interrupting transmitter, not unlike that described in my prior application above referred to, and adapted to transmit over the line to the central station any desired order of circuit interruptions, b' a' and b^2 a^2 being the signaling batteries here shown as located at the subscribers' stations.

A′ and A² are relay electro-magnets located in the individual subscribers' lines adapted to control the switching current impulses from batteries b^3 a^3 and b^4 a^4.

B′ and B² are switching electro-magnets for switching one terminal of each subscriber's line from direct connection with the central office mechanism into connection through a conductor 4 with one pole of a magneto electric generator located also at the central station and shown at the upper right hand side of Fig. 6, Sheet 6.

C′ and C² are switching electro-magnets for disconnecting the other terminal of each subscriber's line from connection with its particular relay A′ or A², &c., and connecting each line directly to and through an automatic releasing electro-magnet G′ or G².

D′ and D² are releasing electro-magnets, the armatures d' and d^2 of which are adapted to hold the armatures b' and b^2 when the electro-magnets B′ and B² are energized.

E′ and E² are releasing electro-magnets, the armatures e' and e^2 of which are adapted to lock the armatures c' and c^2 of the electro-magnets C′ and C² in their upper positions when the electro-magnets C′ and C² are energized.

E³ and E⁴ are also releasing electro-magnets designed to perform the same function as the electro-magnets E′ and E² and act upon the same armature levers e' and e^2 but are energized from another circuit.

F′ and F² are electro-magnets designed to close the proper circuits through their armature levers f' and f^2 for enabling a calling subscriber to automatically restore his particular portion of the switching mechanism at the central or exchange station to normal condition so as to enable him to call any other subscriber when on turning in a call he is automatically warned that the subscriber called is busy.

H′ and H² are releasing electro-magnets, the armatures h' and h^2 of which are adapted to lock the armature levers f' and f^2 of the electro-magnets F′ and F² in their uppermost positions when the latter electro-magnets have been energized.

I′ and I² are additional releasing electro-magnets the armatures i' and i^2 of which are adapted to lock the armature levers g' and g^2 of the electro-magnets G′ and G² in their uppermost positions when the latter electro-magnets are energized.

Referring now to Fig. 2, Sheet 2, J′ and J² are switching electro-magnets provided with switching armature levers j' and j^2 carrying contact springs s^9 and s^{10}, the function of which is to change the circuits of the relay batteries b^3 a^3 and b^4 a^4 shown at the bottom of Sheet 1 from connection with the switching electro-magnets L′ and L² shown in the central part of Fig. 2, Sheet 2, into direct connection through what I call a "percentage circuit selector" shown at the bottom of Fig. 3, Sheet 3, to the electro-magnet M⁹ of the numerical receiver switch and also to the controlling electro-magnets M⁷ of what I call a "time relay" shown at the top of Sheet 4.

The apparatus already described in connection with Sheets 1 and 2 of the drawings and illustrated as in duplicate for two lines is a necessary part of each and every subscriber's line.

The apparatus denominated as the "percentage circuit selector" shown in plan view at the bottom of Fig. 3 and also in side elevational view in Fig. 10 consists of two non-conducting drums D R and D′ R′ carried upon a horizontally disposed shaft s provided with a pulley and a belt b e connected to an electric motor E M or other constant source of power adapted to rotate it in the direction of the arrows.

The shaft s is geared through miter gearing b g with a vertical shaft v s, see Fig. 10, which passes through a vertically disposed cylinder J⁵ upon which is arranged a series of conducting or contact plates e p having enlarged lower ends.

1ʳ, 2ʳ, 3ʳ, are conducting rings carried by the shaft v s and insulated from each other, and s^{19}, s^{17} and s^{18} are contact brushes resting thereon. h h are similar conducting rings insulated from and carried by the shaft s, i i being contacting brushes resting on the conducting rings, h h.

k is a horizontal non-conducting arm carried by the vertical shaft v s and sustaining near its outer end two pairs of electro-magnets M¹⁰ and M¹¹ adapted to rotate over the opposite ends of radially disposed tilting armature levers l m, there being one of these tilting armature levers for each subscriber's line.

f and f' are spirally disposed conducting strips carried by the non-conducting cylinders D R, D′ R′.

j j are contact brushes adapted to make electrical contact with the contact strip f at different times as the drum D R is rotated, and j' j' are corresponding contact brushes adapted to make similar contacts with the contact strip f'. The spirally disposed contact strips f and f' are so located with relation to the ends of the contact brushes j j' that when the left hand brushes j j' of each pair are resting upon said strips, the arm k carried by the shaft v s is directly over the armature lever l so that said armature lever is in the magnetic field of both pairs of electro-magnets M¹⁰ and M¹¹ and similarly when

the right hand pair of brushes j and j' of each pair are in contact with the contact strips f and f', the arm k and electro-magnets M^{10} and M^{11} will be directly over the left hand tilting armature lever m. The contact strips f and f' are connected to the conducting rings h by short conductors 94 and 95. The tilting armature levers l and m are each provided at their opposite ends with conducting springs for changing the direction of the current as will be described in connection with the description of the mode of operation, the arrangement being such that as the arm k rotates in the direction of the arrows, the armature levers l m will be tilted in either direction at will according to the current changes through the magnets M^{10} and M^{11} and the necessary circuit connections made through the brushes j j, j' j' and the contact strips f and f'.

At the top of Sheet 4 is disclosed what I term a "time relay" which is set in operation by the signaling impulses sent into the exchange station by any subscriber, and kept in operation during the time that such impulses are being transmitted and for a given length of time thereafter, dependent upon the adjustment of the instrument itself, the function of this instrument being to permit of the operation of the apparatus only after the numerical receiver switch arm A has arrived at its proper position for discharging the switching balls. This time relay consists of an operating electro-magnet M^7 which is in direct circuit with the electro-magnet M^9 of the numerical receiver switch N' R'.

m^7 is a vibratory steel reed of well known form which may be arranged adjustably in any well known manner so as to vibrate for any brief length of time.

e is a conducting point carried by the free end of the reed m^7 and adapted to contact with a yielding arm s^{15}.

M^8 is a releasing electro-magnet having an armature m^8, the free end of which is attached to a sliding conducting bar a, one end of which is adapted to bear against the side of a conducting head b on the upper end of a sliding pin p carried in a guide-way d and having a non-conducting head c resting normally on the upper surface of the vibratory reed m^7.

s^{16} is a yielding arm having electrical connection through a conductor 91 with a releasing battery B' A', the circuit of this battery being normally open between the contact arm s^{16} and the conducting head b and closed between the vibratory reed m^7 and the arm s^{15} at the point e.

I make no claim in the present application to a circuit controlling device adapted to close an electrical circuit after a definite interval of time, as such a circuit closer constitutes the subject matter of an independent application for a patent filed by me in the United States Patent Office on the 24th day of April, 1893, and bearing Serial No. 471,559. Such a circuit controlling device is only claimed here in combination with other features which constitute parts of my improved automatic telephone exchange system herein described.

For the purpose of rendering the description as simple as possible I have only shown, at the bottom of Sheet 3, a percentage circuit selector having a single pair of tilting armature levers l and m for two lines, viz., line No. 1 and line No. 2, Sheet 1, it being understood that, as I have already indicated, for a greater number of lines there would be additional armature levers and corresponding circuit connections and contacting brushes j j' for each line and that these armature levers would all be located in the same horizontal plane or tier directly below the rotating arm k and electro-magnets M^{10}, M^{11} carried thereby. For the purpose of preventing any possibility of interference in incoming signals I arrange several sets of these tilting armatures in independent planes or tiers above each other and connect the circuits thereof in multiple arc relation, as will be more fully described in connection with Figs. 12, 13 and 14, the arrangement being such that when any one subscriber has sent in a preliminary signal for the purpose of calling another subscriber, he, by the act of such preliminary signal tilts his own armature lever corresponding to the levers l or m on the first tier not in use, which is put in connection with his particular contact brush j through the contact strip f on the rotating drum D R of the percentage selector, thereby securing to himself the use of this particular portion of the apparatus for effecting the necessary circuit connections to the subscriber wanted. It must be understood in this connection that for every tier of the armature levers l, m there are corresponding spirally disposed strips f f', contacting rings h h, brushes i i and connecting wires similar to 92 and 108 leading to the individual tiers and corresponding radially disposed arms k carrying corresponding electro-magnets M^{10} and M^{11}, the radial relation of the strips f to the arms k being such as to always place the arms k over the tilting armature levers of a particular tier when the corresponding contact brushes j are directly in contact with the corresponding strips f, the relation of the strips f' and brushes j' for reversing the position of the armature levers being of course the same.

M^3 and M^4 are electro-magnets provided with armature levers m^3 and m^4 carrying contact springs s^{13} and s^{14}, the functions of these magnets and armature levers being to act as switching devices for preventing any other subscriber from obtaining control of the particular tier of tilting armature levers l and m after a signaling subscriber has obtained such control thereof. These switches, together with the peculiar disposition or arrangement of the contact-brushes j and strips f, act in conjunction in the nature of a non-interfering apparatus to prevent any possibility of inter-

ference of signals, and at the same time allow or permit other subscribers to seize their own tilting armature levers upon any other unused tier thereof and likewise prevent any interference therewith. This will be made more apparent in connection with the description of Figs. 12, 13 and 14.

M^5 and M^6 are electro-magnets having armature levers m^5 and m^6 which are adapted to lock and release at will, the armature levers m^3 and m^4 of the tier controlling switches.

The numerical receiver switch N' R' consists of a vertically disposed shaft carrying at its upper end an open sided pocket B and an inclined pair of arms A and is adapted to rotate step by step in the direction of the arrow under the influence of the armature lever m^9 and its propelling pawl.

0^R, 1^R, 2^R, 3^R, 4^R, 5^R, 6^R, 7^R, 8^R and 9^R are radially disposed inclined pairs of rails, runways or chutes with their upper ends so located that the pair of rotating arms A will fall in alignment therewith as it moves step by step in the direction of the arrow.

S H is a chute and B^2 B^2 are metallic balls resting normally upon this chute, the lower end of which is so located that said balls will, when released, drop into the pocket B and roll down over the arms A, see Figs. 4, 8 and 9, and that particular pair of rails 0^R to 9^R opposite which the free ends of said arms are located.

E is an elevator for the balls B^2 B^2 shown in detail in Fig. 9, said elevator consisting of a pair of driving pulleys W and W', an elevator carrying pockets P O for the balls and arms V adapted to tilt a ball separating device T as they pass under the free end thereof, thereby dropping them one by one into the pockets P O, the elevator being driven by a belt f^2 e^2 and an electric motor E^2 M^2.

q' q' are ball retaining and ejecting devices for the balls, said devices being carried on the free ends of armature levers of electro-magnets Q' Q' which are so arranged that when the electro-magnets are energized one of them will be lifted and the other lowered, always causing the balls to be received and ejected in pairs.

Although I have shown a system of ten individual tracks from 0^R to 9^R inclusive I have only shown three complete sets of tracks running to the switch board, near the bottom of Fig. 6, Sheet 6, and two complete sets of apparatus which I shall now describe as "call accumulating devices" designed to store up or retain any incoming call provided the person called is busy, or his line in use. These two lines with the complete apparatus I have designated as 1^R and 2^R and the third line as 3^R the operation for the entire apparatus for the remaining lines to 9^R being identically the same.

The call or signaling accumulating apparatus shown in Fig. 4, and which I shall for the sake of brevity denominate as "accumulators," consists in each instance of a spirally disposed side track shown in connection with line 1^R as R' S' and in connection with line 2^R as R^2 S^2. All of the tracks, runways or chutes have an inclination from the points of radiation near the free rotating ends of the arms A to the switch board in Fig. 6 of sufficient inclination to carry the circuit controlling balls B^2 B^2 by their own gravity. The accumulators or side tracks R' S' and R^2 S^2 are located above the main tracks and at such a height as will permit any ball running over a main track to pass freely under them. Just in front of these side tracks, and constituting in each instance a mechanical switch, is a tilting sectional track or gate R' or R^2 adapted, when resting in its lower position, to direct the balls over the main track, and when in the upper position, as shown in dotted lines in Fig. 8, to switch them from the main track on to the accumulator or side track R' S' or R^2 S^2, each track, as before indicated, being provided with a similar apparatus.

O' and O^2 are electro-magnets for lifting the mechanical switches or gates R' R^2 from their lower to their upper positions, and N' N^2 are releasing magnets having hooked armature levers n' and n^2 adapted to lock said gates in their upper positions and to release the same when the magnets N' N^2 are energized. The other ends of these side tracks or accumulators R' S', R^2 S^2 have each a sufficient down grade to carry the balls back again on to the main track when released and to thereby allow them to proceed over such main tracks to their destination.

P' P^2 are electro-magnets for operating the ball retaining and ball ejecting devices p' p', p^2 p^2 of these accumulators or side tracks.

Referring now to Fig. 5, Sheet 5, S W and S' W' are what I call "individualizing switches." The accumulators or side tracks have short disconnected sections of rails as shown in Fig. 4 on their outer tracks at $1^{r'}$, $2^{r'}$, $3^{r'}$, $4^{r'}$ and $5^{r'}$ and 1^{r2}, 2^{r2}, 3^{r2}, 4^{r2} and 5^{r2} which are connected by conductors 47, 48, 49, 46, 51, 50, 52 and 53 respectively with other circuit connections to be described later on. In a similar manner one set of the rails of the main tracks 1^R, 2^R, &c., is divided in each instance into short sectional disconnected conductors 1^s, 2^s to 11^s, see Figs. 5 and 6, and these short sectional conductors are connected by individual conductors to different parts of the apparatus. The sections of track 1^s, 2^s, 3^s, 4^s and 5^s, shown in Fig. 5, are connected directly back to the apparatus shown in Figs. 4, 1 and 2, without any intermediate switching apparatus, while the remaining short sections of track already referred to, both on the accumulators R' S', R^2 S^2 and 1^s of Fig. 5, and 6^s, 7^s, 8^s, 9^s, 10^s and 11^s of Fig. 6 are connected directly with what I call the "individualizing switches" S W, and S' W' at the top of Fig. 5. Each subscriber's line is provided with one of these individualizing switches and two are shown in Fig. 5 as applicable to the two individual telephone lines shown in Fig. 1,

Sheet 1. Each one of these switches performs four functions as follows: First, it makes circuit connections whereby any signaling subscriber is automatically warned that the circuit closing balls B^2 B^2, which he has already automatically released at the central station for the purpose of connecting the line of the subscriber signaled with his own line, have been diverted to the accumulator or side track of the person signaled; second, it establishes additional circuit connections whereby the calling subscriber may, if he so chooses, restore his individual portion of the switching apparatus at the central station to normal condition so that he may call any other subscriber or any other subscriber call him; third, it effects additional circuit connections whereby the calling subscriber, after his circuit controlling balls have been released and diverted to the side track or accumulator of the subscriber called and wishes to await his turn for connection to the line of such subscriber, has his apparatus placed in the same condition in which it was placed just previous to the time of the diversion of such balls to the accumulator; fourth, it effects additional circuit connections whereby the call bell of the subscriber signaling is caused to be rung from any track over which the circuit closing balls may have been directed, thereby indicating to him that the proper connections have been established and he may proceed with his conversation. These several sets of circuit connections are effected by multiple sliding contacts insulated from each other and attached to the armature levers of the switching magnets referred to and through individual pairs of contact springs, as clearly indicated, and additional stationary contacts connected respectively to wires 60, 61, 62 and 67.

The switch board proper to which all incoming telephone wires are ultimately connected is illustrated near the bottom of Fig. 6 as applicable to three individual lines and consists of horizontally disposed pairs of disconnected contact plates $c\ p$, $c'\ p'$, there being shown eight such pairs of contact plates connected together by cross connecting wires in substantially the same manner as well known forms of cross connecting switch boards are designed, these contact plates being borne by short arms P t secured to pivoted shafting S h and S′ h', S^2 h^2, S^3 h^3, the normal condition of these pivoted supporting arms being horizontal, in which position they are held by retractile springs as clearly shown on the right near the bottom of Fig. 11, the arrangement being such that when the balls B^2 B^2 are released in pairs they will be directed to the proper switch board plates $c\ p$ and $c'\ p'$ and ultimately make the required connections between such plates for the calling and called subscribers' lines.

The runways, chutes or tracks 1^R, 2^R, 3^R, &c., are horizontally disposed directly over the switch board and are provided with pivoted sections T S, T′ S′ which are capable of assuming either of two positions shown in Fig. 11. When in their lower position they carry the switching balls B^3 B^2 forward and when in their upper position, as shown on the right in Fig. 11, they permit them to drop into circuit connection with the proper circuit connecting plates $c\ p$ and $c'\ p'$, there being one such tilting cross section of track T S, T′ S′ for every transverse section of the switch board thereby making it possible for any pair of balls to be directed to any portion of the switch board and dropped into the proper circuit connections as directed by the signaling subscriber.

M^{17} and M^{20} are electro-magnets having armatures m^{17} and m^{20} attached to the short arms of the pivoted track sections T S and T′ S′, the arrangement being such that when either one of said electro-magnets is energized its corresponding track section will be elevated, as shown on the right near the bottom of Fig. 11.

M^{18} and M^{21} are releasing electro-magnets having armature levers provided with hooked extensions adapted to retain said sections in their elevated position until the corresponding electro-magnets M^{18} or M^{21} are energized.

M^{19} and M^{22} are releasing electro-magnets having armatures m^{19} and m^{22} attached to the pivoted supporting arms P t and P t, the arrangement being such that when said magnets M^{19} and M^{22} are energized the circuit closing balls B^2 B^2 will be released and allowed to return by a return runway or chute R R, as shown at the bottom of Figs. 9 and 11, and also near the bottom of Fig. 4 where they return by gravity to an elevator and are restored to their normal position.

At the top of Fig. 6, Sheet 6, is shown a general recording apparatus R E consisting of a rotary cylinder carried by a pair of upright standards on a car C A having movement in the direction of the length of the cylinder. This recording apparatus is moved longitudinally through the agency of a ratchet wheel R w and a pawl carried by an armature lever m^{27} actuated by an electro-magnet M^{27}, the ratchet wheel being carried by a worm shaft adapted to give the car the necessary movement and at the required speed, said ratchet wheel being stepped forward once in twenty-four hours through the agency of the electro-magnet M^{27} in circuit 68, 69, controlled by a twenty-four hour clock C K and a battery B^2 A^2 seen in Fig. 7, Sheet 7.

M^{30} is an electro-magnet having an armature lever m^{30} provided with a pawl adapted to rotate the recording cylinder R E once in twenty-four hours through the agency of the ratchet wheel R′ w', the electro-magnet M^{30} being in circuit 70, 71 controlled by a clock C′ K′ which closes the circuit from a battery B^3 A^3 three times in each revolution or once in every twenty seconds.

