(No Model.)

12 Sheets—Sheet 1.

R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.

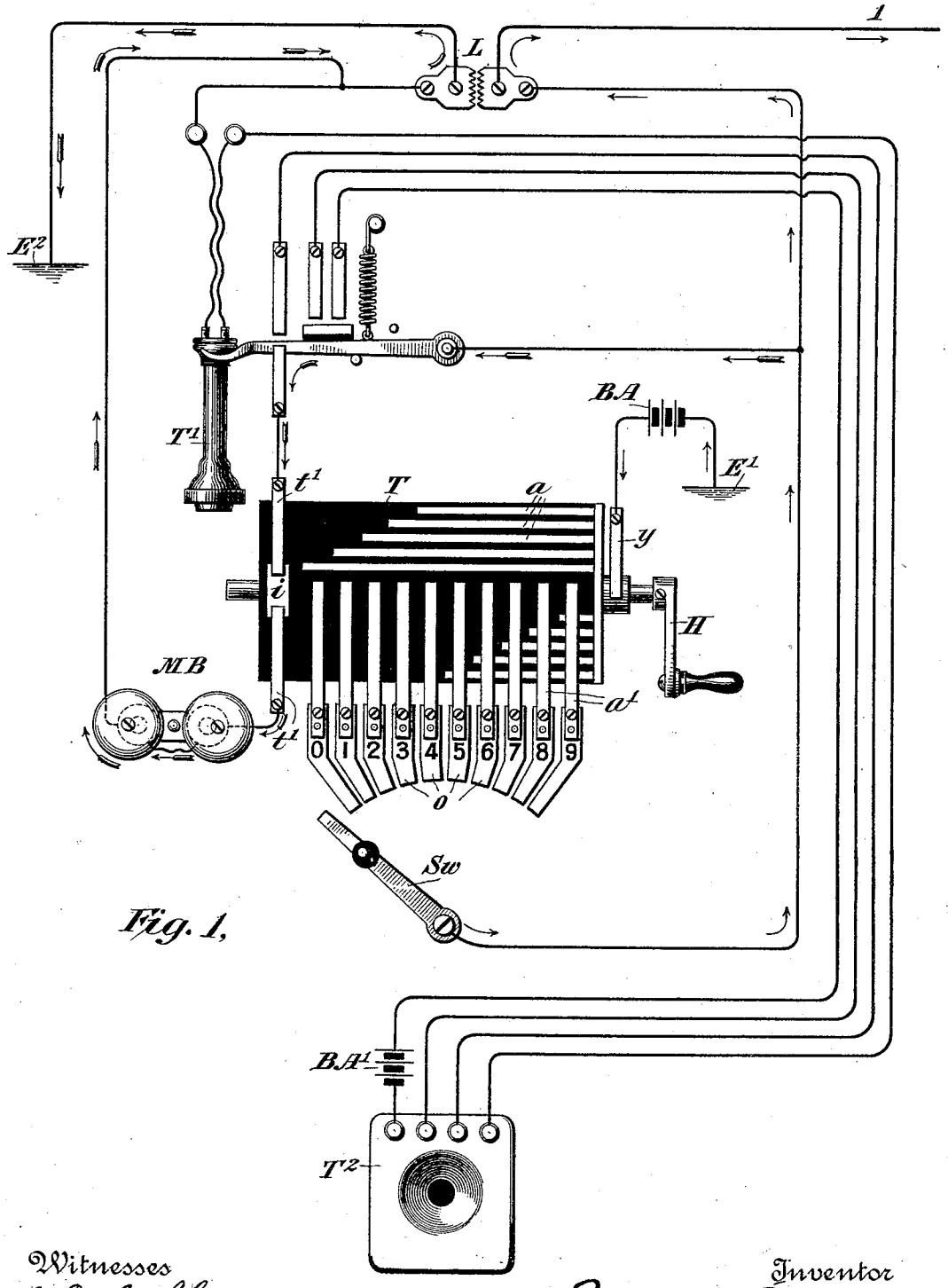

Fig. 1.

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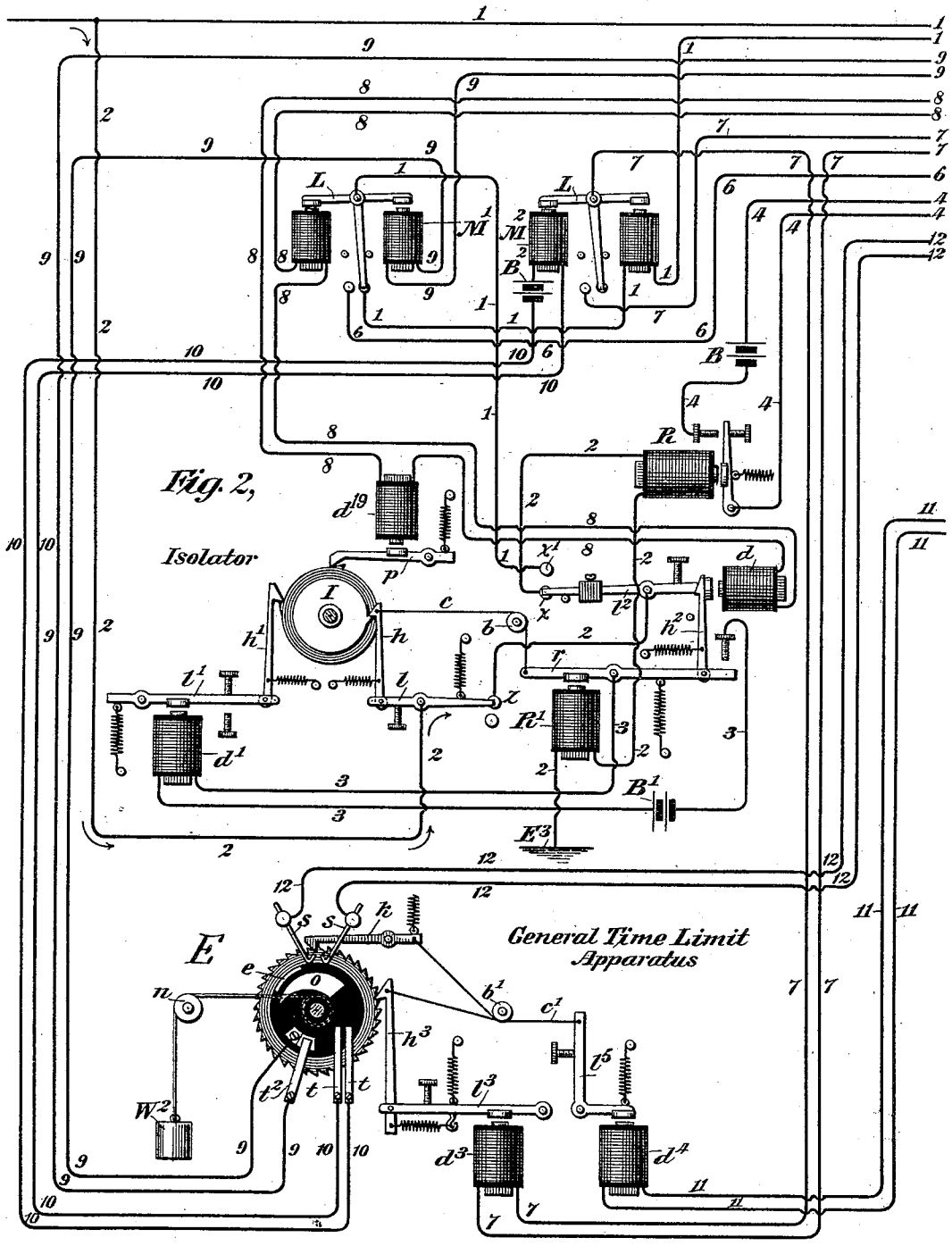
(No Model.)

12 Sheets—Sheet 2.

R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.



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12 Sheets—Sheet 3.

R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.

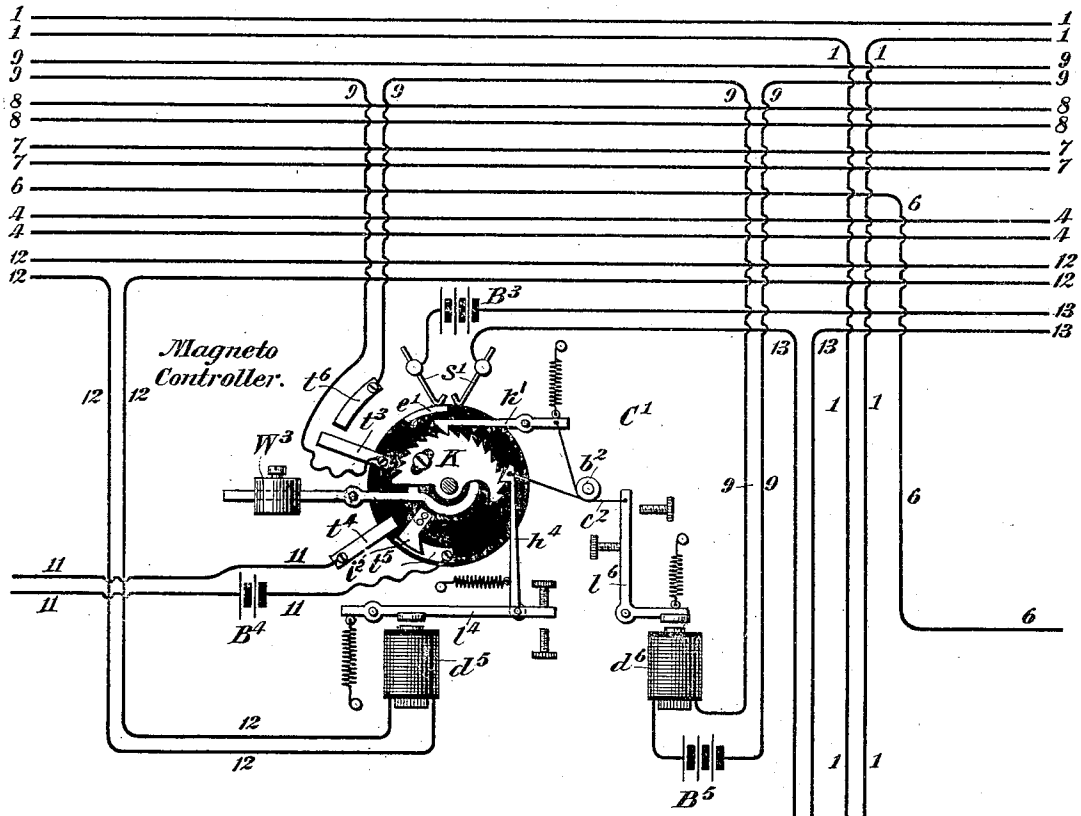

Fig. 3,

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12 Sheets--Sheet 4.

R. CALLENDER.

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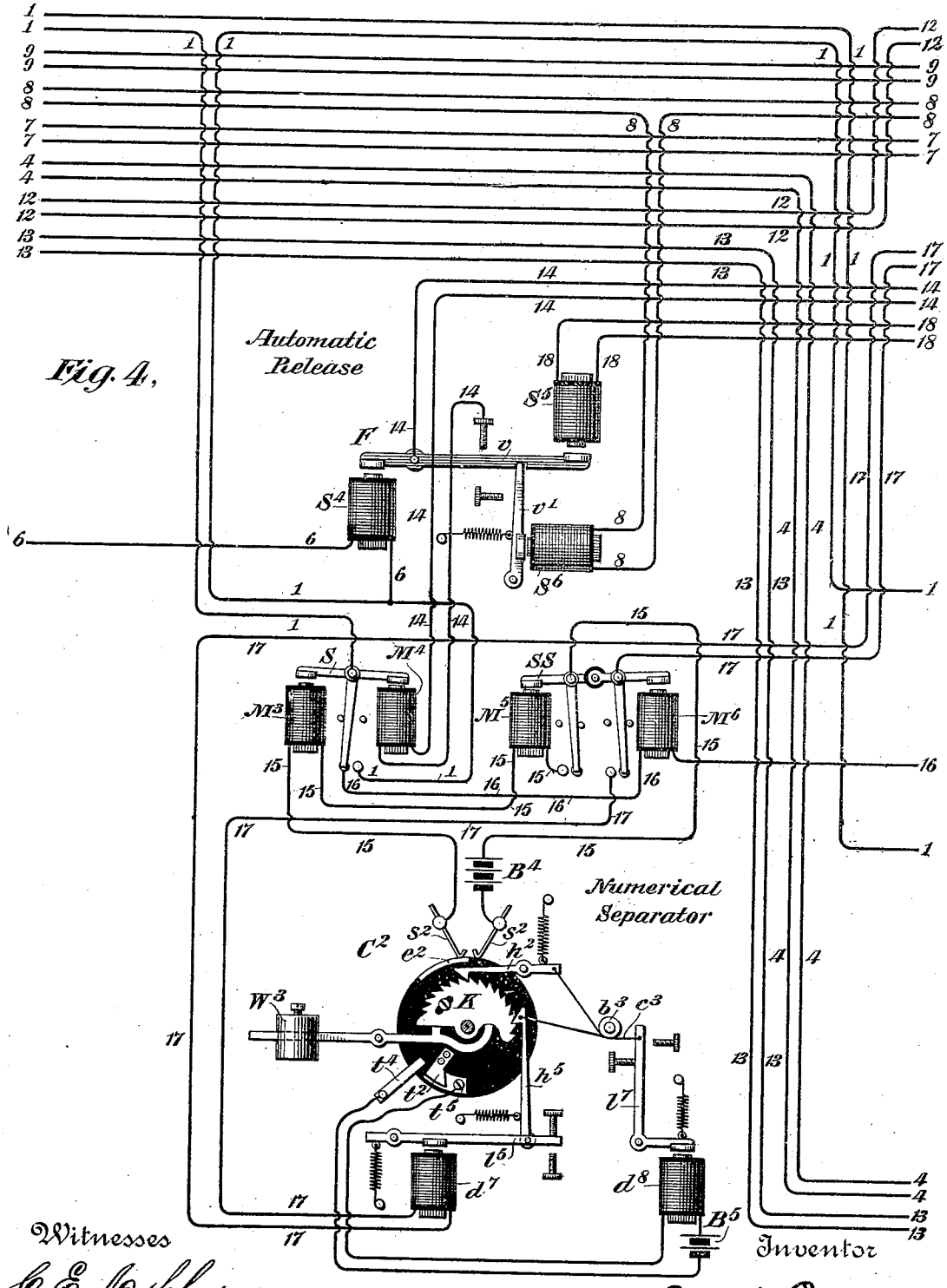
Fig. 4.



