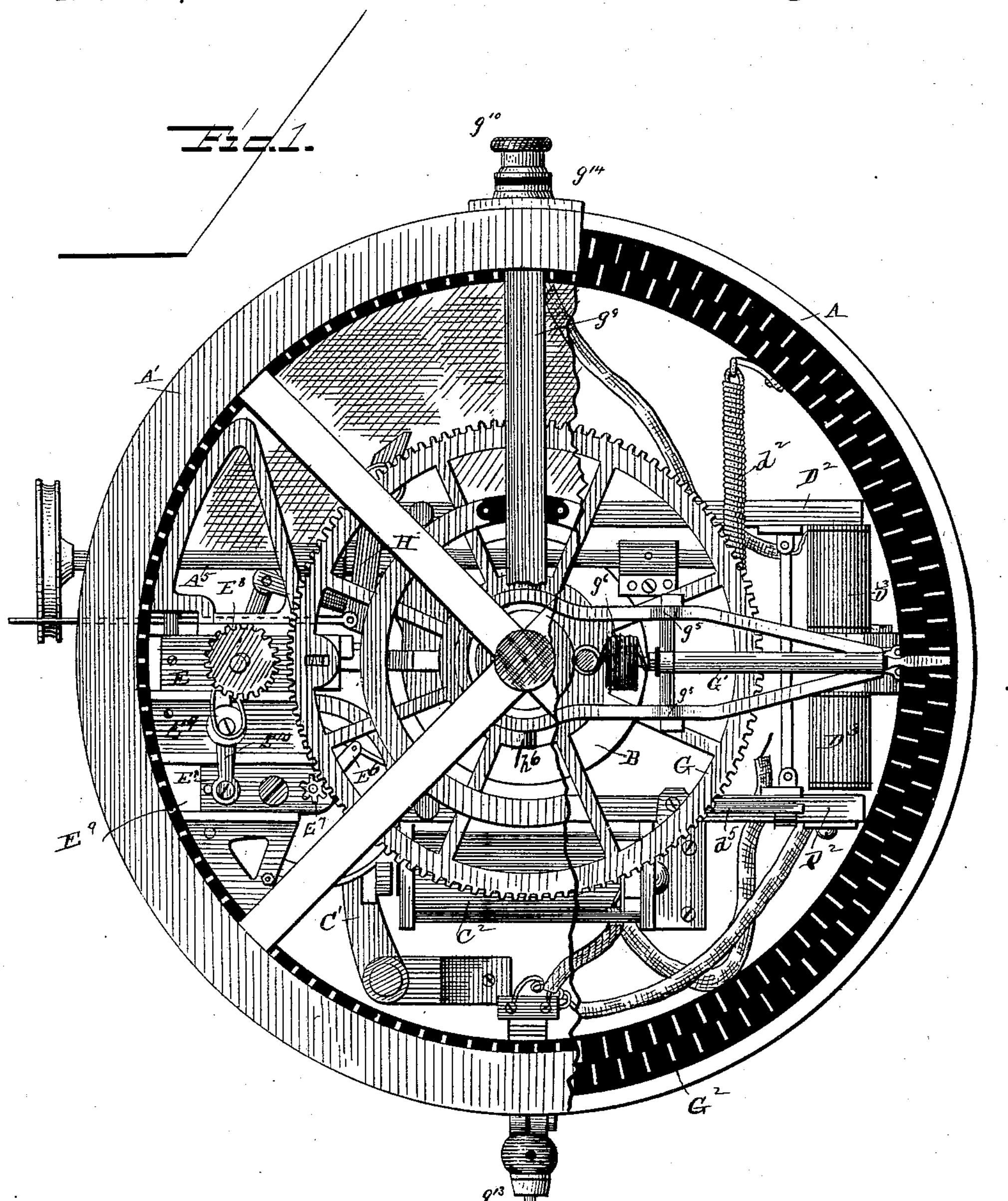
(No Model.)

27 Sheets—Sheet 1.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

Marcellus Bailey

(No Model.)

27 Sheets—Sheet 2.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

Fig. 2.