M^{28} and M^{29} are the recording electro-magnets, the former for subscriber's line No. 1 and the latter for subscriber's line No. 2, the arma-

ture levers m^{28} and m^{29} being provided at their free ends with recording needles adapted to prick or otherwise make a record upon a record paper carried by the rotating cylinder R E, it being understood that there would be as many recording electro-magnets with recording armature levers as there are subscribers' lines, the circuit connections being from the electro-magnets M^{28}, M^{29}, &c., to and through the automatic releasing mechanism and so arranged that ordinarily a call will only be recorded after circuit connection is actually effected between two subscribers.

The apparatus so far described and shown is applied to a system of ten lines of runways or chutes running from 0^R to 9^R inclusive, as shown in Fig. 4, Sheet 4.

In order to show the application of my invention to a system of more than ten subscribers' lines, I have illustrated in diagrammatic view in Figs. 8^a and 8^b, a system of ball runways or chutes and accompanying attachments adapted for use with ninety-nine subscribers' lines, without, however, showing the circuit connections running back to the subscribers or forward to the switch board, the releasing electro-magnets for the numerical receiving switches or the circuit connections in general running to the individualizing switches, &c., these two figures of the drawings being in the nature of a skeleton illustration of the portion of the ball conveying runways or chutes only with their accompanying numerical receiver switch arms and pivoted runways.

The two sheets of drawings upon which Figs. 8^a and 8^b are found should be laid side by side in order to understand the arrangement of parts referred to.

The electro-magnets M^9, four in number, one in Fig. 8^a and the other three upon Fig. 8^b are the counterparts of the propelling electro-magnet M^9 which propels the numerical receiver switch N′ R′ illustrated in Fig. 4, and the rotating switch arms A in each instance are propelled by the armature levers m^9 in the same manner as were the like parts propelled in connection with the receiver switch referred to.

When the system of subscribers' lines extends beyond ten, it is necessary that the numerical receiver switches should make circuit connections forward to corresponding numerical receiver switches in sequence, in order that the rotating arms of such numerical receiver switches may be rotated to the proper connections for conveying the circuit connecting balls B^2 B^2 to their destination. In the first numerical receiver switch N′ R′ therefor one of the arms A is a conducting arm carrying a contact spring adapted to make electrical contact with any one of a number of corresponding fixed electrical contacts x' to x^9 inclusive according to its radial position, said fixed contacts being in turn connected by electrical conductors through the outlying propelling electro-magnets M^9 of the corresponding numerical receivers, there being shown for the sake of clearness, only three such connections running by wires 110, 140 and 170 to each of the electro-magnets shown on Fig. 8^b and having a common return conductor 29. The stationary section of runways or chutes 0^R to 9^R inclusive at the numerical receiver switch N′ R′ are the same as in Fig. 4, but to the outer ends of these stationary sections are pivotally attached ten movable sectional runways or chutes S R united together by a segmental strip L C having sliding bearings U, the opposite ends of said segmental strip being attached directly to armature levers a m and a' m' of switch controlling electro-magnets S′ M′ and S^2 M^2, the function of which electro-magnets, segmental strip and armatures is to place the outer ends of the ten pivoted sectional runways or chutes in alignment with either of two sets of stationary runways or chutes 0^R, 1^R, 2^R, to 9^R inclusive or 10^R, 20^R, 40^R, 70^R to 99^R, the arrangement being such that if the sectional switch rails are in the position shown in full lines any pair of circuit connecting balls traveling on the chutes 0^R to 9^R will make circuit connections at the switch board with any line from 1 to 9 inclusive in the same manner as shown in connection with Figs. 4, 5 and 6, while if said pivotal sectional rails be in the position shown in dotted lines any pair of balls running down the chutes 0^R to 9^R will be diverted to the corresponding stationary runways or chutes running from 10^R to 99^R on Fig. 8^b.

I have shown for the sake of simplicity only three stationary sets of runways or chutes running to numerical receivers adapted to convey circuit connecting balls over runways to the switch board as follows, namely: for any subscriber's line from 10 to 19 or from 40 to 49 or from 70 to 79 the stationary runways or chutes opposite the corresponding rotary switch arms A, Fig. 8^b, having stationary continuations in the nature of runways as are found for the like parts at the outer ends of the stationary runways 1^R to 9^R inclusive, Fig. 4.

Referring now to Fig. 8^a and particularly to the electro-magnetic mechanism and circuit connections for operating the numerical receiver N′ R′, N S is a numerical separator or time relay which is a duplicate of the time relay shown at the top of Fig. 4, and the reed m^{17} thereof is adjusted like the reed m^7 in Fig. 4 to vibrate for a definite time for each electrical impulse passing through the electro-magnets M^{17}. An additional time relay T R identically like the time relay T R shown in Fig. 4 is placed also in the same circuit with the electro-magnet M^{17} of the numerical separator for the purpose of releasing and ejecting the circuit connecting balls B^2 B^2 in the same manner as the latter function is performed in connection with the electro-magnets Q′ Fig. 4.

When the number of subscribers' lines is more than nine it becomes necessary to pro-

vide a numerical separator with each series of numerical receivers of the higher orders in some such manner as was shown and described in my prior application. In that application I provided a clock mechanism which operated through circuit connections, numerical receivers step by step in connection with each of the higher orders of numerical receivers. In the present invention I have done away with this clock mechanism and substitute therefor an individual numerical separator for the first one hundred lines of the system, ten additional numerical separators for one thousand lines and one hundred additional numerical separators for ten thousand lines, making all told one hundred and eleven (111) such instruments in a system of ten thousand subscribers' lines.

S M, Fig. 8[a], is a switching electro-magnet adapted to act on a switching armature lever *s m* and transfer circuit from the incoming conductor No. 30 to and through conductor 109 through one of the numerical receiver arms A and with that one of the conductors 110, 140, 170, &c., with which the contact spring carried by said arm may be in contact.

R M is a release electro-magnet provided with a locking armature *r m* adapted to lock the armature lever *s m* of the switch magnet S M in its upper position and to release it, and is in the same circuit with the releasing magnet to the numerical receiver N′ R′ not shown in this figure of the drawings but shown as M^{12} in circuit 44 in Fig. 4 of the drawings. It will be understood also that the circuit 44 in this instance includes the switching magnet S^2 M^2, the armature of which is adapted to move the pivoted runway rails S R, S R, to their normal positions.

I will now describe the mode of operation of the apparatus illustrated in Figs. 1 to 9 inclusive, Sheets 1 to 7 of the drawings, assuming first that No. 2's circuit is not in use. I will then describe the operation of the apparatus upon the assumption that No. 2's circuit is in use and that the circuit controlling balls of No. 1 released by his preliminary signal have been stored upon the accumulator or side track of No. 2 shown in Fig. 4 of the drawings, and that they are afterward released by No. 2 when he rings off his connection with the subscriber with whom he was first engaged and that they then run forward to their destination and automatically connect the two lines together and ring the call bells of both subscribers.

Subscriber No. 1 causes a single current impulse to be transmitted from battery *b′ a′* to the central station through the armature lever *b′* of the electro-magnet B′, through switch spring *s′*, conductor 98, armature lever *f′*, switch spring s^5, conductor 100, relay electro-magnet A′, conductor 100, switch spring s^2, armature lever *c′* of electro-magnet C′, back by his return wire to his own instrument. This causes the armature lever *a′* of the relay electro-magnet A′ to be drawn forward and a single current impulse is sent from his own relay battery b^3 a^3 by way of conductor 35, through the armature lever j^5 of electro-magnet J′ at the top of Sheet 2, contact spring s^9, conductor 33, branch conductor 103, electro-magnet L′, branch conductor 103, conductor 36, back to the starting point, thereby causing the armature lever *l′* of the electro-magnet L′, Sheet 2, to be drawn forward so that the contact spring s^{11} on the free end thereof is transferred from connection with conductor 43 to connection with conductor 41; at the same time the locking armature lever *m′* of the release electro-magnet M′ is allowed to fall behind the free end of the armature lever *m′* and lock it in its uppermost position where it was just left. At the same time that the current impulse just referred to was transmitted through conductor 103 and electro-magnet L′, Sheet 2, a divisional branch of the current passes directly over conductor 33 through Sheets 3, 4, 5 and 6 to electro-magnet M^{20} at the bottom of that sheet, returning by conductor 15 to and through electro-magnet O′ near the center of Sheet 4 of the drawings, thence by conductor 15 to and through Sheets 3, 2, to conductor 103 where it joins conductor 36 and returns to the battery b^3 a^3, Sheet 1. This second divisional current impulse therefore energizes the two magnets referred to, acting first upon the armature m^{20} attached to the shaft S *h*, see Fig. 6, which carries all of those track sections lying over subscriber No. 1's contact plates with which all other subscribers' wires are cross connected, thereby holding all of No. 1's track sections T S in an elevated position so as to admit of the reception of the circuit controlling balls B^2 B^2 when they shall have reached their particular runway or chute, corresponding in number to the subscriber signaled, in this instance, No. 2. The same current impulse, as just noted, energized the electro-magnet O′, see Figs. 4, and 8, thereby causing the mechanical switch or gate of runway 1^R of subscriber No. 1 to be elevated into the position shown in dotted lines in Fig. 8, thereby disconnecting the main track runway or chute 1^R and providing a shunt path on to the accumulator or side track R′ S′ for the admission of any circuit controlling balls B^2 B^2 which may be released by any additional subscriber who shall call subscriber No. 1 either while he is turning in his signal for subscriber No. 2 or during the time that his, subscriber No. 1's, line is in connection with the line of subscriber No. 2 or that of any other subscriber, the object of this portion of the apparatus being to prevent the possibility of any circuit connecting balls making any circuit connection between his, subscriber No. 1's, line and that of any other subscriber until he is ready to have such connection effected.

I will return to the description of the operation of this apparatus later and describe what disposition is made of any circuit con-

necting balls which are stored on the accumulator or side track. The action of the apparatus so far has put the mechanism at the central station which controls the movement of the circuit controlling balls B^2 B^2 in such a position that no one can release additional circuit controlling balls and cause them to interfere in any manner with subscriber No. 1 until he is ready to receive any such signal.

When the armature lever m^{20} was drawn down or tilted, the shaft S h, as already described, caused the free end of the contact spring s x to be drawn down into contact with a second yielding contact s p, thereby closing an electrical circuit from battery B^5 A^5 as follows: by conductor 59, shaft S h, spring s x, spring s p, conductor 62, electro magnet M^{24}, at the top of Fig. 5, conductor 62, contact spring carried by armature lever m^{24} of electro-magnet M^{24}, conductor 59, thence back to battery B^5 A^5, Sheet 6. This causes the individualizing switch S W to be drawn to the right, thereby establishing several circuits between conducting springs and contact plates and simultaneously rupturing the circuit of battery B^5 A^5 between the contact spring carried by armature lever m^{24} and the contact point connected to conductor 62 and re-establishing a new but temporary open circuit through said spring by a contact point connected to conductor 61. The several functions of the individualizing switch S W will be described in their proper sequence as the operation of the apparatus advances. At this point that portion of the apparatus which I call the "percentage circuit selector" P C shown at the bottom of Sheet 3, is brought into play. This percentage circuit selector, it will be understood, is constantly driven by an electric motor E M or other constant source of power, and the arm k carried by the vertical shaft v s is constantly rotated in the direction of the arrows from left to right.

Returning now to Sheet 2 of the drawings: The next step in the operation of the apparatus in the order of description, which is also simultaneous with the steps just described, is traceable to what I call the "percentage switch" governed by the electro-magnet L' and the movement of its armature l', the free end of which latter, it will be remembered, was moved as already described so that the contact spring s^{11} is now in connection with conductor 41 instead of conductor 43 its normal position as now shown in the drawings. In this locked position of the switch therefore battery B A is brought into play at such time as the cylinder D R of the percentage circuit selector shall have reached such a position with the contact brush j corresponding to the line of subscriber No. 1, which in this instance is connected to circuit 41 shall have made contact with the spirally disposed conducting strip f, while at the same time the radial arm k which carries the electro-magnets M^{10} and M^{11} shall have arrived at a point directly over the tilting armature l which is designed to connect a circuit directly from the relay battery b^3 a^3 of the line of subscriber No. 1 to the electro-magnet M^9, Sheet 4, of the numerical receiver switch in order that subscriber No. 1 may transmit the necessary sequence of current impulses from his relay battery b^3 a^3 and advance the arms A of numerical receiver N' R' to the stationary runway 2^R which is to guide or carry the circuit controlling balls B^2 B^2 when released to their ultimate destination. The circuit from battery B A is therefore traceable as follows: by conductor 20 to armature lever l', spring s^{11}, contact plate p^{11}, conductor 41, electro-magnet J', conductor 41, releasing electro-magnet M', conductor 41, thence to the left hand contacting brush j^2 the free end of which rests upon drum D R, thence through the spirally disposed strip f on the supposition of course that the cylinder has advanced to such a position as will make the contact referred to, thence through conductor 94 to the insulated conducting ring h carried by the shaft S, thence through brush i, conductor 92 and contact brush s^{19} to insulating conducting ring 1^r, see also Fig. 10 of the drawings, thence through upper conductor 92 to the outer electro-magnet M^{10} borne by the arm k, thence through lower conductor 92 to the central ring 2^r, thence by brush s^{17}, thence by conductor 28 to Sheet 4, thence through contact spring s^{13} and the armature lever m^3, thence through conductor 20 and electro-magnet M^3, thence by conductor 20 back through Sheets 2 and 1 to the starting point. This current impulse therefore first energizes the electro-magnet J' elevating the free end of its armature lever j^5 so as to place the contact spring s^9 in connection with conductor 38. At the same time the armature lever k' of the releasing electro-magnet K' drops behind the free end of the lever j^5 and locks it in the uppermost position. The same current impulse energized the releasing electro-magnet M' causing armature m' to be drawn forward thereby releasing the armature lever l' of the percentage switch and allowing it to be returned to its normal position so that the contact spring s^{11} is again in contact with circuit 43 as now shown. The same current impulse energized the electro-magnet M^{10} carried by the arm k at the instant that it was directly over the tilting armature l thereby causing said armature to be tilted in the reverse position to that now shown in Fig. 10, thus establishing new circuit connections for circuits 35 and 36, which circuit connections will be traced later on. The same current which energized the magnet M^{10} as just described energized the electro-magnet M^3 at the upper right hand side of Sheet 4, thereby causing the armature lever m^3 thereof to be drawn into its uppermost position and by that act automatically rupture the circuit just described between the contact spring s^{13} and the conductor 28. As the armature lever m^3 was drawn into its upper position, however, the armature lever

m^5 of the releasing electro-magnet M^5 fell behind the free end of the former armature lever and locked it, leaving the circuit of battery B A ruptured as described. The circuit of the relay battery b^3 a^3 of subscriber No. 1 has now been connected directly with the electro-magnets M^9 and M^7 of the numerical receiver and of the time relay shown on Fig. 4 of the drawings, so that he, subscriber No. 1, may now transmit the necessary number of current impulses to step forward the arms A of the numerical receiver into alignment with the runway or chute 2^R of subscriber No. 2 and at the same time automatically release the circuit connecting balls B^2 B^2 in the chutes S H after the arms have reached this point. In order to step the arms A of the numerical receiver switch forward to the runway or chute 2^R to subscriber No. 2 three electrical impulses are necessary; subscriber No. 1 therefore transmits three such impulses from his battery b' a' which in the same manner as before described actuate his relay A' and caused three impulses to be sent forward to the electro-magnets M^9 and M^7, Fig. 4, by the following circuit: starting from battery b^3 a^3 through the armature lever a', conductor 35, armature lever j^5 of electro-magnet J', which it will be remembered is locked in its upper position by the armature k', contact spring s^9, contact point p^9, conductor 38, thence to the left hand or rear contact point u, Fig. 3, thence by the rear one of a pair of contact springs s^{20} carried by the armature l to an insulated conductor 104 carried also by the armature lever, thence to the rear one of a pair of contact springs s^{21} carried at one end of the armature lever l and now in contact with a fixed contact z attached to conductor 29, thence by conductor 29 to electro-magnet M^7 of the time relay, thence through electro-magnet M^9 of the numerical receiver switch, thence by conductor 30 to the front one of the contacts z, thence by the front one of the contact springs s^{21} carried by the armature lever l, thence by conductor 105 to the front one of the conducting springs s^{20} carried on the free end of the armature lever l, thence by the remaining one of the stationary contacts u, thence by conductor 36 back to the starting point. The transmitted impulses therefore from the battery b^3 a^3 energize the electro-magnets M^7 and M^9, causing the armature lever m^9 of the latter electro-magnet to impart a rotary motion through the agency of a ratchet wheel on the shaft which supports it to advance until the arms A are in alignment with the stationary section of track 2^R. At the same time the continued action of the electro-magnet M^7 upon the reed armature m^7 caused said reed to vibrate back and forth, thereby imparting to the sliding pin p a vertical movement through the agency of the non-conducting head c which rests upon the upper side of said reed. Consequently the upper conducting head b carried by the pin p was lifted into its uppermost position until its shoulder was raised above the sliding conducting bar a thereby allowing the latter to be moved slightly to the left under the influence of the retractile spring attached to the armature lever m^8 of the releasing electro-magnet M^8. When this shouldered head b was lifted, as described, it was brought into direct contact with the yielding spring or arm s^{16}, thereby closing the circuit of battery B' A' through conductor 91 and between the spring s^{16}, the conducting head b and the sliding bar a. The act, however, of setting the vibrating reed m^7 in motion caused the shouldered head b to be locked in the uppermost position and to simultaneously and intermittently interrupt the circuit of the battery B' A' between the now vibrating contact e at the free end of the reed m^7 and the yielding contact spring s^{15} so that as long as this reed m^7 continues to vibrate the battery circuit B' A', although closed between the yielding spring s^{16} and the sliding bar a is now intermittently interrupted between the points e and the spring s^{15} in such rapid succession that the battery B' A' will be ineffective so long as this vibration continues. When therefore the reed settles to its normal position after the last impulse is transmitted the circuit of battery B' A' will be closed as follows: By conductor 91, spring s^{16}, conducting head b now locked in its uppermost position by the free end of the bar a resting under the shoulder of said head, through the bar a, thence through the now stationary reed m^7, contact point e, yielding spring s^{15}, conductor 91 to and through the electro-magnets Q' Q', thence by conductor 91 through a releasing electro-magnet M^8. The result therefore of this closure of the circuit of the battery B' A' is that the electro-magnets Q' Q' are both energized, thereby causing their armature levers q' q' to be moved in opposite directions so that the one next to the open sided pocket B is raised out of the path of the balls B^2 B^2 and the one behind said pair of balls is drawn down, thereby bringing the wedge shaped edge of the ejecting lever, shown more clearly in Fig. 9, into frictional relation with the rear ball and giving to both balls an impetus to start them on their journey. At the same time the electro-magnet M^8 being energized its armature m^8 caused the sliding bar a to be drawn forward, thereby releasing the shouldered head b and allowing it and the sliding pin d to drop into their lower position, so that one edge of the shouldered head locks the sliding bar in the forward position shown, while the other edge of said conducting head is left out of electrical contact with the yielding spring s^{16} and the circuit of the battery B' A' again ruptured at this point the insulated head c resting as shown upon the upper surface of the reed m^7. The instant that the circuit of the battery B' A' was ruptured between the spring s^{16} and the sliding bar a therefore the two electro-magnets Q' Q' which control the