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12 Sheets—Sheet 5.

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TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.

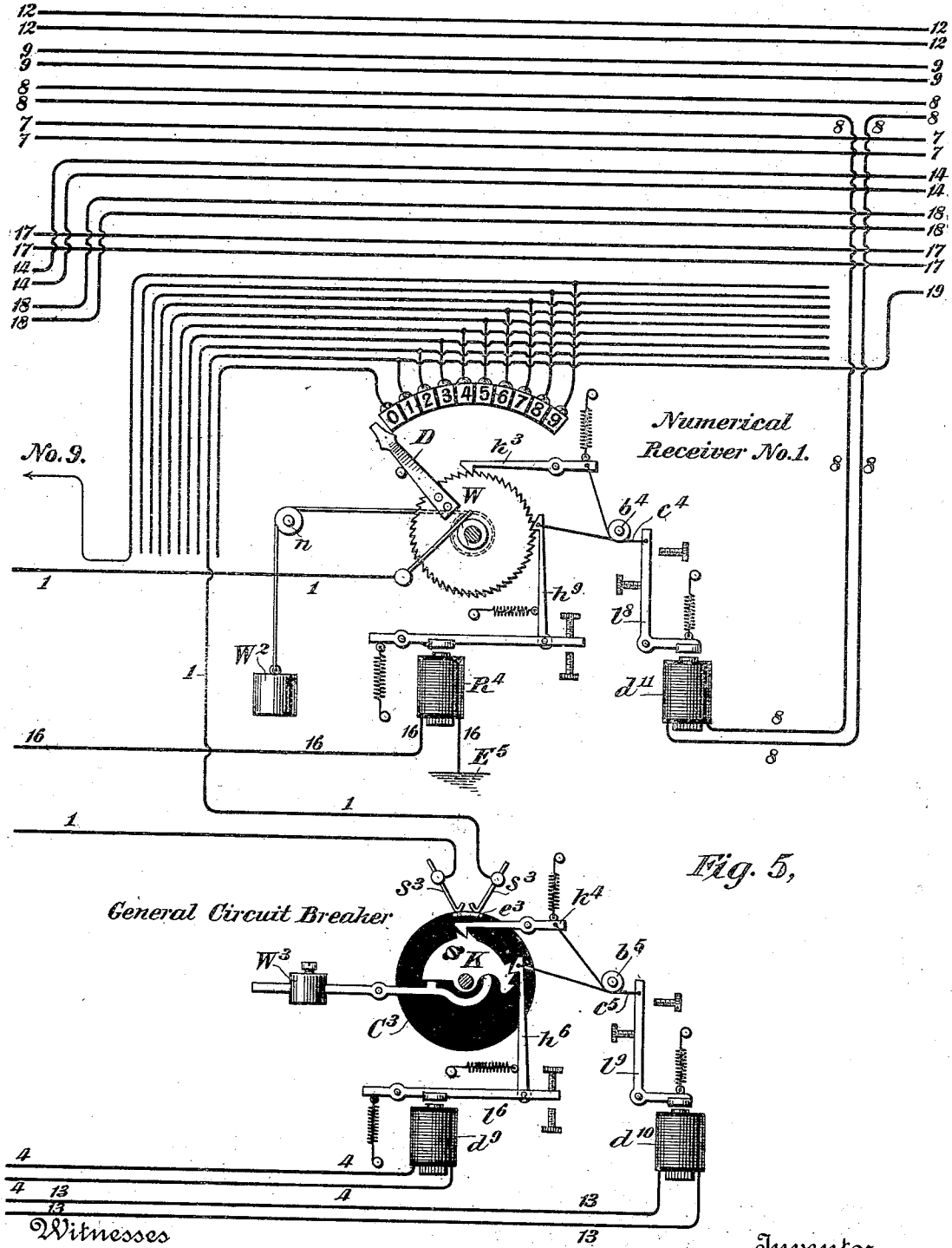

Fig. 5.

Witnesses
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(No Model.) 12 Sheets—Sheet 6.

R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.

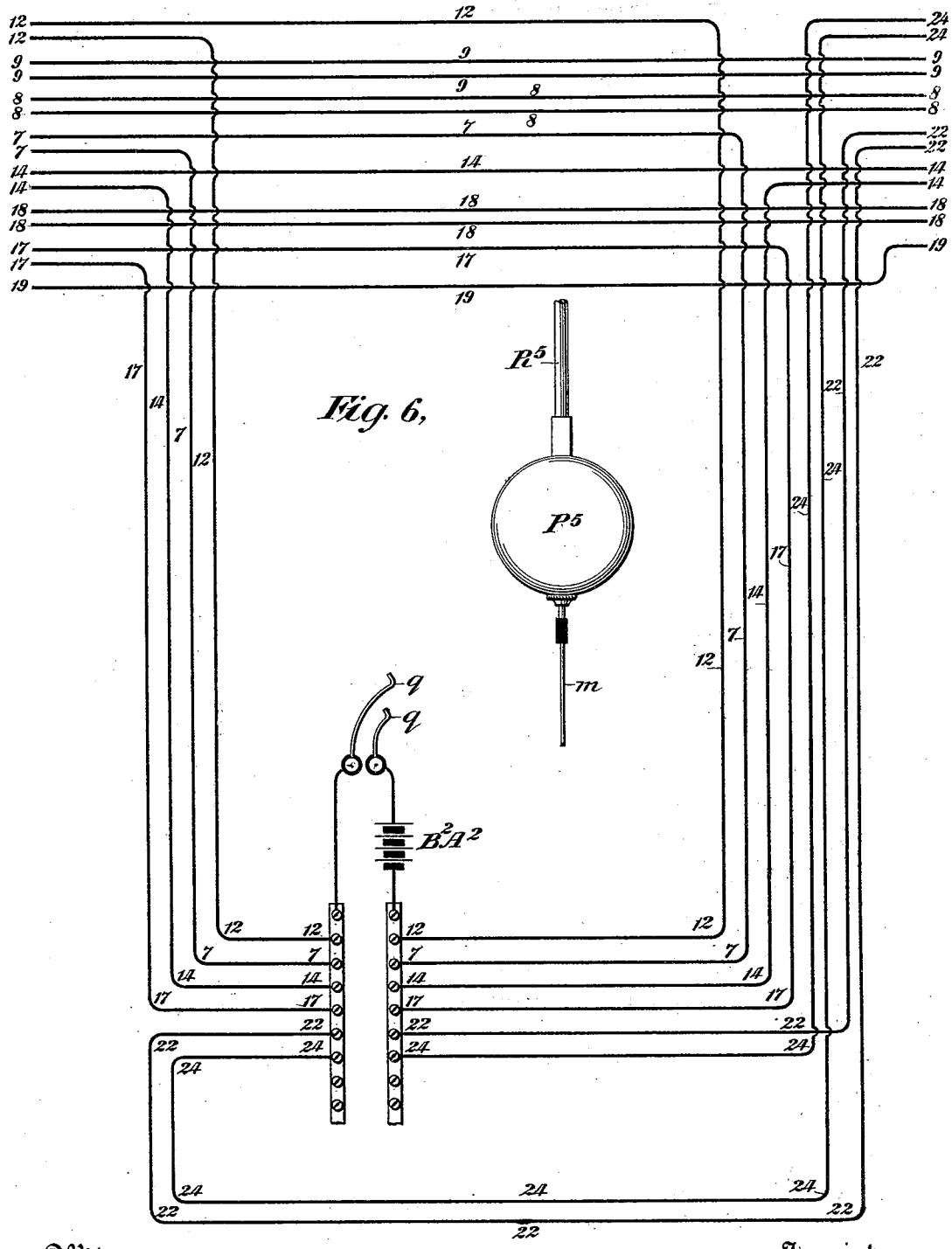

Fig. 6,

Witnesses
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TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.

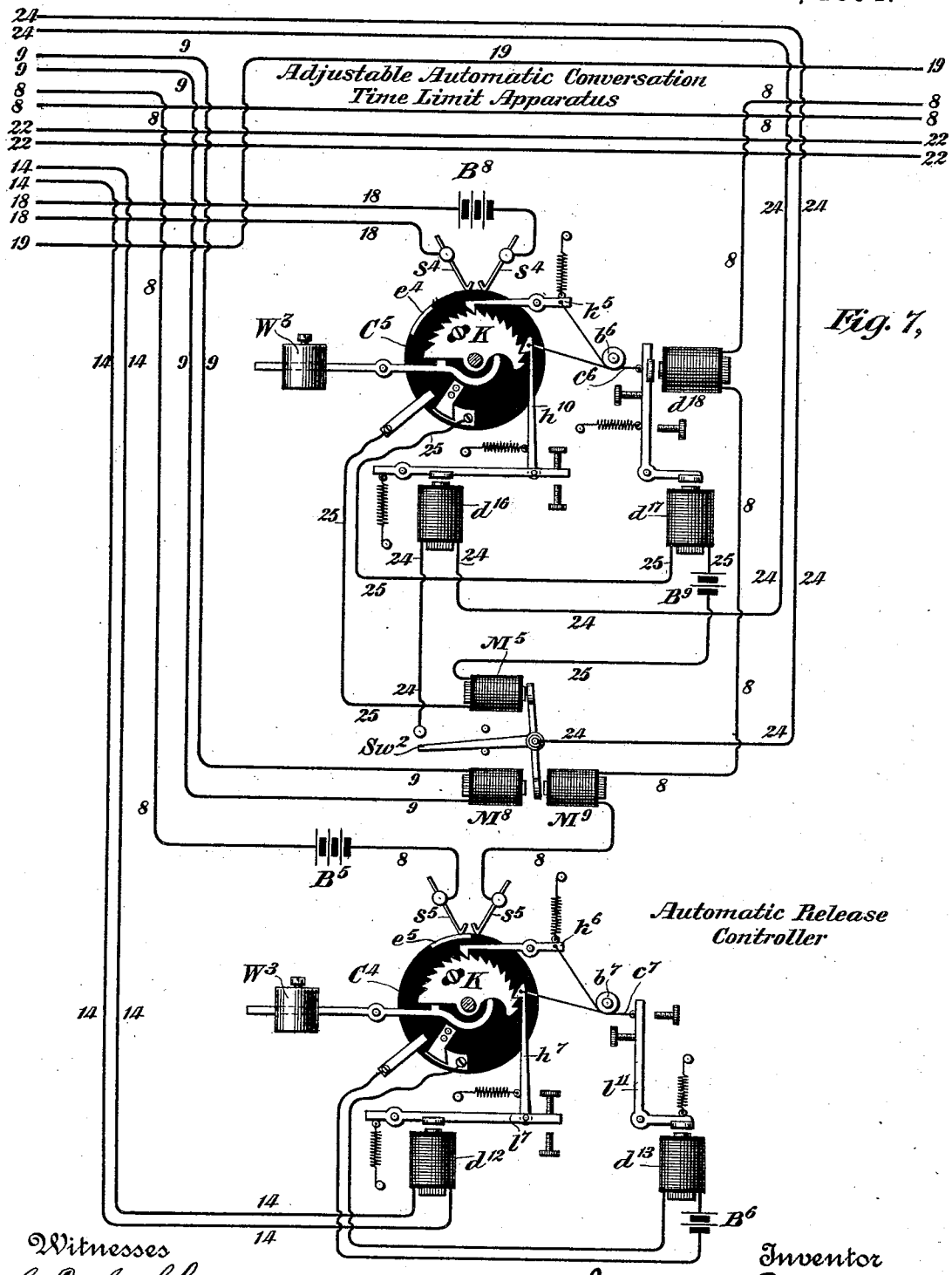

Fig. 7.

Witnesses
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R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.