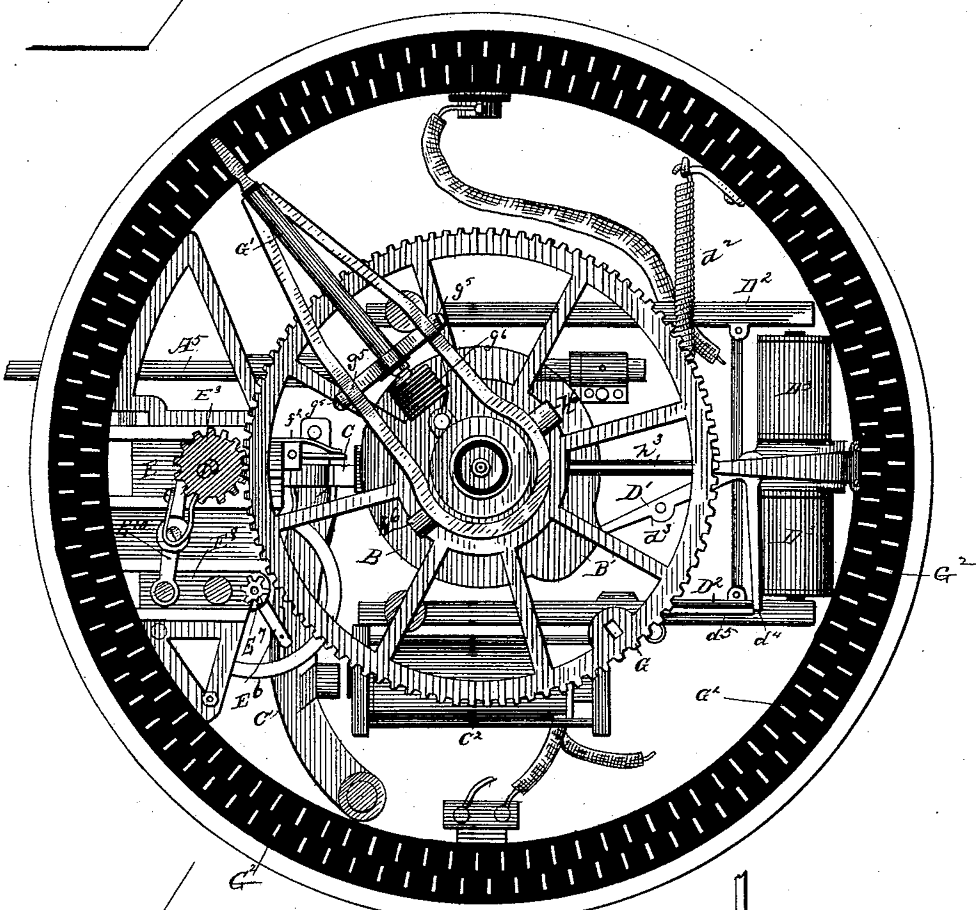
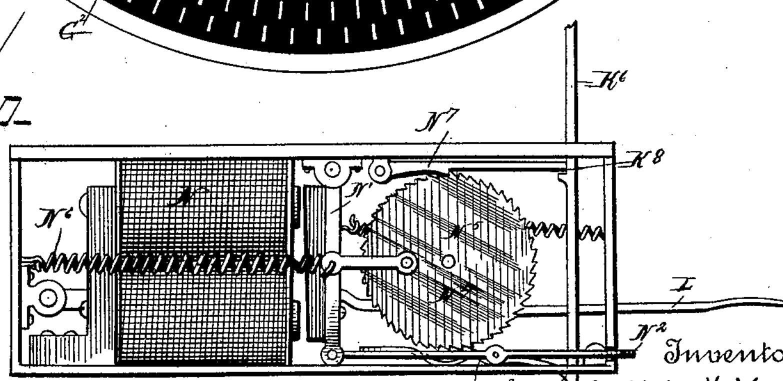


Fig. 50.



Witnesses
Ewell A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

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W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

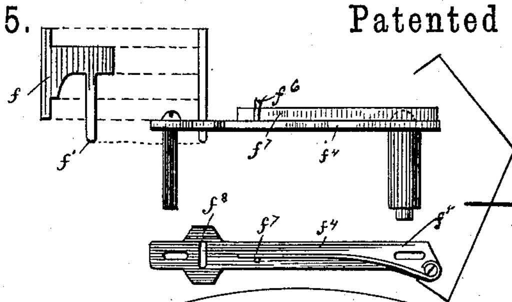


Fig. 7.

Fig. 3.