ball retaining and ball ejecting levers q' q' were demagnetized, thereby allowing them to assume their original position so that the one next the open sided pocket is again in position to check the next pair of balls which will now run down the chute S H into position, the ejecting lever q' being again in position to perform its function as before, when actuated. The circuit connecting balls B^2 B^2 have now been set in motion and pass by their own weight down the inclined arms A on to the runway or chute 2^R passing over the accumulator switch or gate R^2 which is now in its lower position so that they pass directly under the accumulator or side track R^2 S^2 of subscriber No. 2 and on to the continuation of the runway until they reach a point shown at the extreme left hand of Fig. 5 where they close an electrical circuit from a short section of the track 1^s on one side and the other or continuous track 2^R on the other side by conductors 83 and 84 in opposite directions. As the circuit just described is utilized only when the connecting balls have been first diverted to the accumulator or side track it will be unnecessary to further describe its function here. At the same time that the balls are passing over the short section 1^s an additional multiple arc branch circuit is closed to the magneto generator as follows: Passing downward by conductor 44 to the bottom of the sheet, thence to the left through Sheet 4, thence upward through the releasing electro-magnet M^{12} of the numerical receiver switch, thence upward through conductor 44 to the top of the sheet, through the releasing electro-magnet M^6, thence by conductor 44 to conductor 4 located directly under electro-magnet M^6, thence to the right through Sheets 4, 5 and 6 to one pole of the magneto generator, thence through conductor 45 to the bottom of Sheet 6, thence to the left through Sheets 6 and 5 to conductor 84, thence upward through the continuous main rail 2^R through the balls. This current from the magneto generator therefore causes the electro-magnet M^{12} to actuate its armature lever m^{12} which is provided at its free end with a retaining pawl and is operatively connected by a cord passing over a pulley with a propelling pawl carried by the armature m^9. Consequently when these pawls are released the arms A of the numerical receiver are returned to their normal position under the influence of a spring or weight in the same manner as the corresponding parts are restored in the invention disclosed in my prior application. The same current impulse from the magneto generator caused the releasing electro-magnet M^6 to withdraw the locking armature m^6 from beneath the armature lever m^4 of the electro-magnet M^4, thereby establishing an electrical contact between the spring s^{14} carried on the free end of this armature lever with a conductor 87.

For the present we will leave the balls B^2 B^3 upon the section 1^s and trace the operations of that portion of the apparatus affected by the two switches controlled by the four electro-magnets M^3, M^4, M^5 and M^6 at the top of Sheet 4.

Reverting now to the percentage circuit selector at the bottom of Sheet 3 it will be found that the movement of the armature lever m^4 and the contact spring s^{14} last affected and seen near the top of Sheet 4 will put the circuit 27 running to the percentage circuit selector in such relation to it that one of the contact brushes j', namely, that one connected to the circuit 43 and belonging properly to the central station apparatus of subscriber No. 1 will be in position to effect certain operations from the battery B A on Sheet 2, whereby the armature lever l which permitted subscriber No. 1 to obtain control of the numerical receiver switch will be returned to its normal position so as to allow the circuit selecting apparatus to be used by other subscribers. This is brought about as follows: When the drum D' R' advances in the direction of the arrow so that the left hand brush j' comes into contact with the spirally disposed contact strip f' a circuit is closed from the battery B A as follows: by conductor 20, armature lever l', spring s^{11}, conductor 43, left hand brush j', strip f', conductor 95, insulated ring h, left hand contact brush i, conductor 108, brush s^{18}, insulated conducting ring 3^r, see also Fig. 10, conductor 93, inner left hand electro-magnet M^{11} carried by the radial arm k, thence through a conducting spring t carried by the same arm and having electrical contact with the upper ends of a series of contact plates e p, thence through that one of said contact strips which lies directly opposite the ends of the armature lever l and thence through a conducting spring s^{22} carried by the armature lever, it being understood that this armature lever is now in the reverse position from that shown in Fig. 10, so that the upper end of the contact spring s^{22} bears on the enlarged lower end of that one of the contact plates e p through which the current came; thence directly through the armature lever to the pivot point s of the armature and by conductor 27, through the electro-magnet M^4 at the top of Sheet 4, thence through the armature lever m^4 and contact spring s^{14} carried thereby, thence through the lower contact point which is connected to conductor 87, thence through the release electro-magnet M^5 at the right of Sheet 4, thence downward through conductor 87, through conductor 20, thence to the left through Sheet 3 back to the battery B A completing the circuit. This current impulse therefore energizes the electro-magnet M^{11} on the inner end of the arm k and restores the armature l to its normal position as shown in Fig. 10. The same current impulse caused the electro-magnet M^4 at the left and top of Sheet 4 to restore the armature lever m^4 to its normal position where it is locked by the armature lever m^6 of the release electro-magnet M.

The same current impulse energized the release electro-magnet M^5 on the right and at the top of Sheet 4, and allowed the armature lever m^3 of the electro-magnet M^3 to return to normal position with its contact spring s^{13} in connection with circuit 28, thus leaving the percentage circuit selector and its circuit connections free for use by any other subscriber. Having restored the percentage selector and its circuit connections to normal position where they may be used independently by other subscribers we are now prepared to return to the circuit connecting balls which were temporarily left moving over the section 1^s of the runway 2^R. They pass onward to a second short section of track 2^s where they close a new circuit to and through the magneto generator and other apparatus as follows: upward by conductor 81 to conductor 8, thence to the left through Sheets 4, 3, 2 and 1 to electro-magnet B^2 of the apparatus of subscriber No. 2, thence through electro-magnet E^4, thence upward to conductor 4, thence to the right through Sheets 2, 3, 4, 5 and 6 to the magneto generator, thence through conductor 45 to the bottom of Sheet 6, thence to the left through Sheets 6 and 5 to conductor 84, through the continuous track to the starting point, through the traveling conducting balls. This current impulse therefore placed the free end of the armature lever b^2 of the electro-magnet B^2 of the apparatus of subscriber No. 2 in its upper position so that the contact spring s^3 carried thereby is now placed out of contact with circuit No. 99 and into contact with circuit No. 4 preparatory to the ringing of his call bell by the passage of the traveling conducting balls over the next section of the runway of chute. As these balls pass therefore upon this section 3^s they close another circuit as follows: upward by conductor 80 to conductor 7, thence to the left through Sheets 4, 3, and 2, downward and to the left through Sheet 1, upward through conductor 101, thence to the extreme left of Sheet 1 where conductor 7 joins conductor 101, thence upward to and through contact spring s^4 carried at the outer end of the armature lever c^2 of electro-magnet C^2, thence out of the exchange station over the line of subscriber No. 2 through his call bell, not shown, backward through the return line to armature lever b^2, through contact spring s^3, contact point p^3 up and to the right through conductor 4, through Sheets 2, 3, 4, 5 and 6 to the magneto generator, thence downward to conductor 45 to the left, through Sheets 6 and 5 to conductor 84, thence upward to the continuous track 2^R and through the traveling balls. Consequently the call bell of subscriber No. 1 is rung during the time that the balls are passing over the short section of track 3^s. As the balls advance they pass from the short section 3^s on to the next succeeding short section 4^s and a fourth circuit is closed as follows: from the short section of track 4^s upward through conductor 6 to the left through sheets 4, 3, 2 and 1, to the left and upward through electro-magnet C^2 of the apparatus of subscriber No. 2, thence through conductor 6 to and through releasing electro-magnet D^2, thence upward through conductor 4 and to the right through the common return conductor to the magneto generator, thence downward by conductor 45 to conductor 84, Sheet 5, thence upward to the continuous track 2^R through the balls. The electro-magnet C^2 is therefore energized and the contact springs s^4 carried by the armature lever c^2 change their connection with 101 into connection with contact plate p^4 connected to the talking circuit 18. The electro-magnet D^2 was also energized and its armature d^2 drawn forward, thereby releasing armature lever b^2 changing the position of the contact spring s^3 from connection with circuit 4 running to the magneto generator into connection with circuits 99 and 31, the latter, 31, being a through talking circuit. The balls now pass on to the short section 5^s where a new circuit is closed to and through the magneto generator as follows: upward through conductor 79 to conductor 16, thence to the left through Sheet 5, thence to Sheet 4 downward and to the left, thence through electro-magnet O^2, thence upward by conductor 16 to the left, thence upward to the conductor 4 running to the magneto generator on Sheet 6, thence downward and to the left through conductor 45 and upward through conductor 84 to the continuous track 2^R through the balls. The energizing of the electro-magnet O^2 therefore caused the accumulator switch or gate R^2 to be lifted into a position corresponding to that shown in dotted lines in Fig. 8 so that any incoming signals for subscriber No. 2 from any other subscriber will be stored up until conversation between subscriber No. 1 and subscriber No. 2 is concluded, it being apparent that any circuit connecting balls which may be released by any other subscriber than No. 1 over the runway or chute 2^R, he the additional calling subscriber will now run on to the accumulator or side track of subscriber No. 2 and there be held in check by the ball retaining device p^2 until they are released, as will be described later on. The balls now pass on to a short conducting section 6^s at the left of Sheet 6 where another circuit is closed through the magneto generator to other apparatus, which circuit, however, it should be remarked is made dependent upon the individualizing switch S W which it will be remembered was moved to the right in the previous operation of the apparatus so that the contact spring m^{24} is in connection with circuit 61 and the several contact springs above and below in the switch itself are in electrical contact with the metallic sections of the switch. Bearing this in mind therefore the circuit is closed from section 6^s upward through conductor 57, thence to the left to the center of Sheet 5 where it joins conductor 52, thence upward

through conductor 52 through the extreme right hand spring of the individualizing switch S W, thence through the first metallic plate of the switch, thence through the lower right hand conducting spring, thence by conductor 11 to the left through Sheets 4, 3 and 2 to electro-magnet B′ of subscriber No. 1, Sheet 1, thence through electro-magnet E^3, thence by conductor 11, thence to the common magneto conductor 4 connected with the magneto generator Sheet 6, thence by conductor 45 to the bottom of Sheet 6 and upward by conductor 73 to the continuous track 2^R and through the conducting balls. The electro-magnet B′, Sheet 1, of the apparatus of subscriber No. 1 was therefore energized through the contact spring s' carried at the free end of the armature lever b' and changed from connection with conductor 98 into connection with the upper contact plate p' which in turn is connected directly with the common return conductor No. 4 running to the magneto generator on Sheet 6. This last act therefore of connecting the contact spring s' with the common return conductor 4 places the apparatus of subscriber No. 1 in condition for the ringing of his call bell as the balls pass forward to the next section of track. The circuit for effecting this ringing is therefore closed as the balls pass on section 7^s as follows: upward through conductor 56 to the left to the center of Fig. 5 where 56 joins conductor 50, thence upward to the second one of the upper contact springs of the individualizing switch S W, thence downward through the second conducting plate, thence through the second lower contact spring, thence by conductor 86 downward to conductor 10, thence to the left by conductor 10, through Sheets 3 and 2 to the center of Sheet 1 where conductor 10 joins conductor 100, thence upward by conductor 100, through contact spring s^2, armature lever c', thence through the call bell of subscriber No. 1, thence back to the office through the return wire to armature lever b', thence through contact spring s', contact plate p' to the common return conductor 4 connected with the magneto generator on Sheet 6, thence by conductor 45 back to Sheet 6, upward by conductor 73 to the continuous track of 2^R and through the conducting balls. The balls now pass on to the last short conducting section and another circuit is closed therefrom as follows: by conductor 55, to the top of Sheet 6, thence to the left to the center of Sheet 5 where they join conductor 51, thence upward by conductor 51, thence through the third one of the upper conducting springs of the individualizing switch S W, thence downward through the third conducting plate of that switch and through the third lower conducting spring by conductor 85 to conductor 9, thence to the left through Sheets 4, 3, 2, and 1, to and through electro-magnets C′ and D′ of the central station apparatus of subscriber No. 1, thence to the common return conductor 4 of the magneto generator on Sheet 6, thence by conductors 45 and 73 to the continuous track 2^R and through the balls. The act of energizing the electro-magnet C′ caused its armature c' to change the position of the contact spring s^2 from connection with circuit 100 into connection with circuit 19 at the point p^2, which plate in turn is connected to circuit No. 19 or the talking circuit of subscriber's line No. 1. At the same time the armature lever d' was drawn forward and the armature lever b' of the electro-magnet B′ released, allowing the contact spring s' to be restored to its normal position, thereby disconnecting the circuit running to the magneto generator and connecting it directly to the remainder of the talking circuit of No. 1. The balls finally pass under the free or elevated end of the pivoted section of track way T S which is held in that position, it will be remembered, by the hooked armature $s\,p$, this operation having been described in the early part of the specification. As the balls drop into their position upon the contact plates $c\,p$ and $c'\,p'$ one of them momentarily closes contact between two yielding contact springs $t\,e$ and an electrical circuit is closed from battery $B^5\,A^5$ as follows: by conductor 59 to yielding contact springs $t\,e$ and one of the balls, downward by conductor 77 to conductor 64, thence to the left to Sheet 5, thence upward by conductor 64 to the restoring electro-magnet M^{23} of the individualizing switch S W, thence downward by conductor 63, thence to the right, thence downward and again to the right to the center of Sheet 6, thence upward through electro-magnet M^{21}, thence downward by conductor 61 to the left to Sheet 5, thence upward and to the left and again upward by conductor 61 to the upper right hand contact plate to which said conductor is connected, thence through the spring carried by the armature m^{24} which spring it will be remembered was left in connection with that contact plate, thence by armature lever m^{24}, thence by conductor 59 to the right to Sheet 6, thence downward to the other pole of the battery $B^5\,A^5$. The individualizing switch S W was therefore restored to its normal position under the action of the electro-magnet M^{23}. The elevated section of the runway T S was released under the action of the electro-magnet M^{21} and its hooked armature lever m^{21} so that all of the elevated sections of track-way connected to the shaft S h have been restored to their normal or lower positions, thus allowing the passage of balls on other tracks than that of R^2 or R′ for making additional connections at points beyond. It is to be here observed that the short conducting sections 1^s, 6^s, 7^s and 8^s of the runways 1^R, 2^R, 3^R, &c., are all connected in multiple arc relation and that when the individualizing switch S W was returned to its normal position the passage of circuit closing balls on other tracks will not affect in any way the apparatus of subscriber No. 1 or the circuit established between subscriber

No. 1 and subscriber No. 2. The balls B^2 B^2 having found their way into contact with the contact plates c p, c' p' beneath the runway 2^R near the center of Sheet 6 the talking circuit is closed and an uninterrupted conversation may not be had between subscribers No. 1 and No. 2 and through the following circuit: passing by subscriber's line No. 1 to the armature lever b', thence through contact spring s', thence by conductor 98 to conductor No. 1, thence upward to the top of Sheet 2, through Sheets 2, 3 and 4 to the top of Sheet 5, thence downward and to the right through Sheet 5 to Sheet 6, thence up and to the right to a short cross connector which joins the left hand series of contact plates c p in pairs, thence downward, thence through one of the balls to the right hand contact plate c p of the left hand pair, thence through conductor 18 up and to the left to Sheet 5, thence to the left through Sheets 5, 4, 3, 2 and 1 through the electro-magnet G^2 of the automatic release, thence upward by conductor 18 to the contact plate p^4, thence through the contact plate s^4, armature lever c^2, thence out of the exchange station by subscriber's line No. 2 through his instruments, thence back through his return wire, through armature lever b^2, through spring s^3, thence downward through conductor 99 to conductor 31, thence to the right and downward to and through Sheet 2, through Sheet 3, through Sheet 4 and Sheet 5 and upward and to the right to Sheet 6 downward to the left hand contact plate t e of the right hand pair of plates, thence through the second ball, thence to the right hand plate c' p' of the second pair, thence upward and to the left by conductor 19, through Sheets 5, 4, 3, 2 and 1 to electro-magnet G' of the automatic release, thence upward by conductor 19, through contact plate p^2, contact spring s^2, armature lever c' out of the exchange station, through the return wire of subscriber No. 1 to the starting point. Both subscribers may therefore talk at pleasure without any fear of interruption from any other subscriber as no other subscriber can by any possibility obtain connection with the lines of either. When the conversation has concluded the subscribers hang their receiving telephones upon their hooks and either one of them may disconnect or ring off the circuit connections at the exchange system by transmitting a single current impulse over his line. When this is done the circuit impulse which is from one of the batteries b' a' or b^2 a^2, passes over the same circuit throughout the system as was used for the purpose of talking which circuit has just been described. In doing so the current impulse transmitted being from one or both of the batteries b' a' or b^2 a^2 and of greater strength than the currents used in talking will energize the two electro-magnets G' and G^2, Sheet 1, thereby lifting the armature levers g' g^2 so that the armature levers i' i^2 of the releasing electro-magnets will lock them in their upper positions. In these locked positions two local circuits are closed from batteries b^5 a^5 and b^6 a^6.