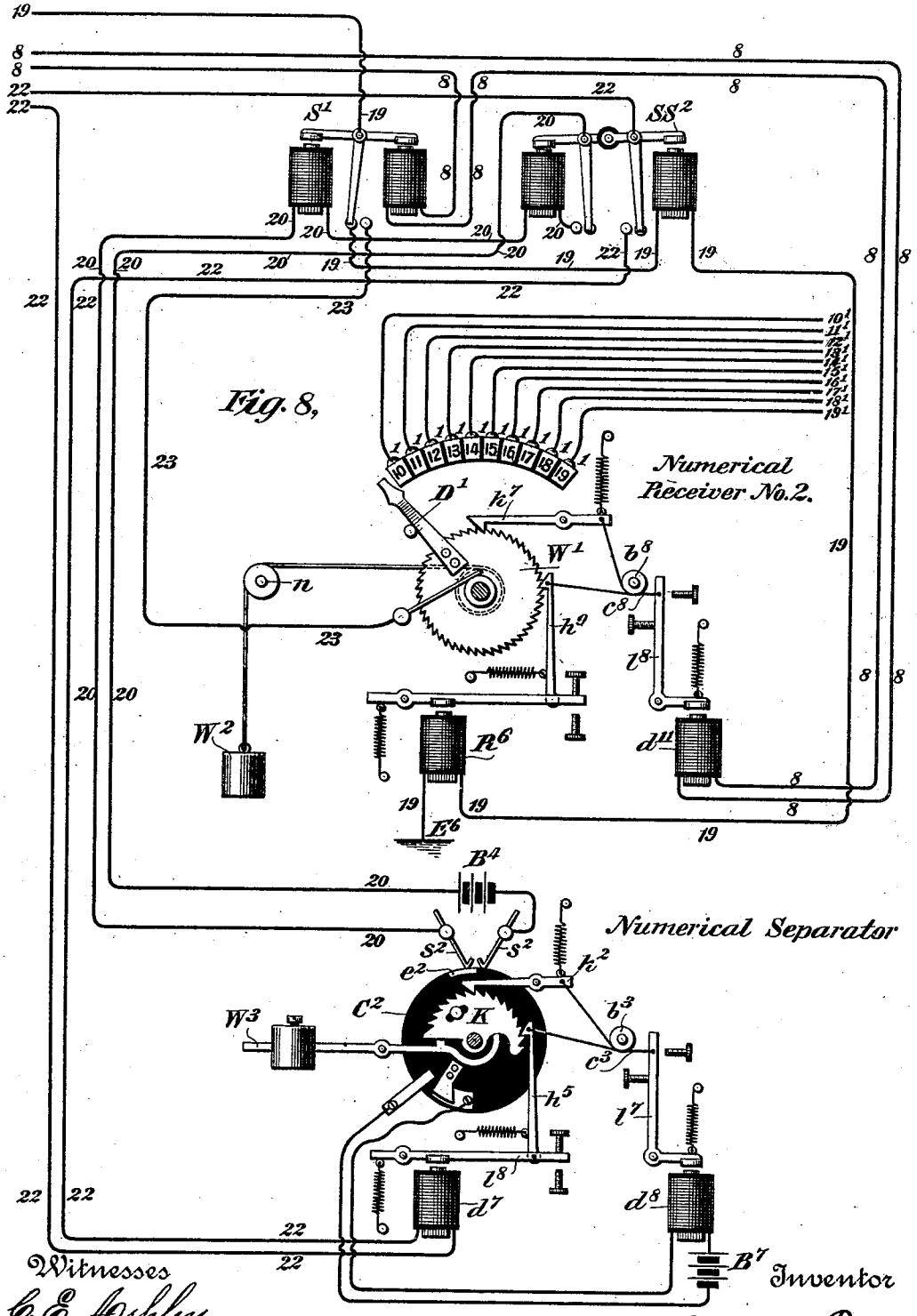

Fig. 8.

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R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.

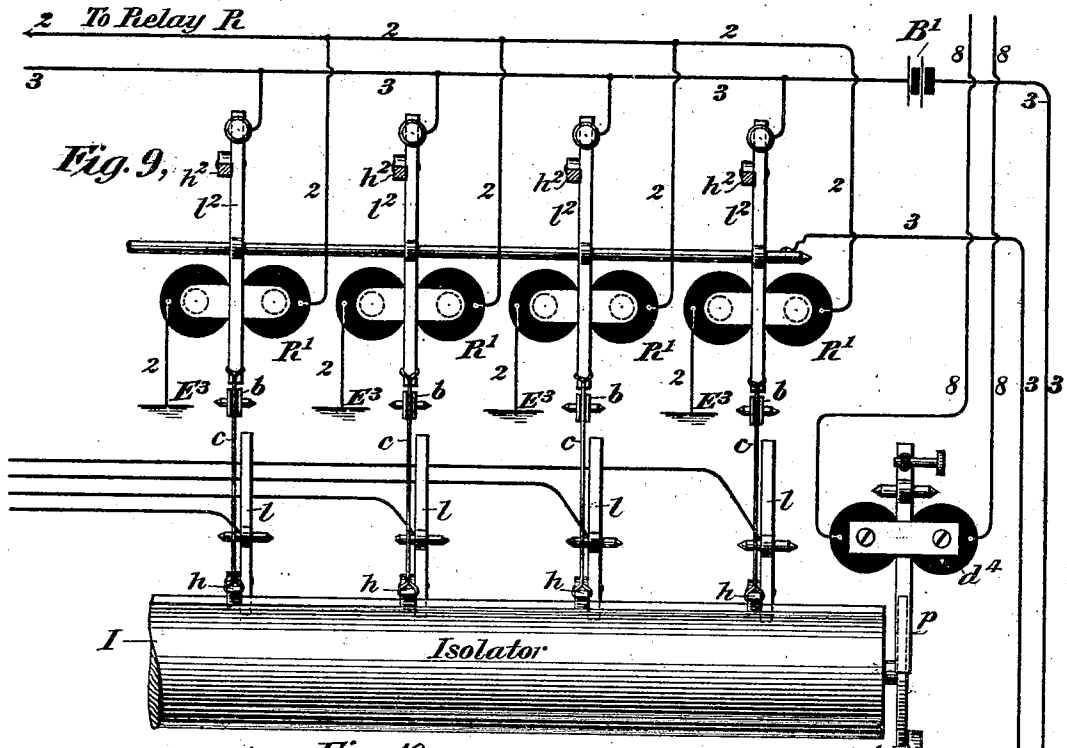

Fig. 9.

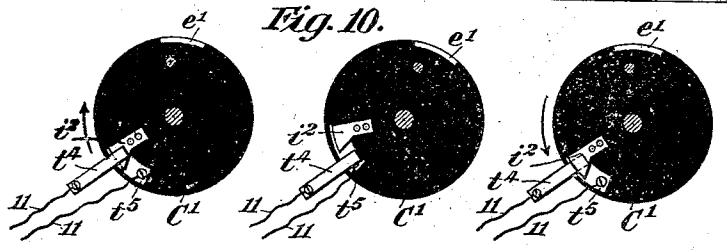

Fig. 10.

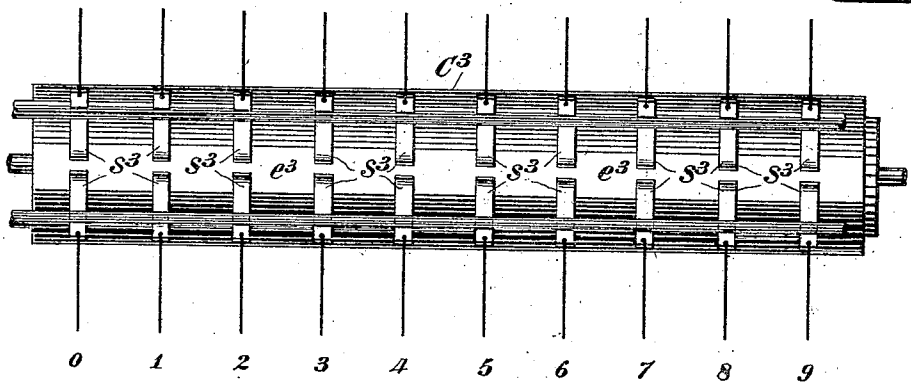

Fig. 11.

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R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

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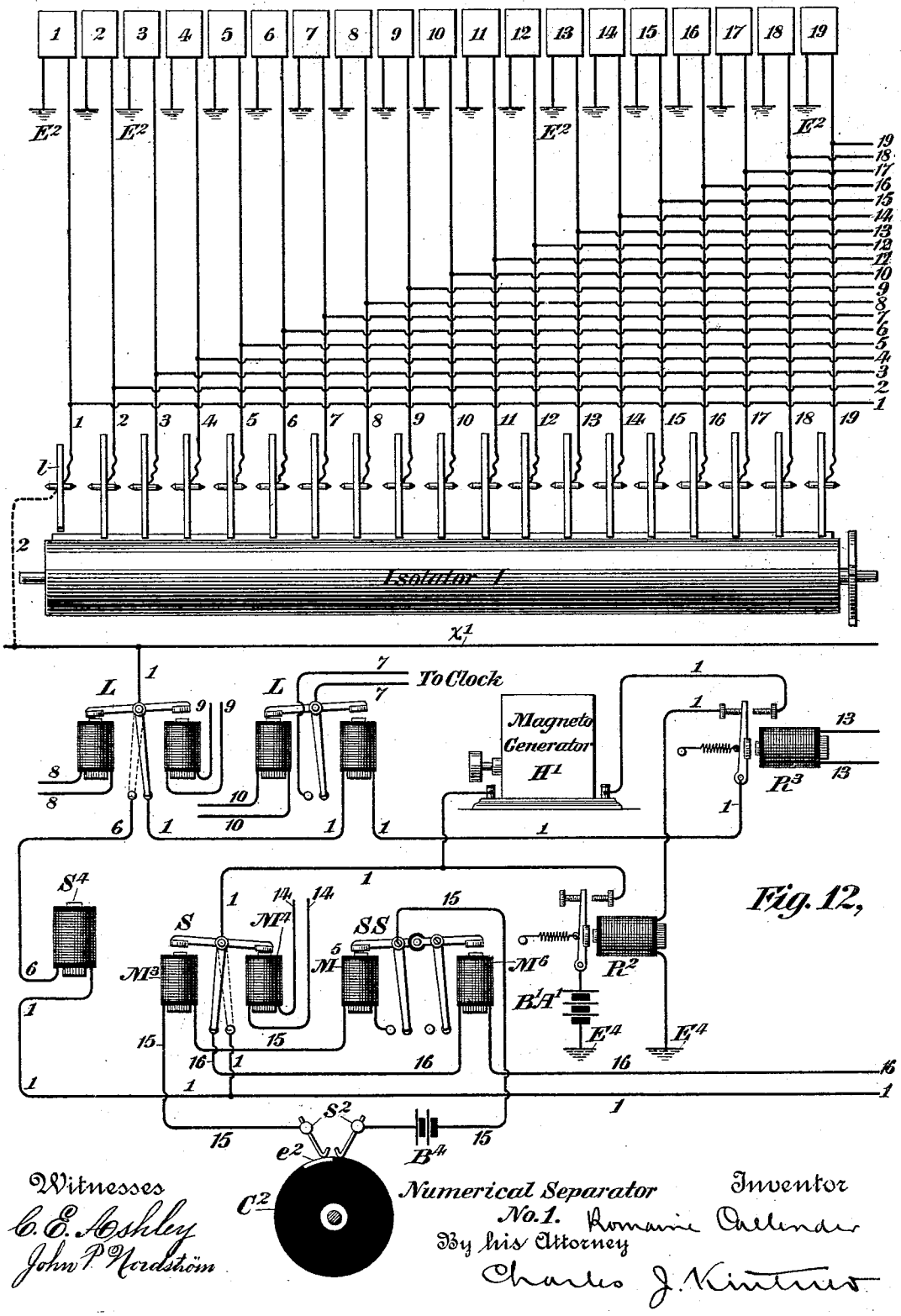

Fig. 12,

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Numerical Separator No. 1.

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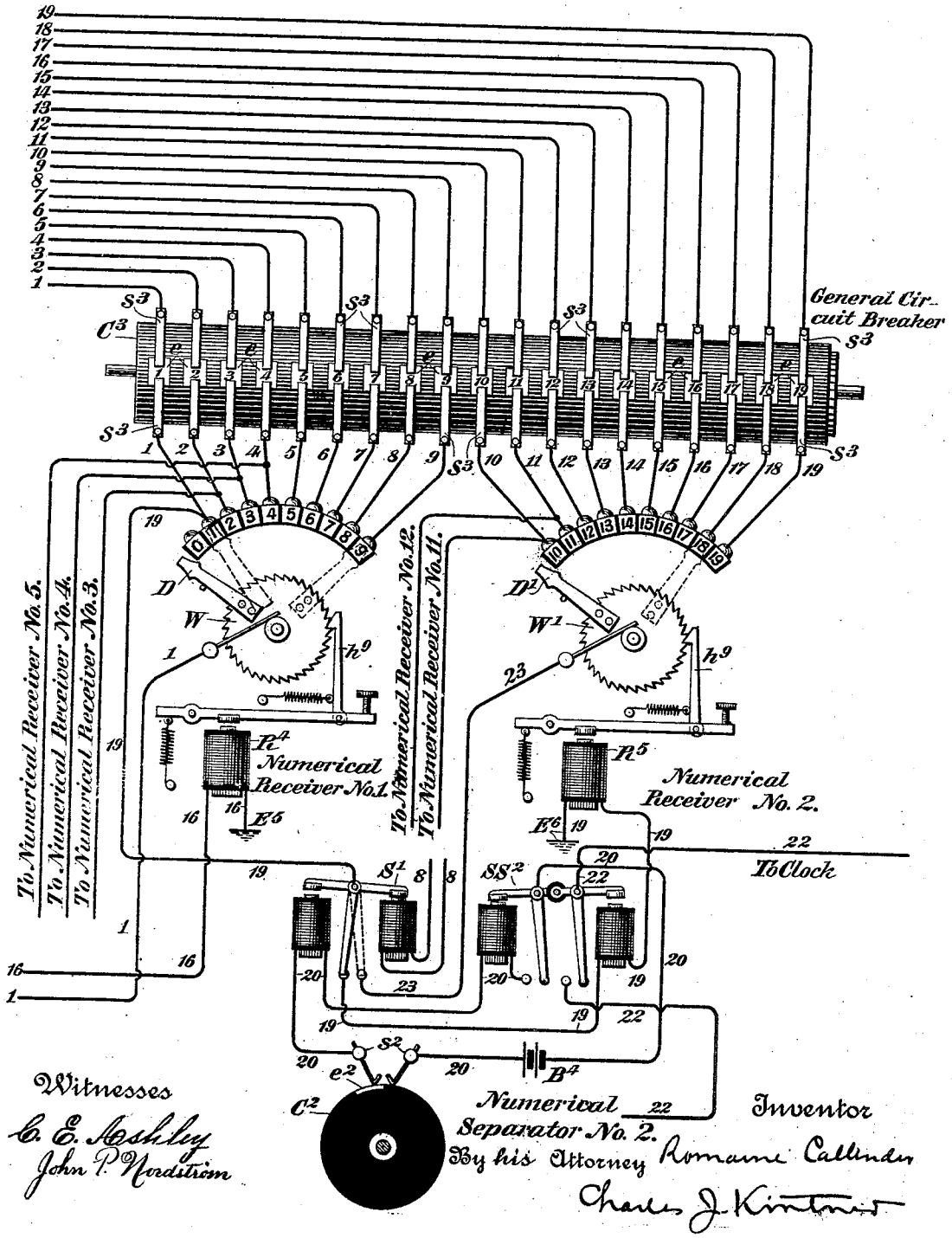
TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.