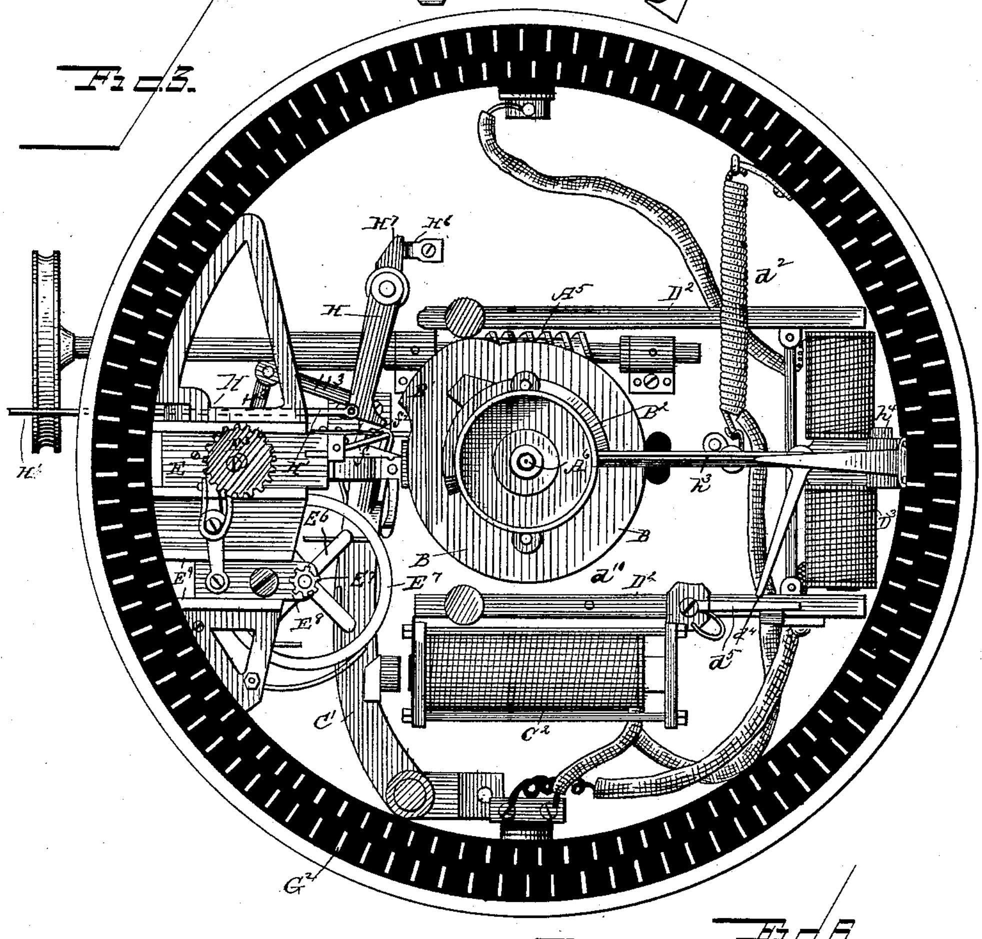
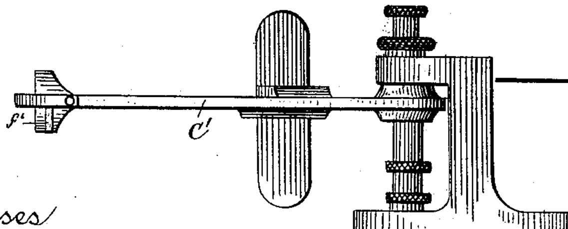


Fig. 8



Witnesses

Edd A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

Marcellus Bailey

(No Model.)