I will first trace the circuit from battery b^5 a^5 which is as follows: passing by conductor 5 through electro-magnet E', thence through conductor 5, through Sheets 2, 3, 4 and 5, downward to the bottom of Sheet 5, thence to the right on Sheet 6, downward and to the left through conductor 64, back again to Sheet 5, thence upward and to the left and again upward to electro-magnet M^{23} of the individualizing switch S W, thence downward by conductor 63 to the right, thence downward to the bottom of Sheet 5, thence to the right through Sheet 6, thence upward to and through electro-magnet M^{21}, thence downward through conductor 61 and to the left through branch 61^a to electro-magnet M^{22}, thence to the left through conductor 26 to Sheet 5, thence upward and to the right back again to Sheet 6, through the recording electro-magnet M^{28}, thence to the left through conductor 3, thence through Sheet 4, thence downward through electro-magnets P' of the accumulator apparatus R' S' of subscriber No. 1, thence to the left through the releasing electro-magnets N' of the accumulator switch or gate of subscriber No. 1, thence upward through conductor 3 to the top of Sheet 4, thence to the left through Sheet 3 to the top of Sheet 2, thence downward through releasing electro-magnet K', thence downward and to the left to Sheet 1 where it joins conductor 22, thence upward through the releasing electro-magnet H', thence to the left where it joins conductor 23, thence upward through releasing electro-magnet I', back through conductor 23, contact spring s^6, armature lever g', to the starting point or battery b^5 a^5. Electro magnet M^{21} was energized but for the present this need not be considered. Electro-magnet M^{22} was energized thereby causing the armature lever m^{22} to tilt the contact plates and their supports downward so that the balls B^2 B^2 will run by their own weight and drop upon the return runway or chute R R, as shown at the bottom of Fig. 11, ultimately returning to the elevator E shown in Fig. 9, where they are lifted one by one in pockets P O and returned to the upper chute S H shown in Fig. 4 for re-use. Electro-magnet M^{23} of the individualizing switch S W was also energized but this need not be noticed here. The electro-magnets P' of the accumulator R' S' were energized, but based upon the supposition that there were no balls standing upon this accumulator, this fact need not be noticed here. The releasing electro-magnet N' of the accumulator switch or gate R' running to the accumulator R' S' of subscriber No. 1 was released in order to place his runway in condition for the reception of incoming balls from other subscribers, seeing that he is now ready for additional calls. The recording electro-magnet M^{28} at the top of Sheet 6 was also energized, thereby causing the armature lever m^{28} and its marker

to make a record upon the paper carried by the revolving recording cylinder R E. The release electro-magnet K′ at the top of Sheet 2 was also energized drawing up the armature k' thereby releasing the armature j^5 of the electro-magnet J′ and allowing said armature to return to its normal position for the reception of other signals from subscriber No. 1. The release electro-magnet E′ at the top of Sheet 1 was also energized, thereby causing its armature lever to permit the return of the armature lever c' so that the contact spring s^2 is in direct connection again with its signaling relay A′ through circuit 100. The releasing electro-magnets H′ and I′ were energized thereby causing the locking armatures h' and i' to release the armature levers f' and g' thus restoring the complete circuit connections to the signaling relay for subscriber No. 1 and automatically rupturing the circuit of battery b^5 a^5. Returning now to the other battery b^6 a^6 and its circuit connections (they are traceable as follows) it being remembered that the armature lever g^2 was left locked in its upper position by the armature lever i^2 of the electro-magnet I^2, the current passes from battery b^6 a^6 by conductor 2 through the releasing electro-magnet E^2 at the top of the sheet, thence to the right by conductor 2 to the releasing electro-magnet K^2 through conductor 2 at the top of Sheets 2, 3 and 4, thence downward through electro-magnets P^2 of the accumulator apparatus R^2 S^2 of subscriber No. 2, thence through the releasing electro-magnet N^2 of the switch or gate R^2, thence to the right and upward to the top of Sheet 4, thence to the right through Sheet 5 to the top of Sheet 6, through the recording electro-magnet M^{29} of subscriber No. 2, thence downward to the bottom of Sheet 6 and to the left to conductor 66, thence to the left to Sheet 5, thence upward and to the left to electro-magnet M^{25} of the individualizing switch S′ W′ of subscriber No. 2, thence downward and to the right to conductor 65 to the bottom of Sheet 5, thence to the right through Sheet 6, thence upward to electro-magnet M^{18}, thence to the left by conductor 60^a to and through electro-magnet M^{19}, thence to the right and upward by conductor 17, thence to the left through Sheet 6, Sheet 5, Sheet 4, Sheet 3, Sheet 2 and Sheet 1 where it intersects conductor 24, thence upward through releasing electro-magnet H^2, thence to the left where conductor 24 intersects conductor 25, thence upward through releasing electro-magnet I^2, thence through contact point p^8, spring s^8 back to the battery b^6 a^6. Electro-magnet M^{18} was therefore energized but this need not be noticed here. Electro-magnet M^{19} was energized thereby rotating the shaft S^3 h^3 and causing any balls which might have been held upon any of the contact plates c p, c' p' to be released and returned to and through the return runway R R back to the elevator; but inasmuch as subscriber No. 1 called subscriber No. 2 and subscriber No. 2 has not called subscriber No. 1 there are no connecting balls in No. 2's cross connections so that the operation of this electro-magnet need not be noticed here. Electro-magnet M^{25} of the individualizing switch S′ W′ of subscriber No. 2 at the top of Sheet 5 was energized but this fact need not be noted here. Electro-magnets P^2 of the accumulator or side track R^2 S^2 were also energized but inasmuch as I have supposed there were no balls upon the accumulator this fact need not be noted here. The release electro-magnet N^2 of the accumulator switch or gate R^2 was energized and that gate released and allowed to assume its normal position thereby leaving his, No. 2's, runway in condition to receive circuit controlling balls from other subscribers. The recording electro-magnet M^{29}, Sheet 6, of subscriber No. 2 was energized thereby causing the armature lever m^{29} and its recording stylus to make a record of the call for subscriber No. 2 upon the record paper carried by the revolving recording cylinder R E. Release-electro-magnet K^2 at the top of Sheet 2 was energized thereby causing its armature lever k^2 to release the armature lever j^2 of the switch magnet J^2, thus placing this part of the apparatus of No. 2 in condition for the reception of incoming signals. The releasing electro-magnet E^2 at the extreme left of Sheet 1 was energized causing its armature lever e^2 to move thereby connecting the spring s^4 with the circuit 101 and restoring it to direct connection with the signaling relay A^2. The releasing electro-magnets H^2 and I^2, Sheet 1, were also energized thereby causing their armature levers h^2 and i^2 to release the armature levers f^2 and g^2, thereby restoring the complete circuit to the signaling relay through conductor 101 and automatically rupturing the circuit of battery b^6 a^6.

The entire apparatus is now in condition for the sending or receiving of signals by or from either one of the subscribers No. 1 or No. 2, it being understood that the switching apparatus at the exchange system was left at the disposal of the other subscribers for their mutual use during the time that No. 1 and No. 2 were holding their conversation, or rather from the time that the numerical receiver switch N′ R′, Sheet 4, was released on the movement of the circuit controlling balls B^2 B^2 over the first short section 1^s of the runway 2^R at the left hand edge of Sheet 5 through the agency of the circuit, consisting of conductors 44, 4, 45 and 84, the magneto generator and the releasing electro-magnet M^{12}, at which time also the percentage switch at the upper left hand side of Sheet 4 was automatically released through the agency of electro-magnet M^6.

Suppose now that immediately after the numerical receiver switch and the armature lever l of the percentage selector had been restored to their normal positions some other subscriber calls subscriber No. 1, and also that still an additional subscriber calls subscriber

No. 2. Inasmuch as both No. 1 and No. 2 are busy, it will be remembered that their accumulator switches or gates O′ O² are in their uppermost positions, shown in dotted lines in Fig. 9, Sheet 4. The apparatus of the subscriber now calling subscriber No. 1 will therefore act as did the apparatus of subscriber No. 1 when calling subscriber No. 2. The preliminary impulse sent by this subscriber will cause his particular relay battery to transmit forward an impulse from that battery which will actuate his particular percentage control switch corresponding to the percentage control switches actuated by the electro-magnets L′ and L² for subscribers Nos. 1 and 2 and found on Sheet 2. It will likewise tilt his particular armature lever corresponding to *l* or *m* on the percentage selector, Sheet 3, and will make the necessary connections through the electro-magnet M⁹ of the numerical receiver switch and the electro-magnet M⁷ of the time relay to enable this subscriber through the agency of his particular relay battery corresponding to $b^3 a^3$ to transmit forward through the electro-magnet M⁹ the two current impulses which will place the arms A of the numerical receiver switch in alignment with the runway 1ᴿ of subscriber No. 1 and will simultaneously set in motion the vibrating reed m^7 which ultimately permits the battery B′ A′ to energize the electro-magnets Q′ Q′ and effect the ejection of an additional pair of balls. These balls being released will drop into the open sided pocket as before, pass thence down to the runway 1ᴿ and ultimately up over the accumulator switch or gate O′ on to the accumulator, which is so constructed that after they reach a certain point of elevation it has a down grade returning again to the main runway 1ᴿ at a point below the starting point, so that when the balls are released they will run on again over the main runway. These balls will, however, be checked by the ball retaining arm p' in the same manner as they were primarily held in check by the arm q' previous to entering the open sided pocket B. This pair of balls is therefore held in check for subscriber No. 1 until released by him, as will be described later on.

It will be remembered that in the description of the operation of the calling of subscriber No. 2 by subscriber No. 1 the preliminary signal sent over the line by subscriber No. 1 to the central station actuated the individualizing switch S W of subscriber No. 1 shown at the top of Fig. 5 and also that the track section over the contact plates of his, subscriber No. 1's, cross-way were elevated for the reception of the circuit connecting balls for making connection between the lines of subscriber No. 1 and subscriber No. 2, and also that the accumulator switch or gate of subscriber No. 1 was elevated simultaneously through the agency of this preliminary impulse. In a similar manner the preliminary signal turned in by the additional subscriber affects corresponding parts of his particular portion of the central station apparatus, namely, elevates his particular track section for the reception of the circuit connecting balls which are to connect his line with that of subscriber No. 1, shifts or sets his particular individualizing switch corresponding to S′ W′ of subscriber No. 2 and places his accumulator switch or gate in position to divert any incoming circuit connecting balls upon his individual accumulator. By the action of this subscriber's individualizing switch therefore the short sections of track 1ʳ′, 2ʳ′, 3ʳ′, 4ʳ′ and 5ʳ′ of No. 1's accumulator or side track have been put in connection with signaling apparatus of the subscriber now calling so that as the balls roll over the first section of track 1ʳ′ of the accumulator R′ S′ a circuit corresponding to the following will be established: passing by conductor 47 to the right to the center of Sheet 5, thence upward through 47 to that point of the individualizing switch of the subscriber calling and corresponding to S′ W′ at the top of Fig. 5; thence through the right hand contact plate of this switch by conductor corresponding to conductor 8, thence to the left to the center of Sheet 1 through the electro-magnet of the corresponding subscriber corresponding to the electro-magnet B³, thence through electro-magnet E⁴ and conductor corresponding to conductor 8, thence through the conductor 4 to the magneto generator, Sheet 6, thence through conductor 45 to the bottom of Sheet 4, thence by conductor 88 to the starting point through the balls, thereby placing the contact spring corresponding to the spring s^3 in connection with its corresponding plate p^3 in direct connection with one pole of the magneto generator. The balls then pass upon the two adjoining sections 2ʳ′ and 3ʳ′ in sequence both of which are connected to a single conductor corresponding to 48 and running to the individualizing switch of the subscriber calling corresponding to the switch S′ W′ as before, and out through the second contact plate of that switch by a conductor corresponding to 7, thence to the extreme left of Sheet 1 and up through a conductor corresponding to conductor 101 and out to the subscriber calling, thence back to the central station through the armature contact spring and contact plate corresponding to b^2 s^2 and p^3 back by the common conductor 4 to the magneto generator on the extreme right of Fig. 6, thence by conductor 45 back to the bottom of Sheet 4, thence by conductor 88 to the other track of the accumulator R′ S′, through the balls to the starting point, sending to the subscriber calling two short sets of signals notifying him that the line of subscriber No. 1 is in use and that his circuit connecting balls have therefore gone on to the accumulator of subscriber No. 1 to await their turn for connection with that subscriber. The balls now pass from section 3ʳ′ on to section 4ʳ′ and make electrical connection through a conductor corresponding to conductor 49 to and

through the third contact plate of the individualizing switch of the subscriber calling and corresponding to switch S′ W′, thence downward through a conductor corresponding to conductor 6 and to the left to the extreme edge of Sheet 1 to and through electro-magnets corresponding to C^2 and D^2 and thence back by the common return conductor 4 of the magneto generator on Sheet 6, thence through the return conductors 45 and 88 to the other rail of the accumulator track. This therefore causes the armature lever corresponding to b^2 of the subscriber calling to be returned to its normal position and elevates the armature lever corresponding to c^2 so that the contact spring corresponding to s^4 is in contact with a plate corresponding to p^4. The balls finally pass over the short conducting section $5^{r'}$ of the accumulator of subscriber No. 1 and an additional electrical circuit is closed through a conductor corresponding to 46, to and through the individualizing switch corresponding to S′ W′, through the fifth contact plate thereof downward and to the left by a conductor corresponding to 14, thence to the center of Sheet 1 through an electro-magnet corresponding to F^2, thence through a conductor corresponding to 21 to the top and right hand side of Sheet 4 where it joins the conductor 4 running to the magneto generator, thence by conductor 45 and conductor 88 back to the other track of the accumulator. This current impulse therefore shifts the armature lever corresponding to the armature f^2 of the subscriber calling into its upper position and into connection with a conductor corresponding to conductor 97. As soon therefore as the balls released by the subscriber calling arrive at their destination upon the accumulator of No. 1 and are held in check by the arm p' two courses of action are open to this subscriber as follows: First he may await his turn until the subscriber called releases the stored up balls by the act of ringing off, in which event they will pass directly upon the main runway 1^R and effect the necessary connections in the same manner as the like connections were effected between subscriber No. 1 and subscriber No. 2 or he may automatically release his particular track section, de-individualize his individualizing switch and restore his own switching apparatus, the operation of which has just been described, to normal condition so that he may, if he chooses, call some other subscriber, it being remembered that the individual pair of balls which he has released and which have been stored upon the accumulator of subscriber No. 1 will remain there until subscriber No. 1 releases them, in which event they will run off by runway 1^R but will not make any electrical connections over that runway as they pass out, inasmuch as the restoration of his individualizing switch has interrupted all of the circuit connections which would have been made had they been sent forward while the switching apparatus of the calling subscriber remained in the position at which it was left when the balls first reached their destination upon the accumulator of No. 1. Inasmuch also as the track section of the calling subscriber has been released they will simply run off at the end of runway 1^R and drop into the return chute R R, without performing any function whatever. The balls will, however, when thus released ring the bell of subscriber No. 1 and warn him that some one has called him but did not care to wait.

I will now describe how the apparatus works in the event of a calling subscriber desiring to await his turn.

As soon as subscriber No. 1 had finished his first conversation, by the act of ringing off he energized his individual electro-magnet G′ of the automatic release apparatus and the armature lever g' was therefore momentarily locked up in its upper position by the armature lever i'. A circuit was closed therefore from the battery b^5 a^5 as hereinbefore described, which included in turn the electro-magnet M^{23} of his own individualizing switch, the track section releasing electro-magnet M^{21}, Sheet 6, the electro-magnet M^{22} on Sheet 6 for returning the balls to the return elevator chute R R, the recording electro-magnet M^{28} at the top of Sheet 6, the ball ejecting and retaining electro-magnets P′ P′, Fig. 4, the accumulator or gate releasing electro-magnet N′, the electro-magnet K′ at the top of Sheet 2, the release electro-magnets H′ and I′ Sheet 1, back to starting point. The balls therefore were started on their journey by the propulsive action of the ball ejecting arm p' and were caused to pass down and back upward a short distance over the accumulator switch or gate which is now in its lower position, after which they return through gravity directly down the runway 1^R and under the accumulator upon which they were just stored. When they reach that section of the runway 1^R indicated by 1^s circuit connection is made by conductor 83, upward through the fourth contact plate from the right of the individualizing switch of the subscriber calling which corresponds to the switch S′ W′, thence back by a conductor corresponding to conductor 24 to the extreme left of Sheet 1 through the release electro-magnet corresponding to the release electro-magnet H^2, thence downward by conductor corresponding to conductor 25, thence through Sheets 2, 3, and 4 to the left hand side of Sheet 5 where it joins conductor 4 running to the magneto generator, thence through conductor 45 back through conductor 84 to the starting point through the balls. This action of the electro-magnet corresponding to the electro-magnet H^2 disconnected the automatic release controller which was put in position by a prior action of the signaling subscriber, as will be remembered, in order that he might disconnect his apparatus in the event of his not wishing to await the pleasure of subscriber No. 1. The action of the balls over the re-

maining sections 2^s, 3^s, &c., of the runway 1^R to their final destination for the purpose of connecting the subscriber now calling with subscriber No. 1 is identically the same as it was as before described in uniting the circuits of subscriber No. 1 with subscriber No. 2, with the exception of course that the balls now enter to the conducting plates *c p* and *c' p'* which lie below the now elevated track section of the subscriber calling, the remaining track sections all being in their lower positions in order to allow the traveling balls to pass over them to their proper destination. In the same manner any calls which have been made by other subscribers for subscriber No. 2 or for any of the other subscribers except the calling and the called subscriber will be stored upon the individual accumulators of the subscribers called, it being understood that the particular individualizing switches corresponding to the particular subscribers called will always be operated in each instance so as to connect the accumulators of the called subscribers individually with the calling subscribers.

It might be well to notice here that in the event of the storing up of two or more sets of balls on any individual accumulator through the independent calls of two or more individual subscribers the individualizing switches of all of the calling subscribers will be actuated in the manner already described so as to put the apparatus of all of the individual calling subscribers into multiple arc connection with the section of track of the accumulator of the subscriber called. Owing to this fact it must be apparent that each time a pair of balls enters upon the sectional tracks of the accumulator, the bell or bells of the subscriber or subscribers who have previously called the same person will be each rung twice, thus indicating to the subscribers in the order in which the calls were made that there are additional subscribers seeking to obtain connection with the line of the same subscriber, except under the condition of course that none of those who have previously called the same person and have themselves automatically disconnected their own apparatus in the manner heretofore described, will of course not be signaled, their signal receiving or circuit connections having been disconnected by their own act.

The operation of the apparatus in connection with Sheets 1 to 8 inclusive is as heretofore indicated, applicable to a system of ten subscribers' lines. When it becomes necessary to increase the number of subscribers' lines and therefore the means of making cross connection between any two of such subscribers, additional apparatus is necessary for effecting the movement of the circuit controlling balls to their proper channels and ultimately to the points of connection between any two of the lines. In this connection reference is had to Figs. 8^a and 8^b which, as heretofore indicated, are diagrammatic views illustrating a skeleton plan of runways, electrical circuits and mechanism applicable to a system of ninety-nine lines based upon the generic principle disclosed in my prior application above referred to of making the necessary connections through successive numerical receivers in the order of units, tens, hundreds, &c.