Fig. 13.



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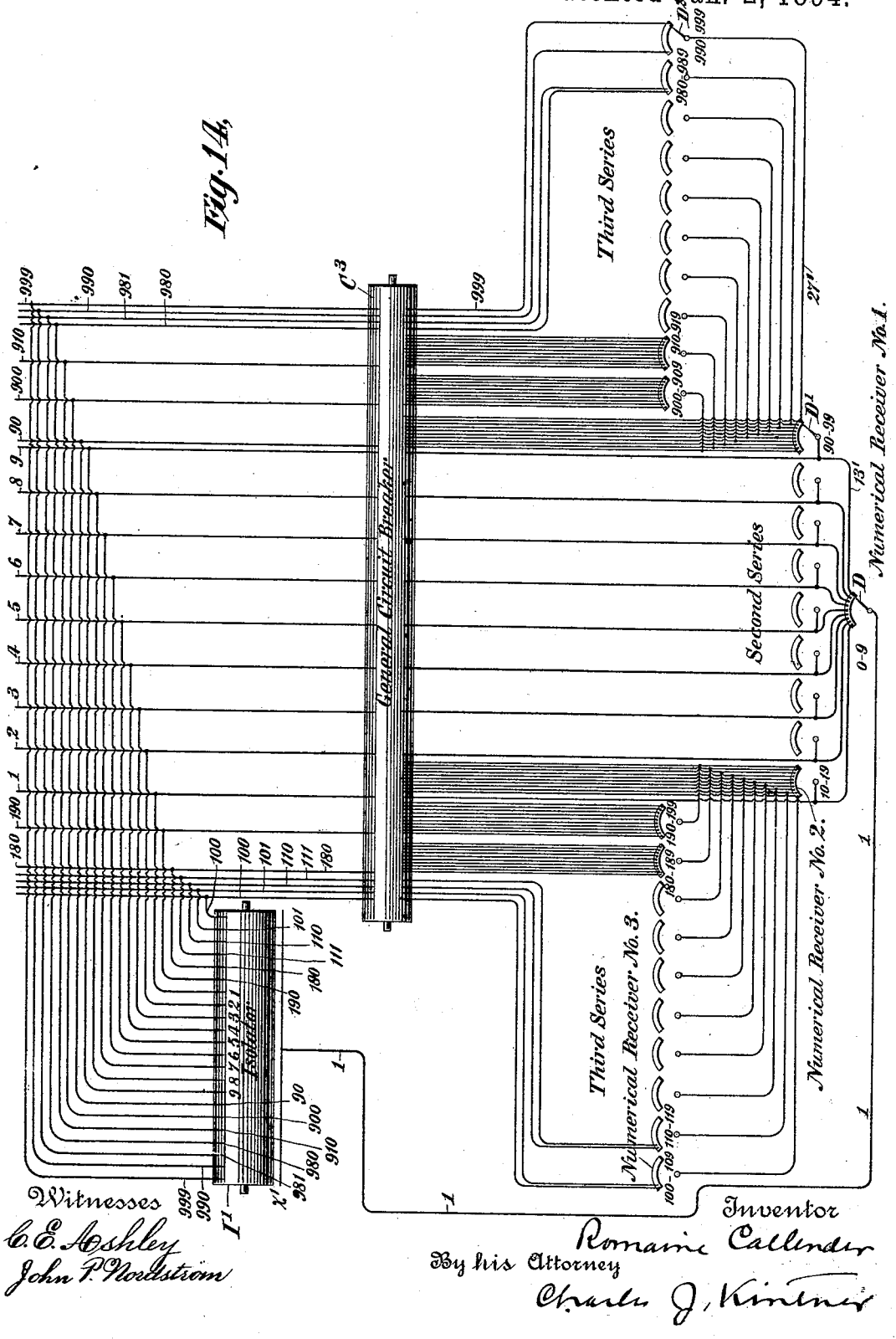
R. CALLENDER.

TELEPHONE EXCHANGE SYSTEM.

No. 511,875. Patented Jan. 2, 1894.

Fig. 14.



Witnesses
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UNITED STATES PATENT OFFICE.

ROMAINE CALLENDER, OF BRANTFORD, CANADA.

TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 511,875, dated January 2, 1894.

Application filed August 13, 1892. Serial No. 442,948. (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, Ontario, in the Dominion of Canada, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a specification.

My invention is directed particularly to improvements in that type of apparatus known in the art as automatic telephone exchange systems in which the subscribers, through the agency of apparatus located at outlying stations and additional apparatus located at a central or main exchange, are enabled to automatically effect intercommunication with each other in any desired order.

My invention has for its objects, first, the construction of such an automatic telephone exchange system as will enable any subscriber to instantaneously effect automatically intercommunication through a central exchange office with any other subscriber and at the same time prevent the possibility of any disturbance or interruption from a third subscriber until after the first two have held their conversation or been "rung off;" second, to provide means whereby a preliminary signal is first sent in to the central station, all of the lines disconnected from a common switching device and finally to connect the lines desired automatically; third, to provide means whereby any two lines of an indefinite number may be automatically connected on sending a simple make and break signal from any outlying station to the central station; fourth, to provide means whereby the subscriber signaling may make the connection desired from his own office through the central office over his own line by simply turning in a signal from a transmitter located in or near his own telephone box; fifth, to provide means whereby when a signal is turned in, a constantly operating generator located in the central station may be automatically connected in circuit with the line of the subscriber sending the signal and that of the subscriber signaled and the call bells at both stations rung, thereby indicating that the two lines are in circuit; sixth, to provide mechanism which shall enable any subscriber to connect his line with that of any other subscriber automatically; to signal the subscriber wanted and finally after the conversation has been effected to automatically ring off both subscribers and restore the lines to their normal condition; seventh, to provide mechanism in the nature of automatic apparatus whereby any two or more subscribers having telephone instruments located on any two of an indefinite series of outlying telephone lines connected with switching mechanism at a central station may effect any of the results necessarily attributable to the apparatus hereinafter described, the novel features of which are particularly pointed out in the claims at the end of this specification. I accomplish these several objects with the apparatus hereinafter described, for a full and clear understanding of which reference is had to the accompanying drawings in which—

Figures 1, 2, 3, 4, 5, 6, 7 and 8 are diagrammatic views illustrating the entire system and for a clear understanding of which, the first eight of the sheets of the drawings should be laid side by side in sequence. Fig. 9 is a part diagrammatic part plan view of that portion of the apparatus which I shall term the "isolator." Fig. 10 is a detail end elevational view of the circuit controlling apparatus which regulates the releasing mechanism of the several portions of the clock or time controlled apparatus. Fig. 11 is a plan view of the general switching mechanism whereby all of the lines which enter the exchange are automatically interrupted when a preliminary signal is sent in from a subscriber and remain interrupted during the time that the automatic connection is being effected between the subscriber who signals and the subscriber signaled. Figs. 12 and 13 represent diagrammatically a complete system of nineteen lines showing the circuit connections from nineteen outlying stations to and through the automatic central station with so much of the controlling apparatus as directly influences the switching portions of the mechanism, and also illustrating in the latter figure the radiating system of connecting conductors for connecting up additional lines. Fig. 14 is a diagrammatic view illustrating the circuit connections in the central station for a system of nine-hundred and ninety-nine lines, the operating apparatus not being shown.

Before entering upon a detailed description

of the drawings in order that a general understanding may be had of my novel automatic system, it may be well at the outset to indicate that all of the automatic apparatus in the nature of switching apparatus, time controlled mechanism and the magneto call generator are located at the central or main office into which the subscribers' lines all enter, there being one or more sets of subscribers' instruments located on each independent line, each of which sets of instruments is provided with a circuit breaking transmitter like that shown in Fig. 1 and lettered T, there being also a signaling battery B A for each independent line earthed at E'. All of the apparatus therefore shown in Figs. 2 to 11 inclusive is located at the central station and all of the incoming independent wires on which the subscribers' instruments are located run to a rotary or oscillating general circuit breaking cylinder C^3, Figs. 5, 11, and 13, their electrical continuity being maintained through a series of metallic contact plates or strips e^3 on the upper surface of this cylinder.

In order to simplify the illustration, I have shown a single outlying line numbered 1, Fig. 1, earthed at E^2 and provided with the usual lightning arrester L, Blake transmitter T^2, transmitting battery B A', receiving magneto telephone T' hung upon its hook in the ordinary way, all of the circuit connections thereof for the transmitter T^2 and receiver T' being what is now well understood by those skilled in the art; the right hand side of the lightning arrester L being connected by the subscriber's line 1 to and through the upper portions of Figs. 2, 3 and 4 to the general circuit breaker C^3 (Figs. 5, 11 and 13) through the contact springs s^3, metallic plates e^3 to No. 1 of a series of contact plates numbered from "0" to "9" which in turn are connected through corresponding subscribers' wires and similar apparatus located at like outlying stations.

In the telephone box of each subscriber or at some point easily accessible to the subscriber, is located a rotary transmitter T consisting of an insulating cylinder having a series of ten metallic strips a successively of different length located upon its surface and electrically in contact with the metallic axis of the cylinder which in turn is connected through a contact spring y with a signaling battery B A earthed at E'. The number of these metallic plates a is equal to that of a corresponding set of conducting springs a' the free ends of which are adapted to bear upon the cylinder T and make contact in succession with the plates a, while their other ends are secured to a fixed set of electrical conducting plates numbered "0," 1, 2, 3, &c., to 9, inclusive, said contact plates being lettered o and corresponding in number with the number of subscribers' lines under the control of the first portion of the apparatus at the central station which I denominate as "numerical receiver No. 1." See Figs. 5 and 13.

S w is a rotating conducting switch the free end of which is adapted to contact with the ends of the conducting plates o and M B is a magneto call bell electrically connected on one side to the lightning arrester L with the earth E^2 and on the other through a pair of conducting springs t' with a short conducting plate i carried by the cylinder T and in turn through the telephone hook with the subscriber's line 1 as clearly shown.

The rotary transmitter T with the transmitting battery B A and the circuit connections just described constitute the only apparatus used by me at the subscribers' stations for effecting automatic intercommunication through a central station with outlying subscribers' on independent lines.

I shall now describe in general terms the apparatus located at the central station, after which I shall describe the mode of operation of the entire system.

In Fig. 6 is shown at the bottom of the drawing, a battery B^2 A^2 and a series of circuits numbered 12, 7, 14, 17, 22 and 24 running to step by step mechanism illustrated in Figs. 2, 3, 4, 5, 7, 8 and 13. These several circuits are automatically opened and closed at the points q q by one or more conducting extensions m of a pendulum R^5 carried by a clock beating seconds or any other preferred elements of time, P^5 being the pendulum ball. I have shown this method of closing these several circuits by a single conducting extension m and through the agency of a pendulum for the reason that this is the simplest method of illustrating this portion of the apparatus. It will be understood that it would of course be preferable to provide independent circuit closing contacts q q for each circuit 12, 7, 14, 17, 22 and 24 and that the circuits might be closed with sliding contacts carried by a rotary drum adapted to make one revolution in any desired time or that there might be a separate rotary drum for each set of contacts and each controlled by an independent clock mechanism and adapted to rotate each at such a speed as the necessities of the case might demand.

Referring now to Figs. 2, 3, 4, 7 and the lower part of 8, that portion of the apparatus which discloses ratchet wheels or ratchet sectors with holding and propelling pawls and operating electro-magnets together with releasing devices are all controlled directly in their forward action step by step by the clock mechanism shown in Fig. 6.

That portion of the apparatus at the bottom of Fig. 2 lettered E I term the "general time limit apparatus," its object being to operate for a specified length of time under the control of the clock (Fig. 6) during which time the subscriber shall have had an opportunity to complete his signal and make the circuit connection with the subscriber sought, after which this portion of the apparatus is automatically released and conversation proceeded with as will be fully described later on.

That portion of the apparatus illustrated in Fig. 3 by the letter C′ I denominate as the "magneto signaling controlling instrument," its function being to automatically connect the constantly driven magneto signaling generator H in a looped circuit between any two subscribers' lines after they have been automatically connected together through the central station.

That portion of the apparatus represented at the bottom of Fig. 4 and lettered C^2 I denominate as the "numerical separator," its function being to enable any subscriber to select a certain one of the remaining subscribers' lines where the total number of those lines amounts to more than nine: that is to say, by the use of the switch S *w* and the transmitter T for one revolution of said transmitter the subscriber may connect his line with the desired one of the lines 0 to 9 in Fig. 5, but when the outlying subscribers' lines amount to more than nine it will be necessary to make two or more revolutions of the transmitter T and to correspondingly change the location of the switch S *w* to any one of the desired numerals 0, and 1 to 9 inclusive, between which revolutions of the transmitter this and other like numerical separators act to aid in bringing about the desired connection as will be fully described in connection with the description of the mode of operation. To make this statement last made more clear, it is to be understood that for the first system of outlying subscribers' wires illustrated in Fig. 5, the switch handle S *w* is to be placed upon that one of the conducting strips "O" 0 to 9 inclusive corresponding to the subscriber's wire wanted and one revolution given to the transmitter T by the handle H and that for connections between the subscriber and any higher number of outlying subscribers' circuits, such as is shown in Fig. 8, the switch handle S *w* would be placed upon any one of the conducting strips 0 to 9 corresponding to the subscriber's wire wanted in the higher number than nine and the transmitter T given a second rotation. In the meantime the numerical separator illustrated at the bottom of Fig. 4 will select the circuits of the higher order of numerals from those of the lower order of numerals during the interval of time between the two rotations of the transmitter T as will be fully described in the description of the mode of operation.