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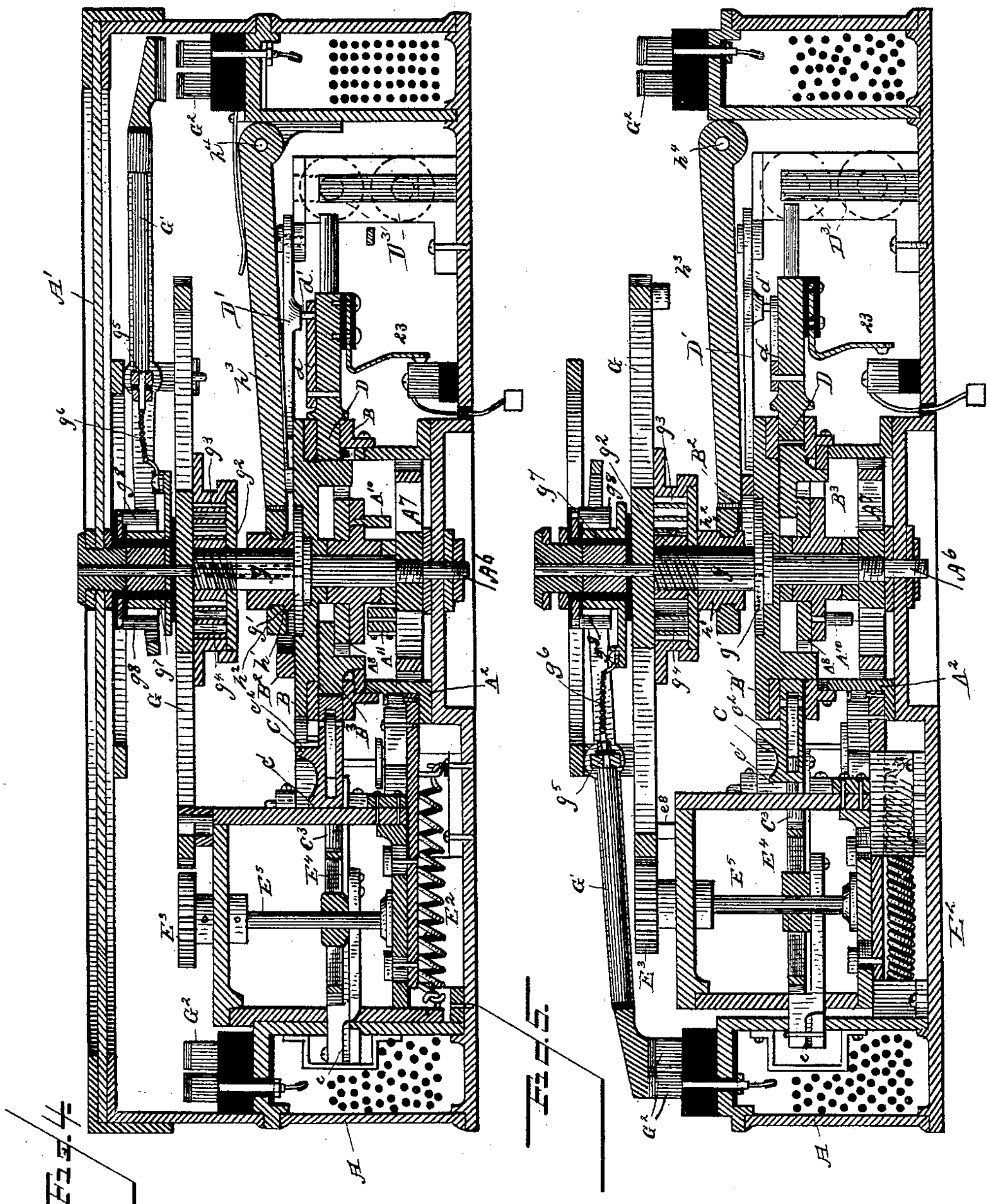
W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