I will suppose that subscriber No. 1 desires to call subscriber No. 79. In order to accomplish this it will be necessary for him, subscriber No. 1, to first place the numerical receiver switch arm A in alignment with the sectional track 7^R and the pivoted sectional track S R at the outer end of 7^R in alignment with the runway 70^R to 79^R, and through the agency of an additional set of impulses place the numerical receiver switch arm A of numerical receiver N^2 R^2 in the extreme lower right hand corner of Fig. 8^b into alignment with and leading to the individual runway of 79^R of subscriber No. 79. The positions of these moving portions of the runways for the circuit controlling balls are shown in dotted lines between the numerical receiver N' R' and the inner end of 7^R, the outer end of 7^R, the inner end of 70^R and between the numerical receiver N^2 R^2 and the inner end of 79^R on the lower side of Fig. 8^a, the arrangement being such that when a pair of balls is released by subscriber No. 1 for forming connection with subscriber 79 they will run by the arms A to 7^R, thence by the arms S R to 70^R, thence to numerical receiver N^2 R^2 and by the arms A to 79^R and finally over the runway 79^R to their destination, the track and switch board relations from 79^R to the point where the switch board connections are made being the same as from 1^R Sheet 4, to the extreme right of Sheet 6, there being for the runway 79^R an accumulator switch or gate corresponding to O', an individual accumulator corresponding to the accumulator R' S' and all of the necessary mechanical and electrical connections which are found in the like parts of the apparatus shown in connection with the lines of subscriber No. 1 and subscriber No. 2 on Sheets 1 to 6 inclusive. Upon turning in his preliminary impulse subscriber No. 1 puts his apparatus in connection with the electro-magnet M^9 of the numerical receiver switch N' R' in circuit 29 and 30 which circuit also includes an electro-magnet M^{71} of the time relay which is the exact counterpart of the time relay shown in Fig. 4 but which serves in the present instance an additional capacity in the nature of a numerical separator for the purpose of separating the two sets of impulses coming from the subscriber's station in order that the first set thereof may step forward the arms A of numerical receiver No. 1 to the position shown in dotted lines, leave it there and effect such additional circuit connections as will enable the second set of impulses from the subscriber

to step forward the arms A of numerical receiver N^2 R^2 into the position shown in dotted lines as will be described.

It will be understood that the preliminary impulse just referred to as coming from subscriber No. 1 was instrumental in raising his own track section, operating his own individualizing switch S W and raising his own accumulator switch or gate O′ to prevent interference from other subscribers. Subscriber No. 1 then transmits over his line to the central station from his battery b' a' eight impulses. These impulses as before described, come from battery b' a' and are ultimately relayed through circuits 29 and 30 energizing electro-magnet M^{71}, electro-magnet M^9 and electro-magnet M^7. Consequently the arms A of the numerical receiver switch No. 1 are stepped forward until their free ends are in alignment with the stationary runway 7^R. At the same time the reeds m^7 and m^{71} of the numerical separator N S and the time relay T R were kept vibrating continuously. It should be noted, however, that the time relay reed m^7 should be so adjusted that it will vibrate for a somewhat longer time than does the corresponding vibrating reed m^{71}, for the reason that the function of the time relay is to permit of the release of the circuit connecting balls, which should not take place until all of the arms A of the numerical receivers to be effected, N′ R′, N^2 R^2 have been put into their proper positions to carry the balls to their final destination. As soon therefore as the reed m^{71} ceased vibrating a circuit was closed from the battery B^6 A^6 as follows: By conductor 112, by release electro-magnet M^8, conductor 112, switch magnet S M, the function of which is to switch the current from the units circuit 30 to the tens circuit 109, thence by conductor 112, spring s^{16}, conducting head b of pin p, sliding bar m, reed m^{71}, spring s^{15}, conductor 112 back to the starting point. The release electro-magnet M^8 therefore automatically ruptured the battery circuit B^6 A^6 between the head b and the spring s^{16} so that the pin p assumed its normal position. The armature s m of the switch magnet S M was locked in its uppermost position by the armature r m of the release electro-magnet R M in circuit 44. The second set of impulses from subscriber No. 1 now come forward while the reed m^7 of the time relay is still vibrating.

By the operation of the switch magnet S M a new signaling circuit is now established for the reception of this second set of impulses, ten in number, which are to rotate the numerical receiver switch arms A of the numerical receiver N^2 R^2 into final position opposite the inner end of 79^R. This circuit is as follows: Entering at 30 as before, passing thence through the numerical separator magnet M^{71}, thence through conductor 30 to armature s m of switch magnet S M, thence through the contact spring carried by the free end of its armature lever now locked in its upper position, thence by the new path through conductor 109 to a contact spring having metallic contact with a conducting portion of the numerical receiver switch which in turn is connected metallically with one of the conducting arms A carrying a contact spring at its outer end adapted to make electrical contact with one of the contacts x' to x^9. The arms A having been moved as already described into the position shown in dotted lines, this contact spring rests upon contact spring s^7, through conductor 170 to electro-magnet M^9 at the lower right hand corner of Fig. 8^b, thence through the return conductor 29 back to the energizing battery. All of these impulses therefore energize the switch electro-magnet S R in the lower left hand side of Fig. 8^a thereby causing the local battery B^7 A^7 to energize an electro-magnet S′ M′, the armature of which a m is attached to a connecting link L C adapted to rotate the pivoted sections of runway S R so that all of the outer ends of the pivoted sections of runways S R are turned to the left and consequently put in alignment with the fixed sections of track running to those series of subscribers' runways higher than nine, through additional runways 10^R to 99^R inclusive, there being only three sets of these continuous runways shown for clearness sake. As the ten impulses come forward therefore through numerical receiver N^2 R^2 the arms A are finally placed in alignment with the runways 79^R. Immediately thereafter the reed m^7 of the time relay which controls the releasing of the balls ceases to vibrate and the electro-magnets Q′ Q′ are energized and the balls set in motion when they run over the route already indicated, and finally find their way to their destination beneath the open track section of subscriber No. 1 at that point of the switch board which is cross connected to No. 79, it being understood that the several functions referred to as having transpired in connection with the runway 2^R of subscriber No. 2 when subscriber No. 1 was calling him have taken place through the corresponding electrical connections through the runways of subscriber No. 79 and the apparatus of both subscriber No. 1 and subscriber No. 79. It will of course be understood that there should be release electro-magnets for the numerical receiver switching apparatus of the several numerical receivers corresponding to the electro-magnet M^{12} and that all of said release electro-magnets are included in series in the circuit 44 together with the restoring electro-magnet S^2 M^2 and the release electro-magnet R M which releases the armature s m of the switch magnet S M for the purpose of restoring all of the apparatus in the system for the use of other subscribers. It will be understood also that the capacity of the system may be increased for a larger number of subscribers by providing the second series of numerical receiver switches N^2 R^2 with apparatus like that shown in Fig. 8^a so that a corresponding switching electro-magnet like S M shall shift the circuit for-

ward through the numerical receiver arm to the next series of numerical receivers of higher order.

With an extended system of apparatus embracing more than ten lines like that shown in Figs. 8ª and 8ᵇ should a subscriber desire to connect his line with that of any other subscriber whose number is less than ten the operation would be as before up to the point where the switching magnet S M operated the switching armature *s m;* but it is to be observed that the apparatus which is in circuit through circuit 109 although placed in circuit will not be operated because no second set of impulses will be sent forward. This being true the switching magnet S′ M′ will not be operated, the operation of the numerical separator M^{71} effecting simply the stepping of the switch arm S M. Consequently the pivoted sectional track release S R will not be moved so that the balls released by the subscriber calling will run over the arm A and that one of the arms 0^R to 9^R inclusive opposite which the free ends of the arms A have been placed and will pass then over the pivoted section S R directly to that one of the stationary runways 1^R to 9^R inclusive which is designed to carry the balls to the subscriber called.

In describing the apparatus and the operation thereof up to the present time, I have assumed that the tilting armature levers *l, m,* &c., one for each subscriber, were all located in a single horizontal plane and that there was but a single radiating arm *k* carrying the operating electro-magnets M^{10} and M^{11} therefor, the first of which enabled the subscriber to connect his relay battery directly with the numerical receiver switch magnet M^9 and the second of which enabled him to reverse this operation. It is to be noted, however, that in this connection with such an arrangement the signaling subscriber who first obtains control of the percentage circuit selector embracing a single series of armatures does so to the exclusion of all other subscribers for the time being, which under ordinary circumstances does not exceed three seconds. It is possible therefore, and in fact probable, that a second subscriber might call during this time, in which event his percentage switch corresponding to the switches controlled by electro-magnets L′ and L^2, Sheet 2, would be actuated but he would not obtain control of the percentage selector until the apparatus of the subscriber simultaneously signaling had released his connection therewith, whereupon the second subscriber would immediately obtain control of the apparatus. This feature is not a serious objection in connection with a limited number of subscribers' lines, inasmuch as it would only cause slight delay in waiting for the apparatus to work or to operate. In a larger system of subscribers' lines I overcome this objection however, by providing a series of tiers or planes of percentage selectors and their necessary circuit connections all arranged in multiple arc relation to each other as shown in Figs. 12, 13 and 14 which I shall now proceed to describe. The individual circuit connections of each of these tiers of apparatus of the percentage selector proper, shown in Fig. 12, is the duplicate of that shown in Fig. 3 and the incoming circuit connections are connected in multiple as described, so that if a subscriber has obtained control of said tier No. 1 of the percentage circuit selector any incoming signal from an additional subscriber will immediately obtain possession of circuit connections through tier No. 2, No. 3 or No. 4, or the first one of the tiers not already in use at the time of his incoming signal.

In describing the operation of the apparatus allusion has heretofore been made to a percentage principle. This principle is intimately associated with a small exchange but is still more closely connected with a larger exchange. In order therefore that said principle may be fully understood I will describe it and will afterward exemplify it by reference to Figs. 12 to 14 of the drawings.

Automatic telephone exchange apparatus as heretofore devised may be divided into two classes; first that class which only contemplated the making of a few connections at one time, and second that class which permitted of a larger number being made but with the attendant disadvantage of complication of mechanism and interference of signals and conversation.

In nearly all the devices known at the present time the prevalent idea has been to provide a conductor for each and every telephone in the system. The percentage system as applied to automatic telephone exchanges is a method of providing switching or connecting apparatus enough to carry the computed maximum number of connection calls likely to be received in the central office simultaneously or within a few seconds of each other.

Referring now to Fig. 12, D R and D′ and R′ are drums the substantial duplicates of the like parts in Fig. 3. They are carried by a shaft S as before and connected through miter gearing *b g* with a shaft *v s* the same as before, but instead of there being a single radiating arm *k* carried by the shaft *v s* there are now found four such radiating arms located at ninety degrees apart and four corresponding pairs of electro-magnets M^{10} and M^{11} carried thereby with tilting armature levers *l m* and circuit connections, the same as in Fig. 3, with a single difference, namely that all of the incoming conductors for each subscriber are connected at the points *u* in multiple arc relation. The four armature levers *l* corresponding to the line of subscriber No. 1 are therefore located one in each tier and directly above each other, and each tier has as many of these tilting armature levers as there are subscribers' lines. Diametrically opposite the four armature levers *l* are located four additional armature levers *l o* of a third subscriber's line; the four corresponding arma-

ture levers m of the second subscriber's line which correspond to the armature m seen on Fig. 3 would not be visible in this figure of the drawings as will be apparent on inspection of the latter figure. The circuit connections to the four points u on the left from the subscriber's line would be the same as are the corresponding connections from subscriber's line No. 1 by conductor 36 to the four points u on the right, and in fact all of the incoming connections to the several sets of individual armatures would be the duplicates of the parts shown. This multiple arrangement of tiers necessitates of course a multiple arrangement of contact brushes $i\,i$, contact rings $h\,h$, one set for each tier, and a like corresponding multiple arrangement of spirally disposed strips $f\,f, f'\,f'$, one set for each cylinder, one of which strips in each set is connected to its corresponding ring $i\,i$ by a conductor 94 or 95. The contact springs carried by the several armature levers, together with the vertically disposed contact strips $e\ p$ on the stationary hubs J^5, are also arranged in multiple sets, the individual circuit connections for each set being the same as those of the corresponding parts shown in Figs. 3 and 10. The contact brushes $j\,j, j'\,j'$ for individual subscribers are the same as the like parts in Figs. 3 and 10. I have shown, however, six pairs of such brushes corresponding to six individual telephone circuits, Nos. 1 to 6 inclusive.

In Fig. 13 is shown in diagrammatic view, a corresponding multiple arc or tier arrangement of accumulators or side tracks necessitated by the tier arrangement of the percentage selector shown in Fig. 12, and in Fig. 14 is shown a corresponding tier arrangement of the track sections lying over the switch board circuit connections similar to those shown in Fig. 11 of the drawings, together with individualizing switches for the complete operation of this tier arrangement of parts.

Before proceeding with the description of the mode of operation of the percentage circuit selector apparatus illustrated in Fig. 12 and the necessary circuit connections therefor for the application of this principle, it may be well to state that it is to be understood that this principle contemplates a multiple arrangement of parts of the entire system; that is to say, all of the apparatus in the percentage circuit selector is arranged in tiers or horizontal planes as shown in Fig. 12, all of the numerical receiver switches are arranged in sets in horizontal planes corresponding thereto, as are all of the accumulators, the runways and switch boards. In other words in a system of say one hundred subscribers' lines I would provide one hundred tilting armature levers corresponding to levers l on each tier, four sets of radiating arms carrying electro-magnets M^{10}, M^{11}, one such set for each tier; one hundred pairs of brushes $j\,j$, $j'\,j'$, four spirally disposed strips f and f' for each drum D R, D′ R′ and four sets of circuit connections as shown, four sets of numerical receiver switches and circuit connections corresponding to the numerical receiver switch N′ R′, Fig. 4, arranged in tiers one above the other and individual circuit connections therefrom to their individual corresponding tiers of the percentage circuit selector; a single elevator corresponding to the elevator E with multiple branch chutes S H running to each of the corresponding tiers of numerical receivers, four sets of numerical receivers N^2 R^2 of the second order arranged in tiers above each other and having their individual circuit connections and operating apparatus connected to their corresponding parts of the first sets of numerical receivers, the individual circuit connections of the several sets being the same as those heretofore described in connection with the apparatus shown in Figs. 8^a and 8^b; four tiers of accumulators, four sets of runways arranged in tiers, runways or chutes, four sets of accumulators as shown in Fig. 13, one for each tier of runways, four sets of switch boards arranged in tiers with elevating track section as shown in Fig. 14. This multiple arrangement of all the parts is made necessary, although not fully illustrated here in order that the different parts of the apparatus from the percentage circuit selector to the switch board connections may be made simultaneously available for different subscribers at the same time. In other words it is to be understood that when any subscriber has seized, say tier No. 1 of the entire apparatus from the percentage circuit selector through to the switch board connections, he has done so to the exclusion of any other subscriber so that any such other subscriber may use either tier No. 2, tier No. 3, tier No. 4, or in fact the first disconnected or unused tier of the apparatus made accessible to him by the rotation of the drums D R, and the available circuit connections therefor.

My novel percentage system is based upon the theory that for a given number of subscribers and with an apparatus in which circuit connections are made within a time not to exceed say about three seconds, there is not even a remote probability that there will ever be a sufficient number of subscribers calling at one and the same time to utilize all of the tiers of an apparatus planned to meet the properly estimated maximum number of calls.

Reverting now to Fig. 13 of the drawings, it will be seen that there are four sets of accumulators R′ S′, four sets of electro-magnets N′ N′, &c., with corresponding accumulator switches or gates, there being four complete sets of these apparatus for every telephone subscriber of the system arranged in tiers, preferably above each other, corresponding to the like tiers of the percentage selector shown in Fig. 12. It will also be noted that the accumulator switches or gates R′ are connected together by a link or rod E B, the lower end of which is attached to the free end of

an armature lever o^3 of a common actuating electro-magnet O′, the arrangement of parts so far being different from that of the like parts shown in Figs. 4 and 8 only in the multiple arc or tier arrangement thereof.

O^3 is an electro-magnet adapted to act upon the same armature lever o^3 as does the electro-magnet O′ after any pair of balls has been released from any one of the accumulators so as to restore the gates and prevent any further release of balls for the time being.

M^{31} is a release electro-magnet for locking or controlling the movement of the armature lever o^3 and is located in the common release circuit 3—3, which it will be remembered is controlled by either the signaling or signaled subscriber after conversation has been completed.

M^{32} is a switching electro-magnet enabling the calling subscriber to elevate his track section only in that tier of track sections corresponding to that tier of the percentage circuit selector through which he has obtained control of the switching apparatus. M^{33} is a release electro-magnet therefor.

M^{34} and M^{35} are electro-magnets of subscriber No. 2 corresponding to M^{32} and M^{33} just described.

I will now describe briefly the application of the percentage principle above referred to and indicate how two or more subscribers may simultaneously use the indvidual parts of the apparatus at the same time. Before proceeding with the description it may be well to indicate that the general operation of the apparatus, in so far as it relates to individual subscribers and their incoming lines and circuit connections up to the point of juncture with the percentage selector is identically the same as in the system shown and described in connection with Sheets 1 to 7 inclusive.