That portion of the apparatus illustrated in the upper portion of Fig. 5, I denominate as "numerical receiver No. 1." It consists of a ratchet wheel W and conducting arm D, operating electro-magnet R^4 and releasing electro-magnet d^{11}, propelling pawl h^9, holding pawl k^3, releasing cord c^4 passing under pulley b^4 and releasing armature lever l^8, W^2 being a weight attached to a cord passing over a pulley *n* and secured to the shaft of the wheel W, the function of the conducting arm D being to convey the current from the subscriber's wire to the desired outlying subscriber whose wire is connected with one of the conducting plates 0 to 9 inclusive. This numerical receiver is positively propelled by the action of the electro-magnet R^4 and pawl h^9 through current impulses sent over the signaling subscriber's line by the transmitter T when rotated, as already described.

That portion of the apparatus illustrated at the bottom of Fig. 5, I denominate as the "general circuit breaking instrument," the same being illustrated in plan view in Figs. 11 and 13, and controlled by electro-magnets d^9 and d^{10}, armature levers l^6, l^9, propelling pawl h^6 and releasing pawl k^4, releasing cord c^5 passing under the pulley b^5.

That portion of the apparatus illustrated in the upper portion of Fig. 7 and lettered C^5, I denominate as the "adjustable automatic conversation time-limit mechanism," its function being to regulate the time for which the conversation between the subscribers may be held, and it is controlled by electro-magnets d^{16}, d^{17}, and d^{18} with propelling pawl h^{10}, releasing pawl k^5, releasing cord c^6 passing under pulley b^6.

That portion of the apparatus shown at the bottom of Fig. 7 and lettered C^4, I denominate as the "automatic release controller" which releases all of the apparatus not already released when the adjustable automatic conversation time-limit restores all of the apparatus at the central station to normal condition ready for the next signal.

That portion of the apparatus shown near the top of Fig. 8, I denominate "numerical receiver No. 2," it being a mere extension of the like portion of the apparatus shown in Figs. 5 and 13 and denominated "numerical receiver No. 1" each one of the several subscribers' lines numbered from 1 to 9 inclusive, Figs. 5 and 13, being connected to an instrument like "numerical receiver No. 1." In other words each subscriber's line running out from "numerical receiver No. 1" in Fig. 5 would be connected to a corresponding conducting arm D′ on a second "numerical receiver" adapted to be connected with any one of a secondary set of subscribers, like that shown in Figs. 8 and 13 thereby largely increasing the connecting capacity of the system.

A more clear understanding may be had of the arrangement of the numerical receivers or switching apparatus which connect up the various lines with each other, on examination of Fig. 14, where the first numerical receiver or numerical receiver No. 1 is shown at the bottom of the drawing, and through which all incoming signals pass for all lines of the entire system. The second series of numerical receivers, each of which is always denominated as numerical receiver No. 2, whenever referred to in this specification, is seen immediately above numerical receiver No. 1; and the third series of numerical receivers, each of which is always denominated as numerical receiver No. 3, whenever referred to in this specification, is located above

the second series and all signals of the third order of decimals pass these receivers, as will be more clearly understood in connection with the description of the mode of operation. This figure of the drawings just referred to shows the circuit connections only for the entire system of lines and the numerical receivers for connecting them together in pairs in any desired order, it being understood that any incoming signal from any outlying subscriber is conveyed first to numerical receiver No. 1, thence through that one of the second series of numerical receivers denominated as numerical receiver No. 2 which is called, and thence through that one of the third series of numerical receivers which is called, it being understood that all lines from 1 to 9 inclusive may be called through numerical receiver No. 1 only while all lines from 1 to 99 inclusive are connected with each other only through numerical receiver No. 1 and the necessary one of the second series connected to the line wanted. In other words all incoming signals of any nature whatever must pass through numerical receiver No. 1. All incoming signals of the second order of decimals or from 1 to 99 inclusive must pass through numerical receiver No. 1 and one of the second series of numerical receivers. All signals from 1 to 999 inclusive must pass through numerical receiver No. 1, some one of the second series of numerical receivers and some one of the third series of numerical receivers.

That portion shown at the bottom of Fig. 8 of the drawings is a duplicate numerical separator and is identical with that shown at the bottom of Fig. 4 of the drawings lettered C^2.

Referring now to Fig. 2; L L are switches controlled by magnets M' M^2. d is a releasing magnet for releasing the weighted switch lever l^2, there being one of these releasing magnets for each subscriber's line and all operatively connected with the circuit 8 with the releasing mechanism controlled by the adjustable automatic conversation time-limit apparatus illustrated in Fig. 7.

S^4, S^5 and S^6, Fig. 4, are releasing magnets operated either by the transmitter T or by the apparatus connected to the adjustable automatic conversation time limit.

S and S S, Fig. 4, are switches controlled by electro-magnets M^3, M^4, M^5 and M^6.

S' and S S^2, Fig. 8, are substantial duplicates of the switches S and S S shown in Fig. 4.

K, K, K, K, K, Figs. 3, 4, 5, 7, and 8 are ratchet segments adjustably secured to the rotary parts C', C^2, C^3, C^4, and C^5, (see Fig. 8,) the size and number of the ratchet teeth being made dependent upon the proportionate times in which it is desired to rotate the disks or cylinders to which they are attached.

W^3, W^3, W^3, W^3 are weights carried by levers pivoted to the frame of the apparatus, their inner or free ends bearing under or beneath the curved portions of the sectors K so that as the disks are rotated the weights W^3 are lifted and when said disks are released, these weights acting through the levers will cause the disks and sectors to assume their normal positions. In place of these weighted levers I may use weights and cords passing over pulleys like those shown at W^2 and n in connection with the ratchet wheel of the general time limit apparatus in Fig. 2.

Referring now to Fig. 10 which is an enlarged view illustrating different positions of the circuit controllers carried by the rotary disks or cylinders C', C^2, C^4 and C^5, t^4 is a strip of conducting metal secured at one end to one of the conductors running to a releasing electro-magnet, in this instance shown as the conductor 11, running to the releasing magnet d^4, Fig. 2, and t^5 is a corresponding conducting plate secured to the edge of the disk C', this plate being in turn connected to the other end of the conductor 11. i^2 is an elastic or yielding metallic plate carried also by the disk C' but insulated from it and the plate t^5. The upper or straight edge of this yielding metallic plate i^2 lies snugly against the end of the disk C', and the lower or V shaped edge is curved outward from the end of said disk and so that it is out of electrical contact with the fixed inner plate t^5, the arrangement being such that as the disk C' rotates in the direction of the arrow in the first position the free end of the metallic plate t^4 rides up over the outwardly curved end of the plate i^2 so that there will be no metallic contact between the contacting plate t^4 and the fixed plate t^5 carried by the disk C' until it leaves the upper curved or angular surface of the insulated plate i^2 and assumes the position shown in the central figure, while on rotating the disk C' in the reverse direction as shown in the right hand of the figure, the plates t^4 and t^5 will be in metallic contact as the former passes under the insulated plate i^2 and maintains contact between the plates t^4 and t^5 until the disk assumes its original position and passes out from under the end of the yielding plate i^2 as said disk rotates in the direction of the arrow shown in the right hand portion of Fig. 10. The action of these corresponding parts in Figs. 3, 4, 7 and 8 in connection with the disks C', C^2, C^4, C^5 and C^3 is the same and the releasing electro-magnets d^6, d^8, d^{13}, d^{17}, and d^8, are adapted to release said disks at the proper intervals of time.

I will now describe the mode of operation of the entire apparatus giving first a description of the method of connecting up two subscribers where the number of the subscribers' wires so connected lies between one and nine, and then describe the method of connecting up two subscribers where the number of wires is over nine, thus illustrating in the second instance how, with a limited number of wires connected to each numerical receiver or two or more sets of such receivers, I may make connections between a large number of outlying subscribers' wires. Suppose in the first instance it is desired to connect the subscriber on

wire No. 1 and whose signaling and telephone instruments are shown in Fig. 1 with another subscriber whose instruments are located on say wire No. 9. The several parts of the apparatus at the outset are in the position shown in the drawings of Figs. 1 to 8 inclusive and in full lines in Figs. 12 and 13. The operator on wire No. 1 turns the switch S w into contact with that contact plate o numbered "0" and then rotates the transmitter T through the agency of handle H one complete revolution, thereby sending to line in the direction of the tailless arrows a single impulse from battery B A by wire 1, switch lever l (Fig. 2) wire 2, weighted switch lever l^2, wire 2, relay R, wire 2, relay R', earth E^3, thus actuating these two relays R and R'. The relay R being energized causes its armature to close the circuit of battery B through the circuit 4—4 and magnet d^9 (Fig. 5) thereby causing the armature lever l^6 and propelling pawl h^6 to act upon the ratchet sector K and rotate the "general circuit breaker" C^3 a fractional part of a revolution interrupting the circuits of all lines in the group, thus disconnecting all of the local branch lines in the central station connecting the numerical receiver between the metallic strips e^3 and the series of contact springs s^3 more clearly shown in Figs. 11 and 13. At the same instant the relay R' which was energized as already described, causes the armature lever r to be drawn down so that the hook lever h^2 near its right hand end catches the free end of the weighted switch lever l^2. The cord c attached to the other end of the armature lever r and to a detent hook h is simultaneously drawn down over the pulley b, thereby drawing the hook h out of the path of a catch on the face of the isolator cylinder I, there being a separate relay R' and corresponding circuit and mechanical connections for each of the incoming subscribers' lines 1 to 9 inclusive as shown in Figs. 9 and 12, the arrangement being such that the operator signaling will draw his particular detent hook h out of the path of its catch, while the remaining detent hooks h will remain in the paths of their catches. At the same instant that the armature r is drawn down by the relay R' a local circuit 3 will be closed from the battery B' to the local electro-magnet d' imparting to its armature l' and a detent hook h' a forward motion, thereby rotating the isolator cylinder I a fractional part of a revolution and allowing a detent pawl p to fall behind a stop on a disk attached to the shaft of the isolator cylinder. This forward motion of the isolator cylinder causes all of the switch levers l (see Figs. 2 and 9) to be tilted forward under the influence of their hooks h except that one which has just been described as having been disconnected from the isolator cylinder by the cord c. It will thus be seen that the circuit is interrupted between all of the incoming subscribers' wires at the switch l and the contact points z by this action of all of the switch levers l except the one last referred to, so that no circuit can now be closed for incoming signals from other outlying subscribers' instruments. It is to be noted also that the clock or other time mechanism illustrated in Fig. 6 is supposed to be running continuously, thus constantly making and breaking the circuit of the battery B^2 A^2 between the yielding contact springs q q and through the circuits 12, 7, 14, 17, 22 and 24 and apparatus connected therewith when any of said circuits are closed at other points as will be described later on. The preliminary impulse sent in by the transmitter T through contact plate o switch S w and circuit No. 1 as just described, has thus disconnected all of the outlying subscribers' lines, save the one who has just signaled. As soon therefore as the relay R' (Fig. 2) was demagnetized, its armature r and hook lever h^2 shifted the circuit from the lower contact point x at its left hand end to a second contact point x' just above, and a new No. 1 circuit was established by wire 1, left hand switch L, wire I, right hand magnet M^2 of the right hand switch L thence by wire 1 through back contact stop of the armature lever of relay R^3 and finally through relay R^2 to earth at E^4, both of said relays being found in Fig. 3 of the drawings. The electro-magnets R^4, R^5, &c., which control the movements of the numerical receivers and the switching magnets S S^2, &c., Fig. 8, which control the circuits in connection therewith, should be somewhat more sluggish than the relays R and R', Fig. 2, in order that the preliminary impulse sent in from any outlying station may not affect such of those magnets as may be in circuit before the branch circuits are all interrupted at the general circuit breaker; or the same may be effected by utilizing a signaling battery B A, Fig. 1, at each subscriber's station of considerably less electro-motive force than the battery B' A', Fig. 3, which controls the aforesaid electro-magnets. The operator at station 1 now places the switch S w in contact with plate No. 9. Supposing he desires to connect his wire with some subscriber on wire No. 9. He then gives to the transmitter T one complete revolution as before, thus sending ten impulses over the line in the same direction as before through lever l^2, (Fig. 2,) upper contact x', wire 1, left hand switch L, wire 1, right hand portion of magnet M^2 which controls and turns the switch L thence through relay R^2 to earth at E^4 at the bottom of Fig. 3 as already described. These ten impulses therefore actuate the relay R^2 and cause the battery B' A' at the bottom of Fig. 3 to send ten successive impulses forward from earth E^4 by armature of relay R^2 and front contact stop by wire 1 through the left hand switch S, (Fig. 4,) thence through wire 16 and right hand magnet M^6 which controls the two point switch S S, (Fig. 4,) thence by wire 16 through electro-magnet R^4 to earth at E^5. These ten impulses therefore impart to the numerical receiver No. 1 in Fig. 5, ten forward steps

through the agency of the hook h^9 and retaining pawl k^3 thereby placing the conducting arm D of this receiver ultimately in contact with the right hand plate 9 as clearly illustrated in dotted lines in Fig. 13 and hence with the circuit running to the subscriber desired.