Suppose any subscriber, say subscriber No. 1, calls subscriber No. 2, his preliminary signal coming in to the office as already described actuates his percentage circuit selector switch controlled by the electro-magnet L′, thereby bringing into play the battery B A, Sheet 2. When, therefore, the drum D R advances until the brush j in connection with conductor 41 comes in contact with the strip f a circuit is closed in the same manner that the corresponding circuit was closed in the original description in the connection of subscriber's line No. 1 with subscriber's line No. 2 as follows: from the brush j, strip f, conductor 94 to the right hand ring i, the conductor d^{92}, through Figs. 13 and 14, thence through electro-magnet M^{42} of tier switch No. 4 T S at the bottom of Fig. 14, thence upward to the top of the figure, and to the left to the top of Fig. 12, through brush s^{19}, contact ring 1^r, thence through electro-magnet M^{10}, and to contact ring 2^r, brush s^{17}, thence by conductor 28, thence to the tier controlling switch magnet corresponding to M^3 at the top of Fig. 4, thence by conductor 20 back to the battery. This tilts the armature lever l of the fourth tier into the reverse position from that shown, thereby making connection between the conductors 36 and 38 to and through the armature lever and its circuit connections to the conductors 29 and 30, see Figs. 3 and 4, to the numerical receiver and the time relay of the fourth tier which corresponds to the fourth tier of the percentage circuit selector. This act therefore has enabled subscriber No. 1 to seize for his own use, the fourth tier of the entire apparatus, including the percentage selector, the numerical receiver switches, the runways or chutes, the accumulators or side tracks, and the track sections of the fourth tier over the corresponding tier of the switch board connections. The energizing of the electro-magnet M^{42} at the extreme right hand lower edge of Fig. 14 caused the armature lever m^{42} to actuate the tier switch so that the contact springs thereof are in electrical contact with their corresponding contact plates. The act of turning in the preliminary signal it will be remembered closed a circuit from the relay battery b^3 a^3 Sheet 1, through the circuit 33^{15} in the apparatus disclosed in Sheets 1 and 7 inclusive, thereby elevating the track section of No. 1; it also elevated the accumulator switch or gate O′, Fig. 4. In the present instance this same circuit elevates all four of the accumulator switches or gates of the apparatus of subscriber No. 1 corresponding to the four tier accumulators shown in Fig. 13, the armature o^3 of the electro-magnets O′ and O^3 in this instance being connected by a link E B to the several gates. The same current also energizes the electro-magnet M^{32} thereby elevating the free end of its armature lever m^{32} to lock it in its upper position so that the contact spring on the free end of armature lever m^{32} is now in contact with circuit 118 running to the magneto generator. The circuit is therefore closed from the magneto generator on Fig. 13 as follows: by conductor 115, branch conductor 119, thence to the right and downward through conductor 124 through the left hand contact plate of No. 4 tier switch, thence downward by conductor 122^d, thence upward to the top of the sheet through electro-magnet M^{20}, thence downward by conductor 122 and to the left to the magnet M^{33}, thence through the armature lever m^{32}, thence through conductor 118 by conductor 113 back to the magneto generator. This does two things. It elevates the track section T S at the top of Fig. 14 corresponding to the fourth tier of the percentage circuit selector through which the incoming signal made connection to the fourth tier of the apparatus throughout, thereby opening the proper tier track section for the reception of the circuit connecting balls. It also through the agency of armature lever m^{33} of electro-magnet M^{33} released the armature lever m^{32} and restored it to normal position. By this time the particular time relay of the fourth tier of the numerical receiver

switches has caused the pair of balls B^2 B^2 in the top or fourth elevator chute S H to be released and started on their journey to the particular runway 2^R to which they were directed by the signaling impulses sent from subscriber No. 1 in the manner already described. These balls therefore advance over the top or fourth tiers of runways 2^R uninterruptedly making the usual circuit connections over the sectional conductors 1^s, 2^s to 8^s inclusive, ringing the bells of the two subscribers, releasing the track section as before and making the necessary circuit between the two subscribers. It will be remembered that in passing over the section 1^s of the runway the circuit 44 was closed to the electro-magnet M^{12} of the numerical receiver switch, Fig. 4, and to the single tier release control electro-magnet M^6 at the top of that figure. In similar manner the numerical receiver switch of the fourth tier of numerical receivers was released, which circuit corresponding to 44 I have lettered as "44^d" Fig. 14, passes through the restoring electro-magnet M^{43} of the tier switch No. 4 T S returning it to normal position. When the balls dropped into their final position beneath the track section S T that section was released in the same manner as was the corresponding track section, Fig. 11, in the early description of the apparatus. Suppose now that an additional subscriber, say subscriber No. 3 calls at identically the same instant of time for subscriber No. 1 as did subscriber No. 1 for subscriber No. 2. It will be remembered that subscriber No. 1 has seized the fourth tier so that the new subscriber No. 3 has no access to that tier of the apparatus but his circuit connections will be made through his conductor corresponding to 36 and through his particular tilting armature lever corresponding to l of that one of the other tiers of armature levers over which the electro-magnets M^{10} M^{11} will pass immediately thereafter so that the electro-magnet M^{10} carried by the arm k of, say the second tier, will seize his particular armature corresponding to l, say $l\,o$, and make the necessary connections to and through the apparatus in the same manner through his particular contact brush j and the strip f and circuit connections running out through conductor b^{92} to the extreme right of Fig. 14, thence through electro-magnet M^{33} of the No. 2 tier switch, thence to the top and to the left through conductor b^{92} to contact spring s^{19} near the center of Fig. 12, thence by conducting ring 1^r, through electro-magnet M^{10}, thence by conducting ring 2^r by brush s^{17} and conductor 28 as before. This will give him control of the second tier which in turn will connect his apparatus with the second tier of the numerical receiver switches and will in the same manner elevate his, No. 3's, individual accumulator switches or gates and will move his switch through the electro-magnet corresponding to electro-magnet M^{32} for effecting the same set of operations for his accumulator apparatus and track section corresponding to T S as was accomplished for subscriber No. 1. It must not be forgotten, however, that although both subscribers sent in their preliminary impulses at identically the same instant of time it was not possible for both of them to obtain control of any part of the percentage circuit selector apparatus at identically the same instant of time, owing to the fact that the revolving drum D R and the spirally disposed strips can only connect one subscriber at a time with any portion of the percentage circuit selector apparatus, so that I will assume for the present that the point of the brush j of subscriber No. 1 was nearest to that particular spirally disposed strip f which corresponded to the location of the arm k above the fourth tier of his armature levers l. Therefore he was the first to obtain possession of a tier which happened in this instance to be the fourth, while subscriber No. 3 happened in the same manner to obtain possession of the second tier. As a matter of fact if No. 1 obtained possession of the fourth tier first, No. 3 would obtain possession of the first tier immediately after owing to the consecutive order or arrangement of the brushes j, strips f and arms k, but I have described No. 3 as having obtained possession of the second tier, for the reason that the circuit connections are more fully portrayed than is possible either in the first or third tiers where the electro-magnets in one instance are in front of and the other behind the shaft $v\,s$ and the stationary hubs J^5. No. 1 and No. 2 are supposed to be conversing. Consequently the accumulator switches or gates R' R^2 of the several tiers of both runways are in an elevated position for the purpose of side tracking any balls which may come over either of their runways. It will be remembered that No. 1's accumulator switches or gates were elevated by the action of the preliminary signal through circuit 33—15 and electro-magnet O'. Consequently when the balls of the signaling subscriber No. 1 pass over a short conducting section of track O s just in front of the short section of track 1^s a circuit is closed through the magneto generator by conductors corresponding to the following conductors: from the magneto generator by 114 to the short section of track O s, thence through the balls and by conductor 117 to electro-magnet O^3, thence back to the other pole of the magneto generator thus tilting the armature lever corresponding to o^3 which controls the elevation of the accumulator switches or gates for subscriber No. 2. Consequently all of the four accumulator switches or gates of each subscriber being elevated, it will be apparent that when the circuit closing balls of subscriber No. 3 are released by the time relay for the second tier with which his apparatus has been connected, they will pass down the runway of subscriber No. 1 and upon his accumulator where they will be stored until either subscriber No. 2 or subscriber No. 1 releases them by the act of ringing off in the manner already described.

For more fully illustrating the action of the circuit closing balls on two or more individual sets of tier accumulators, I have shown a pair of circuit connecting balls on each accumulator or side track of the third and fourth tiers of one telephone subscriber, say subscriber No. 1. Suppose now that subscriber No. 1 and subscriber No. 2 have completed their conversation and either one of them rings off. The act of ringing off puts in circuit the automatic release of both No. 1 and No. 2 in circuit 3—3 for subscriber No. 1 and the corresponding circuit for the other subscriber. These two release circuits for the two individual lines include respectively the electro-magnet M^{31}, Fig. 13, and a corresponding electro-magnet for subscriber No. 2. Consequently both of these electro-magnets are energized and their armatures m^{31} drawn forward thereby releasing the armature s^3 for subscriber No. 1 and the corresponding armature for subscriber No. 2; consequently the following action ensues for both sets of apparatus. I will trace first the operation for say subscriber No. 1 in connection with the circuits, Fig. 13, and it will be appreciated that the operation of the apparatus for subscriber No. 2 is identically the same. When the armature o^3 of the electro-magnet O^3 was released in the manner just explained a circuit was closed between the armature lever and conductor 115 through the magneto generator as follows: From the magneto generator by conductor 113 to a series of contact brushes j^6 adapted to make contact with any one of a series of spirally disposed strips f^2 on a consecutive tier operating cylinder $D^2 R^2$ rotated by an electric motor E′ M′ which strips are connected respectively with insulated conducting rings h^2 upon which rest contact brushes i^2, the arrangement being such that this selector will elect which of the sets of balls upon the accumulator tracks shall be first released so as to prevent the possibility of more than one set of balls being released at one time. Suppose that the strip f^2 is connected with the first ring h^2 on the left. Consequently the circuit is closed when the left hand brush j^6 touches this strip through the conductor 115^h, thence through conductor 115^a, thence through electro-magnet N′ and armature lever o^3 by conductor 115 back to the generator. This releases the accumulator switch or gate of the first tier. In the same manner when the same contact brush j^2 touched the second strip on the continued rotation of the cylinder $D^2 R^2$ which is connected to the second ring h^2 and through the second brush i^2 with conductor 115^g, the circuit was closed to 115^b and thence through the electro-magnet N′ of the second tier, thence by conductor 115^a armature lever o^3 and conductor 115 back to the starting point, thereby releasing the accumulator switch or gate of the second tier.

Up to the present time I have assumed that there were no circuit controlling balls upon either of the accumulators of the first or second tiers. I have supposed that there are balls, however, on each of the accumulators of the third and fourth tiers. Consequently when the cylinder $D^2 R^2$ advances an additional portion of a revolution so as to bring the left hand brush j^6 into contact with the third spirally disposed strip which is connected electrically with the third conducting ring h^2 a circuit is closed as before through the magneto generator through conductor 115^f back by conductor 115^c, the electro-magnet N′ of the third tier, conductor 115^a, armature o^3 by conductor 115 back to the generator, releasing in sequence the accumulator switch or gate of the third tier. Inasmuch as a pair of balls $B^2 B^2$ is found standing upon the accumulator R′ S′ of the third tier, it will be observed that a multiple arc circuit is closed from conductor 115^f, through conductor 115^c to the right, through the ball ejecting electro-magnets P′ to the track-way through the balls to the other side of the track-way, thence downward by conductor 116 to the left, thence through conductor 115^a a by armature lever o^3 to conductor 115 back to the generator. The balls B^2 B^2 upon the accumulator of the third tier are therefore started on their journey. As they pass back on to the main track and run out over the first short conducting section of track O s a circuit is closed as follows: from the upper section O s by conductor 114, through the magneto generator, thence out by conductor 117, through electro-magnet O^3, upward and to the right by conductor 117 to the lower section of the tracks through the balls. This energizes the electro-magnet O^3, lifts the armature lever o^3 to its upper position and permits the armature lever m^{31} to lock it in that position; at the same time it elevates through the link E B all of the accumulator switches or gates guarding the approach to No. 1's track-way. By the rupture of the circuit between the armarture o^3 and conductor 115 the release of the balls B^2 B^2 on the accumulator of the fourth tier is prevented by the further advance of the rotary drum $D^2 R^2$. In other words, before the contact brush j^6 on the left is put into contact with that spirally disposed strip on the drum $D^2 R^2$ which makes circuit connection to the right hand ring h^2, brush i^2 and conductor 115^e running to the upper electro-magnet N′ and upper ball ejecting magnets P′ of the fourth tier the circuit has been interrupted by the balls just released as they pass over the short section O s of track from the accumulator of the third tier. They will remain, therefore, in their locked position until they have been automatically released by the ringing off of either subscriber No. 1 or the subscriber who has just called him. It will be apparent therefore that no matter how many sets of balls may be in position upon any or all of the accumulators of the different tiers there can be no interference of signals and only one pair of balls can be released at a time.

From the previous description of that part of the apparatus covering the switch board or switch boards, it will be noticed that when a preliminary signal was turned in by any subscriber wishing to make connection with another subscriber, the first act done was to raise the track sections T S of the calling subscriber across the whole of the switch board through the agency of the electro-magnet M^{20}. It will also be remembered that when a pair of circuit closing balls were caused to be directed over any particular runway or chute, they eventually found their way to their particular destination and in falling on to the proper contact plates of the switch board under an elevated track section, they, by that act closed the circuit of a local battery through two yielding contact springs which caused the whole of the cross track sections of the calling subscriber to be lowered so that other circuit closing balls running to cross sections near the extreme edge of the switch board might afterward run over them to their points of destination beyond. It will also be remembered that when a subscriber called for some other subscriber who at that time was talking, the circuit closing balls released by the former went on to the accumulator of the latter. Therefore if the calling subscriber, who in the meantime would have been notified of the fact of his circuit closing balls having gone on said accumulator, wished to await his turn for conversation he did not release or ring off thus leaving his apparatus in a certain condition, one feature only of which need be noticed here, and that is the feature of his, the calling subscriber's, individual track section it having been left in an elevated position across the whole of the switch board.. If, now, while awaiting his turn for conversation some one else should turn in a call for some other subscriber whose line was not in use at that time and whose cross connection with the line called was at a point beyond that of the elevated gateway in the line of the runway over which the circuit closing balls would pass, they, the balls of this additional calling subscriber might and would if the office were busy, run under some other track section and obtain a wrong connection. To prevent any possibility whatever of this ever happening even at the busiest times when the switching mechanism at the central station may be all or nearly all in use, I provide an arrangement of individual track sections as shown in Fig. 15 where 1^R, 2^R, 3^R and 4^R are the approachers of the track sections of telephone subscribers 1 to 4 inclusive, and R' S', R^2 S^2, R^3 S^3 and R^4 S^4 are the accumulators of their rsspective tracks. One set of these several approaching runways is connected in multiple arc relation with a conductor 125 running directly to one pole of the magneto generator, the other sides thereof being connected respectively through conductors 127, 128, 129 and 130 in multiple arc relation with individual electro-magnets M^{20}, one for each track section of the entire switch board, the terminals of these conductors 127, 128, 129 and 130 being connected to normally open contact points located in alignment with conducting springs carried at the ends of armature levers m^{32} adapted to be operated by electro-magnet M^{32}, one for each cross connected conductor, each electro-magnet M^{32} being in circuit 33—15 of the preliminary signal circuit of each subscriber.

M^{33} are switching release magnets located in the branches 127, 128, 129 and 130 connected to the armature levers m^{32} at one end and at the other end to a common return conductor 126 running to the magneto.

The operation of the track section in such a system is distinctly individual and I have shown in Fig. 15 connections and cross connections for four subscribers, it being understood of course that a system for a larger number of subscribers embraces a mere extenuation of the parts therein shown.

I will now give an illustration of elevating a single track section of the person calling for the admission of circuit closing balls beneath such elevated track section to the contact plates whereby the necessary connections are made between the calling and the called subscribers. I will suppose that subscriber No. 1 has called subscriber No. 2. The act of turning in the preliminary signal operated the switch electro-magnet M^{32} at the extreme right of Fig. 15 which electro-magnet is in circuit 33—15. Consequently the armature m^{32} was tilted into the position there shown so that its contact spring is in electrical contact with conductor 127. I will suppose that the apparatus heretofore described has gone through the several functions of making the necessary circuit connections through the percentage circuit selector until the balls have been released by the time relay for the numerical receiver switch and that they have traveled down the arms A of the numerical receiver switch and are just entering upon the runway or chute 2^R of subscriber No. 2 just in advance of the accumulator switch or gate of subscriber No. 2 as shown in Fig. 15. I will first suppose that the line of subscriber No. 2 is not in use and hence that the accumulator switch or gate is down so that the balls will pass forward directly to their destination on the switch board. As they enter the section of track 2^R they close a circuit as follows: by conductor 125 to one pole of the magneto generator, thence by conductor 126 through conductor 127, release electro-magnet M^{33}, conductor 127, armature m^{32}, contact spring carried thereby, conductor 127, electro-magnet M^{20} of No. 1's cross-way on No. 2 track, thence back by conductor 128 through the balls and to the starting point. This elevates the individual track section T S of subscriber No. 1 on the runway of subscriber No. 2 only and leaves all other track sections of No. 1 unaffected. At the same time by the energizing of the electro-magnet M^{33} the armature m^{33} was drawn forward, thereby releasing the

armature m^{32} of the electro-magnet M^{32} restoring it to normal position. When the balls ran into their final resting place upon the contact plates $c\ p$, $c'\ p'$ they closed a circuit through a release electro-magnet as before, thereby releasing the track section just referred to and allowing it to return to its normal position. I will suppose now that subscriber No. 3 called subscriber No. 2 during the time that subscriber No. 1 was talking with subscriber No. 2. The preliminary signal sent by subscriber No. 3 closes a circuit through his corresponding set of conductors 33—15 and corresponding electro-magnet M^{32} thereby elevating his armature lever m^{32} and placing the contact spring carried thereby in connection with conductor 129. As the balls pass and enter No. 2's runway 2^R a circuit is closed therefore through conductor 125, the magneto generator, conductor 126, conductor 129, release electro-magnet M^{33}, conductor 129, armature lever m^{33}, conductor 129 through electro-magnet M^{20} of No. 3's cross-way and No. 2's track back by conductor 128 through the balls to the starting point. This elevates the particular track section of No. 3's cross-way in No. 2's runway only. Inasmuch as No. 1 is talking with No. 2, however, it will be remembered that the accumulator switch or gate of No. 2 is elevated so that the balls released by No. 3 will now pass on to the accumulator $R^2\ S^2$ of subscriber No. 2 and remain there until released, after which they will run down in the same manner as heretofore described, pass directly over track section of No. 1 cross-way in No. 2 runway which now is closed to their final destination beneath the track section of No. 3 cross-way which now is raised and closing this track section above them in the same manner as before described. In like manner any one of the individual track sections of any subscriber's cross-way may be actuated by the circuit closing balls on any other runway, and there is no possibility of any confusion.

I do not limit myself to the specific details of construction herein shown and described for effecting the several results sought and obtained.

I believe it is broadly new with me to store up or distribute incoming signals to individual parts of a central station switching apparatus so that a limited number of circuit changing or switching devices may be utilized on a percentage basis for effecting the total connections for a large system of lines, and my claims in this particular are to be construed as of such scope as will cover the application of the generic principle disclosed without regard to any special means. I believe it is also new with me to store up individual signals or calls at an exchange and to permit them to be automatically transmitted to the individual or person called when he shall be ready to receive them, and this without relation to any special form of mechanism for accomplishing such result. Nor do I limit myself to the special type of movable or moving circuit closers herein shown and described, nor to the particular means of conveying said movable circuit closers to the points of connection between any of the lines. I believe I am the first to adopt a series of movable or moving circuit closers provided with automatic means of conveyance adapted to dispose of or place the movable circuit closers in the required relation to connect outlying subscribers' lines, and my claims in this particular are to be construed as covering broadly the automatic disposition of movable circuit closers adapted for use in any order at will. Nor do I limit myself to the automatic application of this feature of movable balls or equivalent circuit closers as they might obviously be thrown by hand into the conveyers or chutes and thus caused to make the required connections, and my claims comprehend this feature also. I also contemplate using any number of balls or movable circuit closers, one or more, although I prefer to use pairs thereof.