Returning now to the right hand switch L at the top of Fig. 2, it will be seen that by the act of shifting the lower end of its switch arm to the left a clock circuit is established from the battery B^2 A^2 (Fig. 6) by way of the conductors 7—7 which circuit includes the actuating electro-magnet d^3 at the bottom of Fig. 2 so that as the pendulum vibrates the general-time-limit apparatus E is set in motion through the operation of the armature lever l^3 and propelling pawl h^3. This mechanism continues to advance step by stem for a period of say twenty seconds or twenty beats of the clock pendulum and during the first fifteen seconds of this forward motion, the contact plate e of the general-time-limit apparatus is brought under the two conducting springs s s, while the holding pawl k retains the apparatus as it is advanced step by step and the restoring weight and cord W^2 are drawn up over the pulley n. When the contact plate e passes beneath the conducting springs s a new clock circuit 12 is established through the contact points q q and battery B^2 A^2, said circuit 12 including an actuating electro-magnet d^5 for the magneto signaling controlling instrument represented by the letter C′ (Fig. 3) so that the ratchet sector K through the agency of the propelling pawl h^4, armature lever l^4 and retaining hook k' is caused to advance step by step as the clock closes the circuit at q q in Fig. 6. During the first of the forward steps of the tooth sector K and hence of the magneto signaling-controlling apparatus C′, the conducting plate e' carried thereby is brought under the two conducting springs s' s' and an additional circuit is thereby closed through the conductor 13—13 from the battery B^3 which circuit includes a releasing magnet d^{10} for the general circuit-breaker shown at the bottom of Fig. 5, thereby performing two functions at the same time: namely, first releasing the general circuit-breaking cylinder C^3 through the agency of the armature lever l^9, releasing cord c^5, propelling pawl h^6 and detent pawl k^4 and allowing this cylinder to assume its normal position or that now shown in Figs. 5, 11 and 13, thereby again restoring all of the subscribers, circuits into through connection with the contact plates e^3 and the numerical receiver circuits, as clearly shown in Figs. 5, 12 and 13. It will be noted at this time that although the general circuit has been re-established for all of the local branch circuits at the general circuit-breaker as shown in Figs. 5, 11 and 13, all of the subscribers' circuits except the signaling circuit are now broken at their points of juncture with the switch levers l by virtue of the previous rotation of the isolator cylinder I so that there is only one path for an incoming current.

The circuit 13 which includes the battery B^3, contact springs s' s' and the releasing magnet d^{10} includes also a relay R^3 located near the bottom of Fig. 3, and it is therefore apparent that during the time that the conducting plate e' of the magneto signaling controlling instrument C′ remains under the contact springs s' s' the armature of relay R^3 will be held forward on its front contact stop. The result therefore is that the constantly operating magneto generator H′ is now looped in circuit with both of the incoming subscribers' lines 1 and 9, and the magneto bells M B at both stations continue to ring during the time that the contact plate e' is under the springs s' s'. As the instrument C′ continues to rotate circuit is made through conductor 9 and contact springs t^3 and t^6 and the battery circuit B^5 near the center of Fig. 3 is closed through circuit 9 including the releasing magnet d^6, (Fig. 3,) the right hand magnet of the left hand switch L at the top of Fig. 2 and the left hand switch magnet M^8 of the switch which controls the adjustable-conversation-time-limit apparatus in Fig. 7. Consequently the left hand switch L at the top of Fig. 2 is turned with its lower point in contact with the left hand contact point as shown in dotted lines in Fig. 12. The contact spring t^4 of the magneto controller C′, Fig. 3, has ridden over the insulated plate i^2 and assumed the position shown in the central view of Fig. 10, thereby closing the circuit of battery B^4 through wire 11 to the releasing magnet d^4 thus releasing the general-time-limit apparatus E in Fig. 2, and allowing it to return to normal position, it having first advanced far enough to close the circuit 10 through contact springs t with a conducting plate o so as to energize the left hand magnet M^2 of the right hand switch L at the top of the drawings and return it to normal position thereby rupturing the clock circuit 7 7. The general time-limit apparatus for controlling the time of turning in the signal has been returned to normal position and has shifted the switch of the right hand switch L at the top of Fig. 2 to its normal position, the magneto signaling controlling instrument has been returned to normal position through the agency of the releasing magnet d^6 and the magneto generator cut out of circuit. The adjustable automatic time-limit conversation apparatus has been set in motion through the agency of the circuit 9, magnet M^8 and switch S w^2 (Fig. 7) a circuit having been established through said switch, the conductor 24, operating magnet d^{16} and the clock circuit at Fig. 6.

It will be noticed that the circuit 9 is provided with circuit closing devices at two points, one on the apparatus C′ in Fig. 3, and the other on the general time-limit apparatus E in Fig. 2, the arrangement being such that

although electrical contact is made between the plates t^3 and t^6 as C′ advances, the circuit will not be closed between the plate t^2 and the rotary plate carried by the general time-limit apparatus until the latter has been released and returned to normal position thereby allowing the general time-limit apparatus to be released first and to afterward release the instrument C′ and to perform the other functions already described. When the relay R^2 (Fig. 3) closed the circuit from battery B′ A′ through line 1, the left hand switch S of Fig. 4 and the right hand magnet M^6, wire 16 and magnet R^4 (Fig. 5) the first impulse sent over the line caused the two point switch S S to reverse its position and to close the clock circuit 17, thereby starting the numerical separator C^2 almost simultaneously with the general time-limit apparatus (Fig. 2). As the numerical separator advances under the action of the armature l^5 and hook lever h^5 it brings the contact plate e^2 under the contact springs s^2 s^2 thereby closing a local battery circuit 15 from battery B^4 through the left hand magnet M^5 of the double switch S S restoring the switch to its normal position and also through the left hand magnet M^3 of the switch S shifting said switch into the reverse position and hence directly in circuit with the arm D of the numerical receiver in Fig. 5 so that the magneto call currents from the magneto generator H′ were caused to take the path through the conductor 1, joining the two circuits thus connected together during the time that the armature of relay R^3 was held forward on its front contact stop, while the contact plate e' of the magneto signaling controlling instrument was passing under the springs s' s'. The uninterrupted talking circuit therefore between the two lines 1 and 9 is as follows. Passing from the earth at station 1 in the direction of the tailless arrows through the wire 2 (Fig. 2) lever l, wire 2, lever l^2, upper contact x' upon which lever l^2 is held by hook h^2, wire 1, switch L and left hand contact point upon which it is now resting, wire 6 through ringing off magnet S^4 in Fig. 4, wire 6, wire 1 directly to the numerical receiver through the arm D to the wire 9 and thence through the contact springs s^3 s^3, metallic plate e^3 on the general circuit breaker directly to the outlying subscriber. See also Figs. 12 and 13. As the numerical separator advances through its complete phase the local circuit of battery B^5 seen at the bottom of Fig. 4 is closed through the electro-magnet d^8 and conductors running to the contact plates t^4 and t^5, the operation being the same as already described in connection with like parts illustrated in Fig. 10, the releasing armature lever l^7 causing the hook lever h^5 and detent hook k^2 to allow the sector K and disk C^2 to return to normal position. Just before the magneto signaling controlling instrument was returned to its normal position by the releasing electro-magnet d^6 in circuit 9 and at the instant that the general-time-limit apparatus returned to its normal position and closed the circuit 9—9, the switch S^2 w^2 of the adjustable automatic conversation time limit apparatus (Fig. 7) was turned into its upper position under the influence of magnet M^8 which is also in circuit 9 so that after the magneto signal has been sent in and the two subscribers connected together as already described, this adjustable automatic conversation time-limit apparatus is now put in operation by the agency of the clock circuit 24 which runs to the clock and energizes the propelling electro-magnet d^{16} thereby causing the sector K of this apparatus to advance step by step for a definite number of seconds or minutes or such time as may be allowed for conversation, the apparatus shown in Fig. 7 of the drawings merely indicating the application of this time-limit principle. As the two subscribers converse therefore the apparatus C^5 advances and ultimately the contact plate e^4 rides under the conducting springs s^4 s^4 closing the circuit of the battery B^3 through the conductors 18 to the releasing electro-magnet S^5 near the center of Fig. 4 of the drawings, thereby lifting the armature lever v and allowing the armature lever v' to be withdrawn from the notch on the under side, thus locking the armature v in its upper position in contact with a conducting contact connected to the clock circuit 14. On the first closure of the clock circuit therefore through the circuit 14 the left hand switch S of Fig. 4 is shifted by magnet M^4 to its first or normal position and simultaneously the automatic releasing mechanism at the bottom of Fig. 7 is stepped forward under the influence of the electro-magnet d^{12} until the contact plate e^5 is carried under the contact springs s^5 thus closing the battery circuit B^5 through the conductor 8 and right hand electro-magnet M^9 shifting the conversation-time-limit switch S w^2 back to its normal position, simultaneously energizing the releasing electro-magnet d^{18} in the same circuit, thereby releasing the adjustable automatic-conversation-time-limit mechanism and allowing it to rotate back to its normal position. At the same instant the releasing magnet d^{11} in the same circuit, 8, of the numerical receiver in Fig. 5 is actuated, allowing the weight W^2 to return the conducting arm D of the numerical receiver to its first or normal position. The electro-magnet s^6 of the ringing off apparatus F Fig. 4, is also caused to draw the armature v' into its forward position and release the armature v. The electro-magnet M′ of the upper left hand switch L in Fig. 2 being in the same circuit 8 causes the switch to be turned to its first or normal position and the releasing magnet d^{19} which is also in circuit 8 in Fig. 2 lifts the pawl p and allows the isolator cylinder to be restored to its normal position. The releasing magnet d which is also in circuit 8 in Fig. 2 is caused to release the armature lever hook h^2 from the end of the weighted lever l^2, thereby allowing said lever to assume its original

or normal position. Last of all the automatic release itself at the lower part of Fig. 7 of the drawings is effected through the agency of a local circuit and electro-magnet d^{13} in the same manner as the apparatus C^2 at the bottom of Fig. 4 was released as heretofore described. It is now apparent that the several parts of the apparatus put in operation from the transmitter T at the station of the signaling subscriber have served their various functions in sequence and that the adjustable automatic-conversation-time-limit apparatus having limited the time of the conversation, the entire mechanism at the central station has again assumed its normal condition and that the isolating cylinder I has again connected all of the outlying subscribers' lines with the signaling receiving mechanism for said lines at the central station. Any other operator may now turn in his signal and automatically connect his particular line with any other line in the system, the operation being identically the same as has heretofore been described. Should any subscriber attempt to signal during the time that the apparatus is in use by reason of a signal previously sent in, it is apparent that he will receive no signal on his own magneto-bell, his line being like that of all subscribers, save the one who has previously signaled, cut out at the isolator cylinder, Fig. 2. He must wait therefore until he obtains a signal on his own bell on turning in a signal before he is aware of the fact that his proper circuit connections have been made. The absence of such a return signal is indicative to him of the fact that the system is in use and that he must wait until the proper circuit connections are again automatically made at the central station. It is to be understood however that although all of the subscribers' outlying lines, save the one who is signaling, have been cut out of circuit at the isolating cylinder (Fig. 2) for transmitting signals, all of said lines are still connected with the numerical receivers for receiving signals at the points "0" to "9" inclusive over which the conducting arm D passes and also through the contact springs s^3 s^3 and conducting plates e^3, the latter attached to the general circuit-breaking cylinder C^3. (See Figs. 5 and 13.)

I will now describe how I am enabled to unite two or more subscribers' instruments located in independent outlying subscribers' lines where the number of such outlying lines is greater than nine.

My system of uniting any two of an indefinite number of subscribers' lines is based upon what I term the "units," "tens," and "hundreds" principle, and I connect the first nine subscribers' lines running into the central station with a numerical receiver which is connected to ten local or branch wires, each one of these local or branch wires being connected in turn to one of a series of secondary numerical receivers having in turn ten similar connections, each one of which runs to one of a series of third numerical receivers and so on indefinitely. Automatic switching apparatus is also included in circuit between the several numerical receivers whereby the circuit connections are shifted so that the main battery B′ A′ at the bottom of Fig. 3 is caused to automatically advance the numerical receiver and its conducting arm D to the desired point through the agency of the relay R^2 (Fig. 3) and the electro-magnet R^4 (Fig. 5) and then shift the circuit connections from this electro-magnet R^4 to the electro-magnet of the next succeeding numerical receiver and so on in sequence, the main battery B′ A′ being utilized to drive these numerical receivers in succession. In other words, the first numerical receiver makes connection directly for nine subscribers' wires and these connections are in turn connected to one of a series of secondary numerical receivers, each of which has provision for connections to one of a series of numerical receivers of the third order, the number of possible connections therefore being in geometrical progression and the circuit connections through the primary numerical receiver being adapted to connect up the individual subscribers' connections through the additional numerical receivers in any desired order.

Fig. 14 of the drawings shows a system approximating a thousand subscribers' lines with circuit connections at the central or switching station through the isolator, the general circuit breaker, and three series of numerical receivers. The apparatus for operating the isolator, the general circuit breaker, and the numerical receivers is not shown in this figure of the drawings, nor are all of the one thousand subscribers' lines shown, the diagram being in the nature of a skeleton which illustrates only a sufficient number of such lines to give a correct understanding of the switching circuits through the exchange.

It will be understood that all the subscribers' lines come into the office at the top of the drawings and divide each into two branches, one of which is connected to the isolator and the other to the general circuit breaker in the manner already described and that all of these lines are broken at the isolator when the preliminary signal is sent in except that line over which the impulse is transmitted, and also that the other branches are simultaneously broken at the general circuit breaker until the proper connections are automatically made through the various series of numerical receivers and circuit connections, after which it (the general circuit breaker) is restored to its normal position, the isolator remaining in its abnormal position until the conversation is through, so that all of the subscribers' lines are disconnected at the isolator during the conversation except that of the subscriber who signaled and that it is automatically released by the act of ringing off, after which any other subscriber may in like manner obtain control of the isolator and

the switching apparatus and send his signal through numerical receiver No. 1 in such manner as to make the desired connection to the subscriber called.

For a higher or greater number of subscribers' lines, say approximating ten-thousand lines, a fourth series of numerical receivers would be necessary, such fourth series of numerical receivers having a similar set of connections with the third series of such receivers, as do the latter with the second series of numerical receivers as will be clearly appreciable on inspection of the drawings. It will thus be apparent that there is no limit to the number of subscribers' wires which may be connected, it being readily appreciable that by this utilization of numerical receivers in which the circuit connections increase in geometrical ratio, I can, with a reasonably small number of such receivers connect a very large number of subscribers' lines.

Suppose now it is desired to connect subscriber's circuit No. 1 with circuit No. 18. Under this condition of affairs the second subscriber's line being in the second order of numerals it will be necessary to bring into play numerical receiver No. 2, of the second series of numerical receivers. See Figs. 8, 13 and 14. The operator at station No. 1 goes through the same operations as before described in transmitting the preliminary signal and for the purpose of connecting up his circuit with that one of the circuits connected with numerical receiver No. 1 which is to continue the connections through to numerical receiver No. 2 of the second series of numerical receivers. He therefore after the preliminary signal has been sent in, places the switch S w on the contact plate numbered 1 and rotates the transmitter T one revolution as before. This advances the arm D of the numerical receiver No. 1 two steps and places it in contact with the contact plate 1. Shown in dotted lines in Fig. 13. It will be understood of course that in advancing the arm D to the point 1, the numerical separator, Fig. 4 of the drawings, has operated as before described, and transferred the circuit through the agency of the switch S S so that the circuit connections on line No. 1 are direct to the arm D and contact plate 1 of the numerical receiver No. 1. Electro-magnet R^4 of numerical receiver No. 1, Figs. 5 and 13 by the operation of the numerical separator has also been disconnected from the circuit running to the main battery B′ A′ at the bottom of Fig. 3 and electro-magnet R^6 of numerical receiver No. 2 (Figs. 8 and 13) has been connected in circuit through conductor No. 19 with that battery. The operator now turns the switch S w upon contact No. 8 and gives to the transmitter a second complete revolution, thereby sending to line nine successive impulses through B′ A′. These nine impulses take the following course: The relay R^2 being energized in the manner already described by the currents from battery B A (Fig. 1) cause the battery B′ A′ to repeat the nine impulses through conductor No. 1, through the switch S (Fig. 4) and lower right hand contact point thereof, it having been tilted in this direction by the action of battery B^4 and the numerical separator, thence by wire 1 directly to the numerical receiver No. 1, thence by wire No. 19 to switch S′ (Fig. 8) thence by the right hand electro-magnet of the two point switch S^2 S^2 and thence through electro-magnet R^6 to earth. See also the same circuits in Figs. 12 and 13. These nine impulses therefore carry the arm D′ of the numerical receiver No. 2 forward to the contact plate No. 18 shown in dotted lines, Fig. 13 in direct connection with the metallic plate e^3 of the general circuit-breaker (Fig. 5), the outlying line being No. 18. The first impulse which came over wire 19 from battery B′ A′ as just described, shifted the two point switch S^2 S^2 (Figs. 8 and 13) in the reverse direction and brought the contacting arms thereof in electrical connection with the contacts at the lower ends, thus closing in the one instance the clock circuit 22 running to the clock and to the numerical separator at the bottom of the drawings, thereby causing the magnet d^7 to be energized by the clock battery B^2 A^2 and to step forward the tooth sector K step by step until the contact plate e^2 rests under the conducting springs s^2 s^2 thereby closing in the second instance the circuit of battery B^4, Fig. 8, through wire No. 20, left hand magnet of switch S′ and left hand magnet of switch S S^2 which turned both of the switches to their left hand positions. Wire No. 19 is now in direct connection with the second numerical receiver through wire No. 23 and subscribers' circuits, Nos. 1 and 18 are connected, the magneto signal having been sent over both circuits through the agency of the magneto signaling controlling instrument and the apparatus in the same manner as was described in connection with the first part of the operation of the apparatus. In other words all of that portion of the apparatus embraced in Figs. 2, 3, 4, 5, 6, and 7 operated as was before described to perform the several functions attributable to such apparatus. The two circuits 1 and 18 being thus connected conversation proceeds as before until the adjustable automatic conversation time-limit apparatus is advanced to its limit and the releasing apparatus actuated as before. The electro-magnet d^{11} being in the releasing circuit No. 8 as is also the right hand switch magnet of the switch S′ at the top of Fig. 8 of the drawings it will be understood that when the automatic conversation time-limit apparatus operated, the numerical receiver No. 2 will be released, the switch S′ (Figs. 8 and 13) will be restored to its normal position and the releasing apparatus connected with the receiver No. 2 will be released by virtue of the local circuit connections with battery B^7 and electro-magnet d^8 when all of the apparatus will return to normal position as before.

Although the restoring of all of the apparatus to normal condition is made dependent as heretofore described upon the automatic conversation time-limit apparatus illustrated in Fig. 7 and the circuit connections through battery B^5 and conductor No. 8 running through Figs. 2, 3, 4, 5, 6, 7 and 8 of the drawings this same function may be performed by either one of the subscribers at the end of their conversation without waiting for the termination of the time, by simply placing the switch S *w* in circuit with the "O" contact and rotating the transmitter T one turn. This will cause the main battery B A at the transmitting station to energize the releasing electro-magnet S^4, Figs. 4 and 12 of the drawings, and return all of the apparatus to normal position and will also release the automatic releaser for the reason that the clock circuit 14 will be closed at the back stop of the armature lever *v* so that the first impulse which passes over the circuit 14 will place the contact plate e^5 under the springs s^5 s^5 thereby closing the general releasing circuit 8 which operates all of the releasing devices.

In Figs. 12 and 13 I have given a diagrammatic view of a complete system of nineteen subscribers' lines earthed at outlying points E^2 and all entering the central station, each subscriber's line having two branches, one of which runs to the isolator I, Fig. 12, and the other to the general circuit breaker, Fig. 13, two numerical receivers being shown, as are also the necessary switching magnets for controlling the circuits in relation thereto, the circuits and circuit connections therefor being as shown in Figs. 2 to 8 inclusive. It will, of course, be understood that all other incoming lines of the higher orders would in like manner enter the central station and branch in the same manner to the isolator cylinder and the general circuit breaker and that the higher orders of branch connections in the station would run in sequence from the contact plates 1, 2, 3, 4, &c., 10, 11, 12, 13, &c., to the successive sets of numerical receivers as illustrated in Fig. 13, the contact plates of each numerical receiver acting as radial points of distribution, each to an individual numerical receiver of higher order and the switching mechanism, controlling magnets and general circuit connections being a mere duplication of the corresponding parts shown in connection with numerical receivers Nos. 1 and 2. To further exemplify this decimal method of connecting up subscribers' lines, suppose that operator No. 1 desires to connect his line with line 999. See Fig. 14. Pursuing the method of operation already indicated he advances the arm D of numerical receiver No. 1 to the last contact on the extreme right; the numerical separator has operated in the meantime and the necessary connections have been made through branch wire No. 13′, for causing the numerical receiver on the extreme right in the second series to advance the arm D′ to the position indicated so that it is in connection with line No. 99 and branch line No. 27′, running to the numerical receiver of the third series on the extreme right. The next numerical separator has operated and made the necessary connections so that the arm D^2 of the last numerical receiver of the third series is stepped forward until it is in contact with line No. 999. Under this condition of affairs line No. 1 is in circuit through the isolator, circuit wire *x*′, wire 1, arm D of numerical receiver No. 1, branch circuit 13′, running to arm D′ of numerical receiver No. 2, branch circuit 27′, running to arm D^2 of numerical receiver No. 3, thence directly through the general circuit breaker to line No. 999 and out to the subscriber.

In operating the apparatus should the subscriber on line No. 999 desire to connect himself with subscriber on line No. 1, it would be necessary for him to send in the same signal which line No. 1 sent in in connecting his, No. 1's, line with No. 999; that is to say, the numerical order of sending in the signal is always from the lower numbers to the higher in sequence, and this for the reason that the numerical receivers operate in sequence in the manner already described, from the lower order of decimals to the higher order thereof. It will be observed that when line No. 1 is connected to line No. 999 there is also connection to line No. 9 and line No. 99. In other words in connecting up any line between line No. 1 and line No. 999 there will always be at least four subscribers connected together, in so far as conversation connections are concerned, and that for any line between 1 and 99 there will be three lines so connected. None of the outlying subscribers, however, can interfere with the persons holding conversation, other than by talking into their transmitters, as the signaling apparatus proper is put wholly out of the control of the subscribers themselves after one of them has once sent in his preliminary signal until the apparatus at the central station has restored the entire mechanism to its normal condition, so that although three or more subscribers may be called up by the same signal it will be an easy matter for the one who signaled to indicate the fact as to which subscriber he desires.

The transmitter T it will be observed is of a very simple nature and its operation for the purpose of uniting any subscriber's line with that of any other outlying line through the agency of the automatic apparatus at the central or switching station is effected by simply turning the handle H one complete revolution after placing the switch S *w* upon that one of the contact plates *o* which corresponds to the line wanted, if said line is among those whose number is less than ten and repeating the operation with one rotation for each line, the number of such operations being dependent upon the decimal relations of the lines to be connected.

Although I prefer to use the special form

of transmitter hereinbefore described and hereinafter claimed, I do not limit myself to the use of this particular form of transmitter as it is obvious that by the proper manipulation of an ordinary make and break key, I might effect the desired order or sequence of current impulses for operating the mechanism at the central station. Nor do I limit myself to the use of all of the apparatus hereinbefore described in connection with an automatic telephone exchange system as many of the features are clearly applicable to a central or switching station in which the connections are made by hand. In this connection it is obvious that the numerical receivers or switches might be operated by hand, as I believe it is broadly new with me to provide a system of cross conductors in a central station in which a limited number of such conductors is utilized with a series of numerical receivers or switches which increase in geometrical order and in which the connections are made in the first instance through one conductor and in the succeeding instances through succeeding radiating or increasing series of like conductors with intermediate switching apparatus.

I make no claim in the present application to the automatic conversation time limit apparatus utilized in connection with the instruments of two or more pairs of subscribers' lines and so related thereto that any two subscribers will be limited to a predetermined time for the purpose of conversation for each independent call and so arranged that the lines of the two subscribers talking will be automatically disconnected at the end of such predetermined time, as this feature constitutes the subject-matter of a divisional application filed by me in the United States Patent Office on the 11th day of December, 1893. My invention contemplates also the use of such apparatus in a generic sense whether with automatic or hand actuated switching devices.

I make no claim in the present application to any of the methods which underlie the application of the generic principles hereinbefore described as this present application 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 an independent 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 which underlie the application of generic principles hereinbefore enumerated, and also the generic principles enumerated in another application filed by me in the United States Patent Office on the 12th day of May, 1893, and bearing Serial No. 474,024 of which the aforesaid application is a division.

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

1. An automatic telephone exchange system having a series of subscribers' lines all connected to a circuit interrupter at one point; branches or forks running to a second circuit interrupter connected to all of the lines; electro-magnetic apparatus for controlling both circuit interrupters and switching apparatus and electrical connections whereby the circuit is interrupted for all of the lines at one point, and for all of the lines save the signaling line at another, in combination with transmitters located in the subscribers' lines for actuating the switching apparatus, substantially as described.

2. A series of telephone or analogous electrical conductors leading to a switching apparatus located at a central or exchange station, said switching apparatus consisting of a numerical receiver switch controlled by an electro magnet adapted to be energized by electrical impulses passing over any one of the incoming lines, in combination with one or more series of similar numerical receivers provided with circuit connections between themselves and the first numerical receiver, and additional circuit connections with the remaining outlying lines, and one or more time controlled separating devices for switching the signaling impulses through the several numerical receiver switches progressively, substantially as described.

3. A series of telephone or analogous electrical conductors leading to a central or switching station, a numerical receiver switch, electro-magnetic means for connecting any one of the incoming lines to the numerical receiver switch electro-magnet, a series of additional numerical receiver switches arranged in sets and provided with circuit connections for connecting them to the first numerical receiver switch in any desired order in combination with one or more time controlled separators for changing the circuit from the numerical receiver switch to any of the additional numerical receiver switches.

4. A series of telephone or analogous electrical conductors running to a central or exchange station, each line being provided with means for connecting it operatively with a single switching device, in combination with one or more sets of similar switching apparatus provided with means for connecting said apparatus to the first switching apparatus, and additional mechanism in the nature of time controlled apparatus provided with circuit connections whereby the switching is effected through the desired switching apparatus during intervals of time between the switching signals transmitted, substantially as described.

5. A series of telephone lines operatively connected with a common or general circuit breaking device at a central or switching station; local branches in the station running from each line to a second circuit breaking device and electro-magnetic means in combination with circuit controlling apparatus lo-

cated at the station and in the outlying lines, whereby both circuit interrupters may be actuated and restored.

6. A series of telephone lines each connected by two branch wires to two independent circuit breakers adapted to break the circuits of all of the lines save the signaling line, in combination with electro-magnetic means for controlling the movement of both circuit breakers, substantially as described.

7. A series of telephone lines running to a common or central switching station and connected with a corresponding series of branch wires and a common circuit controlling device; additional branch conductors running to a controlling relay, in combination with a second circuit controlling relay and electro-magnetic switching apparatus and circuit connections whereby the first set of branch wires is wholly interrupted, the second set all interrupted except the one connected to the line over which a call has been sent in and the first circuit controlling device restored so as to connect all of the lines at the first point of interruption and only one at the second, substantially as described.

8. A series of telephone lines leading into a central or switching station and to a common circuit controlling relay R′, a series of branch lines equal in number to the incoming lines and all connected through a switch or circuit controlling device under control of the aforesaid relay; circuit connections from said branches through a switch having electro-magnetic means for causing it to automatically connect up the desired circuits, in combination with releasing and restoring devices for returning the common circuit controller and the switching apparatus to normal position, substantially as described.

9. In an automatic telephone exchange a series of telephone lines having each two branches at the central station and provided with general circuit interrupters at the exchange adapted to interrupt the circuits of all of the incoming lines excepting that of the subscriber signaling at two points, in combination with means for controlling their operation, substantially as described.