I make no claim in the present application to any of the methods which underlie the application of the generic principles hereinbefore described as the present appplication is directed broadly to means only for effecting the application of such principles, while the methods referred to in this disclaimer are made the subject matter of a divisional application filed by me in the United States Patent Office on the 23d day of November, 1893, and bearing Serial No. 491,794, said application being directed wholly to methods underlying the application of the generic principles hereinbefore enumerated.

Having thus described my invention, what I claim, and desire to secure by Letters Patent of the United States, is—

1. An automatic exchange system for effecting intercommunication between any two of a series of telephone or analogous electrical circuits comprising a portable circuit closer adapted to be controlled by all of the incoming lines in common, in combination with means for conveying it to a point where it will unite the two lines to be connected.

2. An automatic exchange for effecting intercommunication between any two of a series of telephone or analogous electrical circuits comprising means whereby two portable gravity actuated circuit closing agents are released at will by any of the calling subscribers and are directed by their own weight to two points where they unite the two lines to be connected.

3. An automatic telephone exchange comprising telephone lines, signal storing mechanism, signal distributing mechanism and means for thereby uniting the lines in individual pairs.

4. An automatic telephone exchange having a series of runways conveyers or chutes, circuit closing agents adapted to be conveyed by said runways conveyers or chutes and accumulators or waiting tracks having switches

or gates adapted when moved from their normal position to divert the circuit closing agents from their normal paths to said accumulators or waiting tracks; together with means whereby one of the signal impulses from a signaling subscriber causes his accumulator switch or gate to be moved from its normal position for the purpose of preventing interference by other signaling subscribers.

5. An automatic telephone exchange provided with a call accumulator or waiting track for storing movable circuit closing agents when diverted from their normal path by a controlling switch or gate, together with means for restoring said controlling switch or gate to its normal position by the turning in of a release or ringing off signal by a telephone subscriber.

6. An automatic telephone exchange provided with call accumulators or waiting tracks and accumulator switches or gates for diverting movable circuit closing agents from their normal paths to said accumulators or waiting tracks; together with means for retaining and ejecting the stored agents and for causing the releasing or ringing off signal to liberate the stored agents automatically and direct them to their ultimate destination.

7. An automatic telephone exchange having a series of runways, conveyers or chutes and circuit closing agents adapted to be conveyed by said runways conveyers or chutes, together with a call accumulator consisting of a track adapted to store or hold in check the circuit closing agents when diverted from their normal path and having means for afterward restoring them to said normal path; said call accumulator being normally disconnected from all of the outlying telephones and connected with individualizing mechanism whereby it may be operatively connected to any of the outlying telephones for the purpose of automatically transmitting a signal from the central exchange.

8. An automatic telephone exchange system provided with a main track having above or near it a second or accumulator track, together with means for automatically switching moving circuit connecting agents from the main track to said accumulator track.

9. An automatic telephone exchange system having an accumulator switch or gate provided with a releasing mechanism a ball ejecting device and circuit connections whereby the releasing mechanism and ball ejecting device will operate simultaneously.

10. An automatic telephone exchange system provided with a main track having above or near it a second or accumulator track, and having means for automatically switching moving circuit connecting agents from the main track to said accumulator track, together with additional means whereby circuit connecting agents may be liberated and allowed to return to the main track.

11. An automatic telephone exchange system provided with a series of runways conveyers or chutes, circuit closing agents adapted to be conveyed by said runways conveyers or chutes, and accumulator switches or gates for the purpose of diverting said circuit closing agents when a subscriber is signaling or talking.

12. An automatic telephone exchange system provided with duplicate series of tiers or planes of individual runways conveyers or chutes for the conveyance of movable circuit closing agents, and having means whereby when one set of movable circuit closing agents has entered on one of said individual runways conveyers or chutes the corresponding individual runways conveyers or chutes of the remaining tiers or planes will be temporarily closed.

13. An automatic telephone exchange having a series of runways conveyers or chutes and circuit closing agents adapted to be conveyed by said runways conveyers or chutes, together with a call accumulator consisting of a track adapted to store or hold in check the circuit closing agents when diverted from their normal path and having means for afterward restoring them to said normal path; said call accumulator being normally disconnected from all outlying telephones and connected with individualizing mechanism whereby it may be operatively connected to any of the outlying telephones and a releasing device placed in circut therewith.

14. An automatic telephone exchange system provided with a series of portable circuit closing agents controllable by all of the incoming lines in common, and having electromagnetic mechanism together with circuit connections for holding said agents in check.

15. An automatic telephone exchange system provided with a series of portable circuit closing agents controllable by all of the incoming lines in common, and having electromagnetic mechanism and circuit connections for holding said agents in check together with additional means for starting them on their journey when released.

16. An automatic telephone exchange system provided with a series of broken tracks connected through switching mechanism to an outlying telephone, a magneto generator, a circuit closer adapted to run over said tracks and means for signaling each individual subscriber to the exclusion of all other subscribers, the form of the signal depending upon either the length or the number of broken tracks, or both.

17. A series of rocking armatures arranged radially and having each a contact spring on its inner end normally out of engagement with fixed corresponding contact strips when any one of said armatures is rocked out of its normal position, in combination with a revolving arm carrying two electro magnets, one having circuit connections for rocking into engagement that armature over which it is pass-

ing, when energized, and the other having circuit connections for afterward reversing the position of said armature.

18. A telephone exchange system comprising a series of telephone lines, a switching apparatus for connecting any two lines together, means for storing up signals for lines in use at the time additional signals are sent in and additional means for causing the stored up signals to be properly received and to effect the required ultimate connections substantially as described.

19. A telephone exchange system embracing two or more normally disconnected lines or circuits, means for receiving signals and effecting interconnection between any two lines and additional means for storing up such signals when the subscribers called are busy; said storing up means being also adapted to release the stored up signals in sequence when the signaled subscriber is ready to receive them, substantially as described.

20. An automatic telephone exchange system provided with duplicate series of tiers or planes of individual runways conveyers or chutes for the conveyance of movable circuit closing agents and having means whereby when one set of movable circuit closing agents has entered one of said runways conveyers or chutes the corresponding individual runways conveyers or chutes of remaining tiers or planes will be temporarily closed, and additional means for re-opening said individual runways conveyers or chutes successively on various tiers in consecutive order.

21. An automatic telephone exchange system having call accumulators and accumulator switches or gates in combination with means whereby one of the signal impulses from a signaling subscriber will cause his individual accumulator switch or gate to be moved for the purpose of storing incoming calls for said signaling subscriber.

22. An automatic telephone exchange system provided with runways conveyers or chutes and having circuit closing agents adapted to run over or through said runways conveyers or chutes, together with means whereby a calling subscriber may liberate one or more of such circuit-closing agents for one of said runways conveyers or chutes for the purpose of effecting a connection with another subscriber, and additional means for causing said circuit closing agents to elevate the accumulator switch or gate of the individual track over which they have been directed.

23. A series of numerical receiver switches of the second order with individual conductors leading from contact points in the path of a contact brush carried by a numerical receiver switch of the first order, in combination with a conductor leading to said numerical receiver switch of the first order, said conductor including in its circuit a time relay or separator for automatically changing the circuit out of the numerical receiver switch of the first order to and through that one of the numerical receiver switches of the second order corresponding with the connection to the contact point on which said contact brush rests or with which it is in electrical connection.

24. An automatic telephone exchange system provided with a per-centage circuit-selector having a capacity in proportion to the estimated maximum number of calls likely to be received at one time consisting of a revolving drum or cylinder carrying contact strips insulated from each other, adapted to be put into electrical connection with each incoming line successively, each of said contact strips being electrically connected through an electro-magnet carried by a revolving arm over a series of contact makers, together with electro-mechanical means and circuit connections whereby the first contact strip not in use, which is rotated into electrical connection with a signaling subscriber, will be seized and held by said subscriber, leaving the remaining contacts and connections for other signaling subscribers.

25. An accumulator track or pair of runways, one runway of a pair being connected to one pole of an electrical generator the other runway being broken into sections insulated from each other and connected by electro-magnetic switching mechanism to and through the call bell of an outlying telephone to the other pole of said electrical generator.

26. A telephone exchange system provided with a series of subscribers' lines; electro-magnetic calling mechanism at each subscriber's station, a calling electrical generator at the exchange, automatic means for connecting the generator to any pair of lines and through both sets of calling mechanism, automatic mechanism also at the exchange for connecting the lines together in independent pairs, and means at each subscriber's station whereby any subscriber may connect his line with that of any other subscriber, ring both alarms, hold conversation with the subscriber called and afterward restore his switching mechanism to its normal condition.

27. A series of rocking armatures arranged radially in a plane, each armature having contacts at either end adapted to simultaneously connect the outer end to a pair of individual telephone wires and the inner end to another pair of wires leading to switching mechanism.

28. A telephone exchange system provided with a series of subscribers' lines, a series of runways, conveyers or chutes, circuit closing agents adapted to run thereon and electro-magnetic mechanism and circuit connections for connecting independent pairs of lines together simultaneously, in combination with means for preventing a third subscriber from interfering with connected lines, consisting of a series of mechanical switches for diverting an interfering circuit-closing agent from the individual runway conveyer or chute, and means at each subscriber's station for controlling said automatic mechanism.

29. One or more tiers or planes of circuit selecting apparatus, each tier governed by two electro-magnetic switches, and circuit connections whereby when the controlling switch has seized its tier or plane of circuit selecting apparatus it will automatically place in circuit the other switch for the purpose of afterward releasing the tier and restoring it to general use.

30. A revolving arm carrying a contact brush against a fixed commutator having contact strips of enlarged section at one end in conjunction with a series of radially disposed rocking armatures carrying contact springs adapted to engage with the enlarged ends of the contact strips on said commutator, together with a pair of electro-magnets carried by a revolving arm over the inner ends of the said armatures for the purpose of tilting them into engagement with the enlarged ends of the commutator contact strips.

31. A series of movable circuit closing agents adapted to connect two lines or circuits together electrically, in combination with a return runway conveyer or chute and an elevator for restoring them to their normal position.

32. An automatic telephone exchange system provided with a numerical receiver switch having a pivotal cup or open sided pocket adapted for the reception of metallic or other circuit closing agents, in combination with a directing track or pair of arms along which the circuit closing agents move after they fall into the cup.

33. An automatie telephone exchange system provided with a numerical receiver switch having a pivotal cup or open sided pocket adapted for the reception of metallic or other circuit closing agents, a directing track or pair of arms along which the circuit closing agents may be directed, and means for bringing the free ends of the directing track or arms opposite any point in their radial path.

34. An automatic telephone exchange system provided with a numerical receiver switch operatively controlled step by step by an electro-magnet, and having a pivotal cup for the reception of metallic or other circuit closing agents, with a directing track or pair of arms along which the circuit closing agents may be directed, together with a contact spring carried by one of the said arms adapted to make electrical contact with any one of a series of contact plates lying in its radial path.

35. A telephone exchange system embracing a series of telephone circuits and provided with means for distributing incoming signals to the unused sections of a per-centage signal receiving apparatus, said means consisting of a revolving cylinder carrying spirally disposed contact strips adapted to be brought into electrical connection with each one of the incoming telephone lines successively, each contact strip having electrical connection with one of a number of duplicate switching apparati, and additional means for transferring such signals to the individual subscriber wanted.

36. A series of radially disposed rocking armatures having contacts on their inner ends adapted to make electrical connection through a pair of common conductors with a switching apparatus connected thereto, a revolving arm carrying an electro-magnet having circuit connections for rocking any of said armatures into engagement with said pair of common conductors and a switch for automatically opening the circuit of said electro-magnet for the purpose of preventing engagement with a pair of common conductors of more than one armature at one time.

37. An automatic telephone exchange system provided with a revolving drum or cylinder carrying a series of contact strips having electrical connection with a series of switching apparati common to all of the incoming lines, in combination with a series of contact brushes held against said cylinder, and such relation of brushes and contact strips as will allow each one of a number of incoming lines to simultaneously make electrical connection with different contact strips and will allow only one contact brush on each contact strip at one time.

38. A numerical receiver switch of the first order, a series of runways conveyers or chutes, a series of numerical receiver switches of the second order, an additional or second series of runways conveyers or chutes, one or more circuit closing agents adapted to be carried by said runways conveyers or chutes, means whereby the circuit closing agent will be directed over one of the first series of runways conveyers or chutes by one set of impulses and then directed over one of the second series of runways conveyers or chutes by a second set of impulses.

39. A numerical receiver switch of the first order, a series of runways conveyers or chutes, a series of numerical receiver switches of the second order, a second series of runways conveyers or chutes, one or more circuit closing agents adapted to be carried by said runways, and means whereby said circuit closing agents are directed over any one of the first series of runways by the numerical receiver switch of the first order to one of the numerical receiver switches of the second order, and additional means for changing the further direction of the circuit closing agents by the movement of any one of the numerical receiver switches of the second order.

40. A numerical receiver switch operatively controlled by an electro-magnet, step by step, a contact brush held against the pivotal part of said switch, a contact spring carried by an arm of said switch passing over and electrically connecting with a series of contact plates lying radially in its path, together with means for changing the circuit automatically out of the operating magnet to and through the pivotal part of the numerical receiver switch to

and through that one of the contact plates with which it may engage and out to the corresponding one of a series of extended electro-magnets controlling other like numerical receivers.

41. An automatic telephone exchange system having a revolving drum or cylinder carrying spirally disposed contact strips insulated from each other and each connected electrically to duplicate sets of electro-magnets carried by revolving arms over duplicate series of rocking armatures, said armatures adapted to be tilted when in the magnetic field of said electro-magnets.

42. A per-centage telephone exchange system comprising a series of telephone lines having each a switch controlling relay in the exchange operatively connected through means for distributing incoming calls in accordance with the capacity of the switching apparatus, said means consisting of a revolving cylinder carrying spirally disposed contact strips adapted to be brought into electrical connection with each one of the incoming telephone lines successively, each contact strip having electrical connection with one of a number of duplicate apparati, and additional means for transferring such signals to the individual subscriber wanted.

43. A telephone system comprising a movable conveying channel, in combination with two or more fixed conveying channels and a movable circuit closing device adapted to move over or through the movable channel and either or any of the fixed channels at will, substantially as described.

44. A telephone exchange system having a series of telephone lines all connected to a switchboard provided with disconnected contacts; a series of portable conducting circuit closers adapted to be controlled by all of the incoming lines in common and to bridge the disconnected contacts; a series of fixed and a series of movable chutes for conveying the circuit closers into electrical connection with the disconnected contacts and additional means for removing and returning them to their starting points.

45. A telephone exchange system comprising a series of runways, conveyers or chutes pivotally secured at one end and having their other ends connected to electro-magnetic mechanism for moving them out of alignment with a fixed series of runways conveyers or chutes into alignment with a second series of fixed runways, conveyers or chutes, in combination with a series of portable circuit closing agents adapted to be conveyed by said runways conveyers or chutes.

46. A series of individualizing switches controlling a series of circuits leading in multiple from an individual runway conveyer or chute to the switching mechanism of two or more subscribers, circuit closing agents adapted to run over said runway conveyer or chute and means whereby any subscriber so connected may move his individualizing switch by turning in a signal, and automatically connect a switching mechanism to the individual runway conveyer or chute.

47. An individual receptacle for holding circuit closing agents adapted to rest in it and complete a circuit between two telephone lines, in combination with two or more broken tracks conveyers or chutes connected to the line of an individual telephone subscriber through an individualizing switch for the purpose of controlling the switching mechanism of, and signaling to, the said subscriber.

48. A telephone exchange system comprising a series of telephone lines, a switchboard having a series of directing runways conveyers or chutes for automatically conveying any of a series of movable circuit closing agents to any part of said switchboard, in combination with two or more duplicate sets of switching mechanism and means for uniting the lines through the switch board simultaneously in pairs in any desired order.

49. An automatic telephone exchange system having a normally open branch circuit from an individual relay to a pair of metallic conductors placed in multiple arc relation to two or more rocking armatures having contact springs adapted to engage with said metallic conductors and from the other ends of the rocking armatures out to one of a series of numerical receiving switches, together with mechanism for allowing only one armature of each tier at a time to engage with one of said pairs of metallic conductors, for the purpose of completing a circuit through one armature of each tier at a time.

50. An automatic telephone exchange system provided with two or more series of rocking armatures arranged radially in planes or tiers having contacts on each end of said armatures adapted to simultaneously connect their outer ends to metallic conductors passing in multiple through the outer ends of such tiers or planes and thence to telephone terminals, and their inner ends on each separate tier engaging with an individual pair of metallic conductors, each pair leading to an individual duplicate set of switching apparatus.

51. An automatic telephone exchange system having two or more terminals from outlying telephones, contact brushes in line with the axis of a revolving drum or cylinder, spirally disposed contact strips carried thereon and insulated from each other, duplicate revolving arms carrying electro-magnets over duplicate tiers of radially disposed series of armatures, together with such arrangements of parts that as each strip carried by the drum or cylinder passes under any one contact brush, the corresponding arm of said strip will simultaneously pass over the armature on that tier corresponding to said brush.

52. An automatic telephone exchange system having a series of electro-magnetic switches, a series of contact brushes arranged in a line with the axis of a revolving drum or cylinder carrying spirally disposed contact strips

insulated from each other, electrical connections from said contact strips to electro-magnets carried by duplicate revolving arms, each arm being located over duplicate tiers of rocking armatures, and circuit connections whereby the controlling switch will not be energized when its brush passes over contact strips connected to tiers in use but will suspend its operation until the first unused strip is in contact with said brush.

53. A telephone switch board having a series of directing ways conveyers or chutes for automatically conveying any of a series of movable circuit closers, controllable by all of the lines in common, to any part of said switch board, together with means for diverting superfluous circuit closers from tracks in use, and preventing more than two telephones from being connected in one circuit at the same time.

54. An automatic telephone exchange system comprising a series of telephone lines, a series of relays, one for each line, a circuit selector or distributing device operatively connected to all of the relays through intermediate connections, a series of numerical receivers each provided with means for controlling the movement of one or more movable circuit controllers, a switch board having switch connections with all of the lines and a series of runways conveyers or chutes for conveying the movable circuit controllers to the points of line connections in the switch board, all acting substantially as and for the purpose specified.

55. An automatic telephone exchange system having a revolving drum or cylinder carrying spirally disposed contact strips insulated from each other, electrical connections from said contact strips to duplicate pairs of electro-magnets carried by duplicate revolving arms over duplicate series of rocking armatures arranged in duplicate planes or tiers, contact brushes arranged in a line with the axis of said drum or cylinder, and tier releasing switches placed in circuit by the energizing of any pair of said electro-magnets for the purpose of automatically releasing that one tier when signaling has gone through it.

56. An automatic telephone exchange system having a revolving drum or cylinder carrying spirally disposed contact strips insulated from each other, electrical connections from said contact strips to duplicate pairs of electro-magnets carried by duplicate revolving arms each located over duplicate series of rocking armatures arranged in duplicate planes or tiers, contact brushes arranged in line with the axis of said drum or cylinder, and circuit breaking switches for isolating one of the planes or tiers as soon as its pair of electro-magnets is energized.

57. An automatic telephone exchange system having a call accumulator normally disconnected from all of the outlying telephone lines and connected with individualizing mechanism whereby said accumulator may be operatively connected to any one of the outlying lines and a releasing device placed in circuit therewith, together with means for automatically reversing the operation of said individualizing mechanism by the transmission of an electrical impulse over the line of the individual subscriber.

58. An automatic telephone exchange system having a revolving drum or cylinder carrying spirally disposed contact strips insulated from each other, electrical connections from said contact strips to duplicate pairs of electro-magnets carried by duplicate revolving arms each over duplicate series of rocking armatures arranged in duplicate planes or tiers, a series of contact brushes arranged in a line with the axis of said drum or cylinder for the purpose of receiving signals from several subscribers (which signals may arrive simultaneously) and for storing and distributing each set of signals individually one after the other to the several unused tiers or planes.

59. Two or more telephone lines connected to a switch board having cross connections, in combination with a series of conducting balls, controllable in common by all of the incoming lines, and runways conveyers or chutes adapted to convey the balls into contact with any pair of cross connections.

60. A telephone exchange system having a series of radiating runways conveyers or chutes, provided with means for connecting them together end to end, in combination with one or more movable circuit closing devices adapted to travel over said runways and be deposited between the disjointed ends of two or more electrical conductors, substantially as described.

61. A telephone exchange system having a series of fixed and a series of movable conveying channels or ways, in combination with a switch board having circuit connections with all of the subscribers' lines, and a series of gravitating circuit closing devices adapted to pass to the switch board contacts by way of the conveying channels, substantially as described.

62. A telephone switch board having a series of directing ways conveyers or chutes for automatically conveying any of a series of movable circuit closing agents, controllable in common by all of the incoming lines, to any part of said switchboard, together with means for diverting additional circuit closing agents from those conveyers that are in use.

63. A switch board for a telephone system having exposed contact surfaces and a series of runways, conveyers or chutes, in combination with a series of conducting balls adapted to descend by gravity into contact with the contact surfaces and additional means for returning the balls to their normal position, substantially as described.

64. A telephone system having a series of telephone exchange lines all connected to a switch board provided with plug holes or ex-

posed contact plates, a series of rolling or movable conducting circuit makers, a series of chutes runways or conductors adapted to convey said circuit makers to and away from the plug holes or contact plates of the switch board, and means adapted to restore them to their normal position, substantially as described.

65. A telephone exchange system having a series of runways conveyers or chutes arranged in increasing radial relation, a series of pivoted runways conveyers or chutes having means for placing them in alignment with the fixed chutes and a series of movable circuit closers adapted to travel in or over said chutes, in combination with a switch board having circuit connections adapted to receive the movable circuit closers from the chutes, as described.

66. A telephone exchange system provided with a switch board having means for connecting it with all of the subscribers' lines, in combination with a series of gravitating movable circuit closers, controllable by all of the lines in common, and means adapted to convey any of said circuit closers to any plug or contact points of the switch board.

67. A series of runways conveyers or chutes pivotally secured at one end and having their other ends connected to electro-magnetic mechanism for moving them out of alignment with a series of runways conveyers or chutes into alignment with another or second series of runways conveyers or chutes, together with a time relay and circuit connections for effecting the switching after the expiration of the time limit.

68. An automatic telephone exchange system having a pair of runways conveyers or chutes one runway conveyer or chute connected to one pole of an electric generator, the other being broken into sections insulated from each other, and connected to and through the energizing magnets of electro-magnetic switching mechanism, together with one or more circuit closing agents and means for directing them over said runway conveyer or chute for the purpose of actuating the switching mechanism of individual subscribers.

69. A telephone exchange system having a series of normally disconnected pairs of subscribers' lines and a series of movable circuit closing devices for affording connection between the lines in pairs, in combination with a series of conveying channels runways or chutes for the movable circuit closers; the conveying channels being arranged so that all of the movable circuit closing devices must pass over the first conveying channel and over only such of the other channels as the numerical order of the signal will determine for the connection of the two lines requiring each other, substantially as described.

70. A telephone exchange system comprising a cross connected switch board, means for connecting the cross connections to outlying lines, in combination with a series of runways, conveyers or chutes and a series of circuit controlling balls, governable by all of the incoming lines in common, adapted to travel on said runways conveyers or chutes and to make circuit connections through the cross connections of the switch board.

71. A series of conductors leading from individual broken tracks runways conveyers or chutes to outlying telephone subscribers, having circuits open at two points, with means for closing circuit at one point by the action of an individualizing switch, and for afterward closing it at the other point by the movement of one or more circuit closing agents.

72. A series of broken tracks runways conveyers or chutes individually connected to the call bells of outlying telephones through switching mechanism, a series of individualizing switches, and means whereby when the circuit closing agents pass over such tracks runways conveyers or chutes none of the call bells will be affected excepting such as may have been previously connected by the movement of their individualizing switches.

73. A telephone exchange system comprising a series of telephone lines connected to a cross connected switch board, movable circuit closers, controllable by all of the incoming lines in common, for completing the cross connections through the board and any two lines of the series, and a series of numerical receivers and runways conveyers or chutes adapted jointly to guide and carry the movable circuit closers to the points of connection which unite the lines of the signaling and signaled subscribers.

74. An electrical circuit including an individualizing switch placed contiguous to an individual runway conveyer or chute adapted to carry a circuit closing agent and means whereby the circuit closing agent as it passes off the runway conveyer or chute will complete the circuit for the purpose of de-individualizing the individualizing switch.

75. A telephone exchange system having a series of telephone lines, a cross connected switch board, a series of conducting balls, controllable by all of the incoming lines in common, and runways conveyers or chutes for conveying said conducting balls to the switch board cross connections, in combination with electro-magnetic means operated by the subscribers for directing the movements of the balls.

76. An automatic telephone exchange system having a series of telephone lines, a cross connected switchboard, a series of runways conveyers or chutes a series of gravitating circuit closers, controllable by all of the incoming lines in common, for affording cross connections at will and electro magnetic switching mechanism controlled by the subscribers and adapted to govern the movements of the gravitating circuit closers so as to connect any two lines at will.

77. A telephone exchange system comprising a series of telephone lines, a switch board

adapted for cross connecting any two lines together in any desired order, means for automatically connecting said lines to the switch board and a series of runways conveyers or chutes having movable circuit closing agents controllable by all of the incoming lines in common and adapted to run over said runways conveyers or chutes for connecting said telephone lines in circuit with each other in independent pairs, and additional mechanism controlled by the subscribers for restoring the line connections to normal condition.

78. An automatic telephone exchange system comprising a series of telephone lines, means for receiving or selecting simultaneously at one receiving point a number of incoming signals and distributing them to different parts of the system, in combination with a series of short radiating switching tracks, a switch board having connection with all of the lines and a series of movable circuit closers, controllable by all of the incoming lines in common, adapted to run over said switching tracks and to make the necessary connections at the switch board.

79. An automatic telephone exchange system having a final talking circuit consisting of a branch circuit at the exchange including a releasing electro-magnet of low resistance, in combination with a runway conveyer or chute and a moving circuit closing agent adapted to run thereon together with additional means for putting the final talking circuit into effect by the movement of the automatically directed circuit closing agent.

80. An individual receptacle for holding movable circuit closing agents and completing a circuit between two telephones or analogous lines, consisting of electrically disconnected metallic plates normally covered by a section of a track runway or chute, said track section adapted, when moved, to intercept the circuit closing agents and direct them into connection with said plates.

81. An automatic telephone exchange system having a series of metallic or other movable conducting circuit closing agents, two or more tiers of duplicate runways conveyers or chutes accessible in common to and adapted for conveying said movable circuit closing agents, in combination with means for restoring the used circuit closers to the several tiers of runways conveyers or chutes.

82. An automatic telephone exchange system comprising a series of telephone lines each operatively connected to means in the exchange for storing calls made by a signaling subscriber for other subscribers whose lines are in use at the time such calls are made.

83. An automatic telephone exchange system having a series of telephone lines each operatively connected to means in the exchange for storing calls made by a signaling subscriber for other subscribers whose lines are in use at the time such calls are made, and additional means for automatically rendering the calls effective as soon as the various called lines are in disuse.

84. An automatic telephone exchange system having a series of telephone lines each operatively connected to means in the exchange for storing calls made by a signaling subscriber for other subscribers whose lines are in use at the time such calls are made, and additional means for automatically rendering the calls effective as soon as the various called lines are in disuse, in combination with means at the exchange for automatically transmitting a pre-arranged signal to a calling subscriber for the purpose of notifying him that his call has been stored.

85. An automatic telephone exchange system having a series of telephone lines each operatively connected to means in the exchange for storing calls made by a signaling subscriber for other subscribers whose lines are in use at the time such calls are made, and additional means for automatically rendering the calls effective as soon as the various called lines are in disuse, in combination with means at the exchange for automatically transmitting a pre-arranged signal to a calling subscriber for the purpose of notifying him that his call has been stored, and additional means for enabling the calling subscriber to cancel his stored call at will.

86. An automatic telephone exchange system having a series of gravitating portable circuit closing agents normally held in check, in combination with a series of runways conveyers or chutes and means for enabling all of the incoming lines in common to release and direct any of the circuit closing agents over any of said runways conveyers or chutes.

87. An automatic telephone exchange system having a series of gravitating portable circuit closing agents for connecting telephone lines together in individual pairs, in combination with a controlling mechanism for said circuit closing agents and means for enabling it to be operated by all of the lines in common.

88. An automatic telephone exchange system having a series of runways conveyers or chutes terminating in a series of track sections, a series of circuit closing agents adapted to be conveyed by said runways conveyers or chutes and a series of receptacles for receiving the circuit closing agents and for closing through them a circuit between two individual telephone lines, said track sections being adapted when open, to intercept circuit closing agents and when closed, to act as runways over which the circuit closing agents may pass without interference when destined for other points.

89. A telephone exchange system having a pivoted runway conveyer or chute, adapted to be placed in alignment with any one of a series of fixed runways conveyers or chutes and one or more movable circuit closers carried by said runways, in combination with a

switch board having cross connections with a series of telephone lines and means for receiving said movable circuit closers as they leave the runways, substantially as described.

90. An automatic telephone exchange system, having a recording device provided with means for automatically recording each individual connection, in combination with electro magnetic mechanism and circuit connection for automatically placing the recording device in circuit as soon as connection is effected.

91. A series of telephone lines connected to a switch board having cross connections, a series of conducting balls for completing connections between any two lines, a series of stationary runways for carrying said balls to the points of cross connection, one or more pivoted runways operatively connected with electro-magnetic mechanism controlled by signals sent over the lines by subscribers, and means for releasing the balls when the pivoted runways have arrived at their proper discharge points, substantially as described.

92. An automatic telephone exchange system, provided with a telephone connection recorder having revolving cylinders carrying impression paper together with a series of individual electro-magnets each having an armature, a lever and a stylus, in combination with means for automatically placing the connection recorder in circuit with individual pairs of connections when such connections are effected.

93. An automatic telephone exchange system provided with a recording device having a movable recording surface and individual record making devices each operatively connected with and controlled by an individual subscriber, in combination with means for automatically placing the record making devices in circuit with individual pairs of connected lines and for causing release signals to operate said record making devices whereby records are made of all connections made through the system.

94. An automatic telephone exchange system provided with a time relay set for any predetermined interval of time and operatively connected with electro-magnetic mechanism for the purpose of liberating one or more movable circuit closing agents.

95. An automatic telephone exchange system provided with a time relay included in the signaling circuit and set for any predetermined interval of time, operatively connected to switching mechanism for the purpose of changing the path of any impulses arriving over said signaling circuit after the expiration of said time limit.

96. A time relay and circuit connections for controlling a two point switch having one point connected to a numerical receiver switch of the first order and the other point connected to one of the numerical receiver switches of the second order.

97. An automatic telephone exchange system provided with a switch board having individual runways conveyers or chutes passing over it, in combination with hinged track sections and means whereby any subscriber on turning in a signal will elevate his individual hinged track section in one of said runways or chutes.

98. An automatic telephone exchange system having an individual track section provided with mechanism and circuit connections for elevating it on the turning in of a signal by an individual subscriber, together with means for restoring it to its normal condition as soon as signaling subscriber has obtained connection with another subscriber.

99. An automatic telephone exchange system having a series of hinged track sections in alignment with fixed track sections and means whereby when any subscriber transmits a set of signals to said exchange one or more circuit closing agents will be liberated, and additional means for elevating the track section of the signaling subscriber only in that runway or chute over which said subscriber has caused his circuit closing agents to be directed.

100. An automatic telephone exchange system, provided with a general recording device operatively connected with each subscriber's line through individual circuit connections, and having additional means for giving it rotary and longitudinal motion, in combination with means for automatically placing the recording device in circuit with individual pairs of connected lines and for causing release signals to operate said recording devices whereby a continuous individual record is kept of all connections made through the system.

101. An automatic telephone exchange system having an individual track section provided with mechanism and circuit connections for elevating it on the turning in of a signal by an individual subscriber, together with means whereby said signaling subscriber may restore his track section to its normal condition at any time after sending in a signal without waiting his turn for connection to the subscriber called.

102. An automatic telephone exchange system having a longitudinal track way consisting of one or more series of broken tracks and having signaling lines connected to them, a series of circuit closing agents adapted to run over said trackway and means for completing a circuit only through such signaling line as has been previously individualized or put into operative connection.

103. An automatic telephone exchange system having a series of runways conveyers or chutes, and a series of movable track sections adapted, when moved from their normal position, to intercept the circuit closing agents, together with means for causing the restoration to normal of the track section through the instrumentality of the intercepted circuit closers.

104. An automatic telephone exchange system having a series of runways conveyers or chutes, a series of incoming telephone lines, each line passing through a circuit controller and being then connected in multiple to all of the runways conveyers or chutes, and a series of circuit closing agents adapted to run over said runways conveyers or chutes, in combination with means provided for enabling each subscriber to effect an operative connection with any track at will.

105. An automatic telephone exchange system provided with a signaling track having a plurality of telephone lines connected to it, in combination with movable circuit closers adapted to run over said track and means for causing a signal to be sent over one line to the exclusion of the remaining lines.

106. An automatic telephone exchange system provided with a series of signaling tracks having a plurality of telephone lines in multiple connection therewith, in combination with movable circuit closers adapted to run over any of said tracks and means for operatively connecting one line to all of the tracks in common, to the exclusion of the remaining lines.

107. An automatic telephone exchange system having a series of main runways or tracks, an additional series of accumulator runways or busy tracks, a series of circuit closing agents adapted to run over any of said tracks and a series of accumulator switches for diverting the circuit closing agents from the main runways to the accumulator runways or busy tracks, in combination with means for causing the circuit closers to automatically signal the subscriber who initiated the movements of said circuit closing agents.

108. An automatic telephone exchange, provided with a series of circuit closing balls, a series of runways or tracks adapted to carry said balls and a pivoted receiving cup provided with means for directing the balls over any of said runways or tracks.

109. An automatic telephone exchange, provided with a series of circuit closing balls, a series of runways or tracks adapted to carry said balls and a pivoted receiving cup provided with means for directing the balls over any of said runways or tracks, in combination with means for automatically restoring the cup to its normal condition as soon as the circuit closing balls pass on to any of said tracks.

110. An automatic telephone exchange system provided with a series of runways or tracks and a series of portable circuit closers, in combination with a series of accumulator switches for diverting the circuit closers from the tracks, said switches being normally inoperative but provided with means for rendering them operative by the passage of circuit closers over any pre-arranged portions of the tracks.

111. An automatic telephone exchange system having a series of subscribers' lines, two or more series of switching mechanisms accessible in common to all of the incoming lines and controlling in common the interconnection of all of the lines, one or more sets of circuit controlling apparatus presented successively to the signaling subscriber for enabling him to select some one of the two or more series of switching mechanism not in use at the time, a series of portable circuit closers, two or more series of duplicate sets of runways conveyers or chutes adapted to convey any of said circuit closers, together with corresponding duplicate sets of cross connecting intercepters and means enabling a signaling subscriber to operate that one of his cross connecting intercepters corresponding with the particular switching mechanism and set of runways selected by him through the instrumentality of that set of circuit controlling apparatus that was operatively presented to him.

112. A telephone exchange system in which the instrumentalities for effecting intercommunication between the lines are divided into independent components and in which the capacity of the exchange is increased without extra mechanism by a proper proportioning of the constituent parts in relation to the length of time each element will be in use when active, consisting of apparatus in operative connection with the signaling lines for selecting a circuit leading to an unused switching series element, apparatus for releasing one of a series of portable circuit closers over any one of a series of runways over which it runs until intercepted by a cross connecting mechanism by which it is caused to interconnect the lines in any desired order and to leave them connected without holding the connecting elements contributing to the various steps of the connection, the arrangement being such that each separate element reverts to common use as soon as it had served its proper function.

113. An automatic telephone exchange system having one or more series of fixed and one or more series of movable runways conveyers or chutes and a series of portable circuit closing agents adapted to run over said runways conveyers or chutes, together with automatic means for aligning the movable runways into such relation with the fixed runways as will determine the direction of the circuit closing agents when they are caused to run over said runways conveyers or chutes.

114. An automatic telephone exchange system having a series of telephone lines, two or more series of duplicate switching mechanisms adapted to be controlled by any subscriber, two or more series of duplicate runways conveyers or chutes having two or more corresponding series of cross connectors in conjunction therewith, together with a series of individualizing switches for rendering operative the cross connectors of that series corresponding to the series of runways over which a signaling subscriber has obtained control.

115. An automatic telephone exchange system having a series of runways conveyers or chutes, portable circuit closing agents adapted to run over any of said runways, a series of telephone lines adapted to control the movement and direction of the circuit closing agents and to be operatively connected each to any one of its individual series of cross connectors extending across the runways conveyers or chutes, together with means for operatively connecting a signaling line to that cross connector of its individual series corresponding to the particular runway selected by said signaling line.

In testimony whereof I have hereunto subscribed my name this 10th day of May, 1893.

ROMAINE CALLENDER.

Witnesses:
C. J. KINTNER,
M. M. ROBINSON.