10. An automatic telephone exchange system in which all of the lines lead to two general circuit interrupters adapted to break the circuit of said lines at two independent points and to leave one line connected with the exchange, in combination with automatic circuit switching apparatus which makes the necessary circuit connections and again restores all of the lines to normal circuit connection at the first point of connection but leaves them all interrupted at the second interrupter save the line which conveyed the signal.

11. In a telephone exchange system a series of telephone lines leading into a central exchange, each line having two local branches in the exchange, one of which is connected to earth through an isolator or circuit breaking device provided with means for interrupting all of the circuits save that of the subscriber signaling, while the other branch is connected to contacting devices carried by a general circuit breaker provided with means for interrupting the circuits of all of the lines during the time a signal is being turned in and afterward restoring circuit at these points, substantially as described.

12. A series of telephone lines leading into an exchange, each line having two branches at the exchange one of which leads to a general circuit breaker for all of the lines and the other to and through a relay or electro-magnet R′ to earth, while the first branch is left normally open.

13. In an automatic telephone exchange system one or more numerical separators or rotary switching devices having electrical circuit connections with a time mechanism; one or more two point switches and controlling electro-magnets therefor with circuit connections between the numerical separators the time mechanism and the controlling electro-magnets whereby the time mechanism circuits are automatically brought into action, the switches operated and the time mechanism circuits again discontinued.

14. In an automatic telephone exchange system a series of subscribers' lines all normally connected through a general circuit breaker through individual switches having electrical connections and electro-magnetic controlling devices whereby only one of a series of lines may be left in circuit through the circuit breaker, while the others remain disconnected, in combination with an electro-magnetic restoring device for restoring the general circuit breaker to its normal position.

15. In an automatic telephone exchange system a series of subscribers' lines all normally connected through a general circuit breaker and a controlling electro-magnet therefor each line having an independent switch operatively connected to the circuit breaker, in combination with controlling electro-magnets for said switches and circuit connections whereby any line may maintain continuous circuit connections through the circuit breaker while the others are disconnected therefrom.

16. In an automatic telephone exchange system a series of subscribers' lines normally connected through a general circuit breaker in combination with circuit switching apparatus for automatically connecting any two lines, and electrical and mechanical connections whereby any line is left connected through the circuit breaker the switching apparatus and any other outlying line while the circuits remain interrupted for all other lines at their points of connection with said general circuit breaker.

17. A telephone exchange system consisting of a series of telephone lines radiating from a central station; a series of switching devices for connecting any two lines together,

said switching devices consisting of a single short branch line and one or more series of like short branch lines located in the central station and means for connecting said short branch lines together and to the telephone lines in any desired order, the arrangement being such that the connection is always made through one single short branch line for all orders of connection and through the other short branch lines in sequence for the higher orders of connection, substantially as described.

18. In a telephone exchange system a branch switching line and one or more series of additional branch switching lines all located in the central station; means for connecting the branch switching line to all outlying telephone lines and additional means for connecting said branch switching line to the additional branch switching lines which in turn are provided with means for connecting them to any of the outlying telephone lines whereby all signals and communications between any two telephone lines are had over the first short branch line and the desired one of the additional series of branch lines.

19. A telephone exchange system having a series of outlying telephone lines operatively connected through switching mechanism with a branch switching line, one or more series of connecting lines arranged in decimal order and provided with means for connecting them with the branch switching line and certain of the outlying telephone lines or with the branch switching line and with each other and additional outlying telephone lines.

20. In a telephone exchange system a series of telephone lines provided with means for connecting them to a single short branch line; a series of radiating short branch lines provided with means for connecting them to the first branch line and a third series of short branch lines provided with means for connecting them to a second series of short lines each short branch line of each series being connected in turn to some one of the outlying telephone lines.

21. In an automatic telephone exchange system a numerical receiver or switch having circuit connections of decimal order, with a second series of like receivers or switches and circuit controlling devices and connections whereby all outlying lines of all orders of numerical value are connected through the first switch and through the other series of switches in the order of their decimal relations.

22. In a telephone exchange system a single branch conductor united to a switch adapted to contact with a series of conducting contacts in combination with a series of like switches provided with means for connecting any one of them through any one of the aforesaid contacts with outlying subscribers' lines and means for connecting them through the switches; the arrangement being such that the connections for the lower numbers are through the first switch only, and for the higher numbers through the first switch and the successive series as described.

23. A telephone system provided with signal transmitters on each outlying line; a central exchange including a series of numerical receivers or switching devices, the first of which has a single branch connection and means for connecting it to any subscriber's line, while the others of like construction are arranged in increasing series so that all circuit connections pass through the first single branch wire, substantially as described.

24. An automatic telephone exchange system having a numerical receiver or switch normally out of circuit with all outlying lines and provided with connections for connecting any two lines through it in combination with circuit interrupting mechanism for disconnecting all of the lines but the signaling line and then restoring connections through the remainder of the lines at a point near the numerical receiver or switch and finally advancing the latter until the proper connection is made.

25. A telephone exchange system having a single switch, the stationary part of which is connected to a short conducting switching line provided with means for connecting it with any one of the entire series of subscribers' lines, the movable part of said switch being adapted to be connected with stationary or fixed contacts which in turn are connected to the fixed parts of similar switches, the movable parts of which are adapted to contact with fixed contacts operatively connected with individual subscribers' lines, substantially as described

26. In an automatic telephone exchange system a series of subscribers' lines; one or more numerical receivers or switching devices; a magneto calling generator and a time limit apparatus for limiting the time of connecting and calling a subscriber, in combination with releasing mechanism for restoring the apparatus to normal condition, substantially as described.

27. A series of telephone lines; a number of short branch lines for connecting said telephone lines together in pairs, one of said short branch lines being provided with means for connecting it to any one of the telephone lines, and additional means for connecting it to any one of the remaining short branch lines, in combination with means for connecting the second set of short branch lines each to an outlying telephone line, substantially as described.

28. A telephone exchange system provided with a system of cross or connecting conductors arranged in increasing decimal series whereby all orders of less than ten are connected through a single conductor and all above ten through divided or radiating branches connected to the first conductor and switches for making the necessary connections, substantially as described.

29. A signaling transmitter for an automatic telephone system consisting of a series of contact plates of varying length connected to a common conducting axis, and a corresponding series of fixed contact plates with their free ends resting on the first named plates and the fixed ends lying in the path of a switch in combination with an electrical circuit and a time relay or separator and means whereby when two or more series of impulses are transmitted to a central exchange each series will be automatically directed over a path differing from that taken by the preceding series.

30. A transmitter having a series of movable contacts and a corresponding series of fixed contact plates adapted to contact therewith at their free ends, their fixed ends having contacts lying in the path of a single contact switch in combination with a movable contact having an earthed circuit connection through call mechanism, substantially as described.

31. A transmitter having means for transmitting one or more current impulses at each revolution and a switch adapted to vary the number of such impulses at will, in combination with a circuit closing plate carried by said transmitter, and connections therefor adapted to close a circuit through a magneto call bell or other signaling device when said transmitter is in its normal position of rest.

32. A transmitter having means for transmitting one or more current impulses at each revolution, a switch adapted to vary the number of such impulses at will, a circuit closing plate carried by said transmitter adapted to close a circuit through a magneto call bell or other signaling device; together with such arrangement of parts that when the transmitter is revolved, the magneto call bell or other signaling device will be cut out of circuit.

33. In an automatic telephone exchange system a series of subscribers' lines provided each with one or more sets of telephonic apparatus and signaling or circuit interrupting call apparatus; a time limit apparatus for limiting the time of turning in a call and ringing alarms at any two stations; automatic switching apparatus connected electrically with circuit controlling apparatus and automatic releasing mechanism for restoring the lines to their normal condition after a given time.

34. In an automatic telephone exchange system a series of numerical receivers or switching devices; one for the tens, and a series of like apparatus for each order of numerals in increasing ratio, in combination with one or more numerical separating devices and electrical and mechanical connections whereby any two lines may be automatically united in any desired order according to their numerical relation, the first numerical receiver being connected on one side to a single short line and on the other side through additional short lines to the second series of numerical receivers which in turn are connected to outlying telephone lines, substantially as described.

35. In a telephone exchange system a series of telephone lines arranged in numerical order of units, tens, hundreds and thousands; a numerical receiver switch of the first order connecting to units; a series of numerical receivers of the second order connecting to tens and units; a series of numerical receivers of the third order connecting to hundreds, tens and units, and a series of numerical receivers of the fourth order connecting to thousands, hundreds, tens and units; in combination with one or more numerical separating devices and electrical circuit connections for shifting the circuits in the desired order of tens, hundreds and thousands and electrical and mechanical connections whereby a maximum number of line connections in pairs is effected with a minimum number of wires in the central station.

36. In an automatic telephone exchange system a numerical receiver or step-by-step switch having a movable contact arm controlled by an electro-magnet adapted for connection with any one of a series of incoming lines in combination with automatic switching mechanism controlled by a time controlled separating device for switching the circuit from the controlling electro-magnet into said movable contact arm.

37. A numerical receiver or circuit changing switch for changing the circuit relations through subscribers' lines, said switch being connected to a conductor and to a second normally open switch; means for connecting any calling subscriber to the numerical receiver and for advancing it step by step and additional means consisting of a time controlled separating device and circuit connections whereby the numerical receiver is actuated, the propelling electro-magnet cut out of circuit and the receiver then connected to the line of the subscriber called.

38. In an automatic telephone exchange system a numerical receiver or circuit changing switch of the first or units order; a series of numerical receivers of the second or tens and units order; means for connecting a calling subscriber to the numerical receiver of the first order and for advancing it step-by-step and additional means consisting of time controlled separating devices and circuit connections for then cutting out the propelling electro-magnet, changing the circuit to one of the numerical receivers of the second order, advancing it step-by-step and finally cutting its propelling electro-magnet out of circuit and connecting through said receivers to the line of the subscriber called.

39. In an automatic telephone exchange

system a series of subscribers' lines; a time mechanism and a time limit apparatus for limiting the time of sending in a signal; means for causing the time mechanism to actuate the time limit apparatus for any pre-determined length of time on the reception of a signal at the exchange from an outlying subscriber and additional means for restoring the apparatus to normal condition at the expiration of the time limit.

40. A circuit controlling device consisting of an insulated plate i^2 overlying a conducting plate i^5 carried by a moving surface and having circuit connections with an electro-magnetic releasing device which permits the moving surface to return to its normal position after it has carried the circuit controller forward and closed the circuit through the releasing device, substantially as described.

41. A circuit controlling device carried by a rotary or movable switch having electro-magnetic means for advancing it step by step and separately connected through a time controlled mechanism whereby the switch is released and restored to normal condition after a pre-determined time, substantially as described.

42. A circuit controlling device carried by a rotary or movable switch having electro-magnetic means for advancing the switch step by step, and a releasing device operatively connected to the controlling device provided with means whereby the switch is restored to normal position after it has advanced to such a position as will automatically close the circuit through the circuit controlling device and the releasing device, and will also keep the releasing circuit closed until the switch has returned to its normal position, substantially as described.

43. In an automatic telephone exchange system a series of subscribers' lines; a series of electro-magnetic switching devices for uniting any two of said lines together, all of the switches being normally disconnected from all subscribers' lines and provided with circuit connections through one or more time controlled numerical separating devices whereby the switching devices are actuated in sequence and caused to connect the subscribers' lines therethrough in any desired order.

44. In an automatic telephone exchange system a series of subscribers' lines provided each with telephonic instruments, a signaling generator and a circuit breaking signal transmitter all connected to two general circuit interrupters through branch circuits; a series of cross connecting circuits and a series of electro-magnetic switching devices all normally disconnected from circuit but provided with electro-magnetic means for operating them in sequence and connecting up any two lines, in combination with automatic releasing mechanism connected to and controlled by a time mechanism for limiting the time any two lines are connected together, substantially as described.

45. In a telephone exchange system a series of subscribers' lines; means for automatically connecting any two subscribers' lines together in combination with a releasing device and additional means consisting of a time controlled apparatus adapted to be set for any pre-arranged time limit and having circuit connections whereby such releasing device is automatically placed in the circuit of any two connected wires for the purpose of automatically disconnecting them after the expiration of any pre-determined time limit.

46. In a telephone exchange system having outlying subscribers' lines provided with signaling mechanism; one cross connecting line located in the exchange and adapted to be connected to any telephone line and one or more series of additional cross connectors each of which is adapted to be connected to the first cross connecting line in combination with time controlled separating devices for automatically joining up in one circuit the cross connectors selected by the signaling subscriber.

47. In a telephone exchange system having outlying subscribers' lines provided with signaling mechanism; one cross connecting line located in the exchange and adapted to be connected to any telephone line and one or more series of additional cross connectors adapted to be connected to the first cross connecting line, in combination with time controlled separating devices for automatically joining up in one circuit the cross connectors selected by the signaling subscriber and joining the line of the calling subscriber to that of the subscriber called.

48. A telephone system having a series of subscribers' stations provided with signaling transmitters adapted for sending impulses over any line of the system in sets or series; an automatic exchange station having a numerical receiver of the first or units order; a series of numerical receivers of the second or tens order; a series of numerical receivers of the third or hundreds order, and a series of numerical receivers of the fourth or thousands order, together with means for receiving the signaling impulses and additional means consisting of time controlled separating devices and circuit connections for distributing said signaling impulses to as many orders of receivers as there may be sets or series of signaling impulses received.

49. In a system of telephonic intercommunication in which signaling impulses in series or sets are transmitted to the exchange by individual subscribers for the purpose of obtaining intercommunication with other lines, a time controlled separating device for automatically separating the various series of impulses transmitted by the signaling subscriber.

50. In an automatic telephone exchange station a series of subscribers' lines; means for automatically connecting any two of said lines together in combination with a releasing device automatically placed in the circuit to enable either subscriber to disconnect, and additional means consisting of a time controlled switch and circuit connections for automatically controlling said releasing device at the expiration of any predetermined time limit.

ROMAINE CALLENDER.

Witnesses:
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