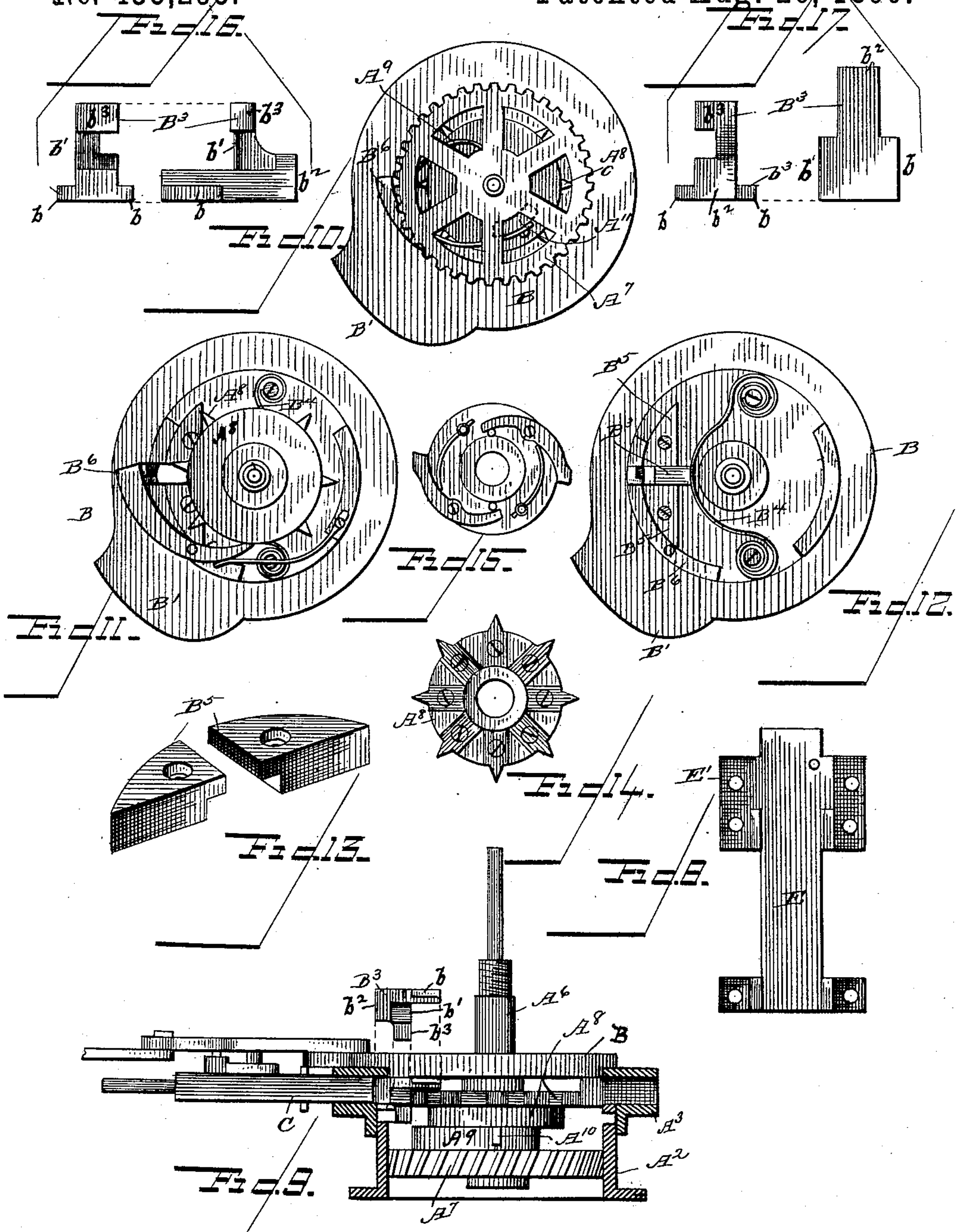
Marcellus Bailey

(No Model.) 27 Sheets—Sheet 5.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses;
Ewell A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

(No Model.) 27 Sheets—Sheet 6.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

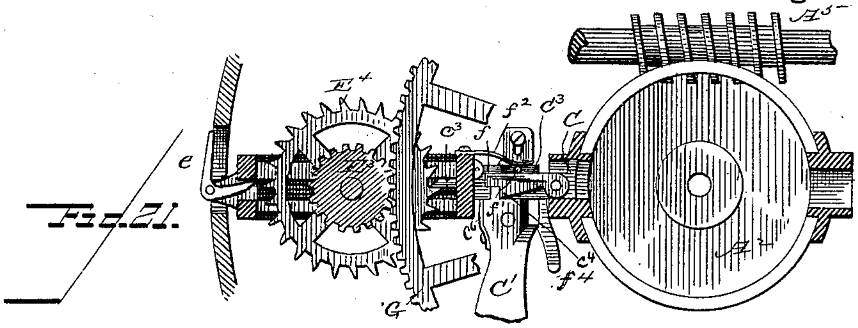


Fig. 21.

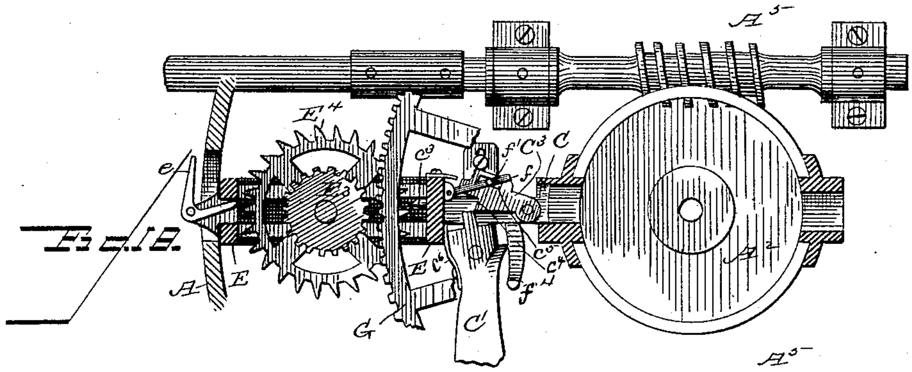
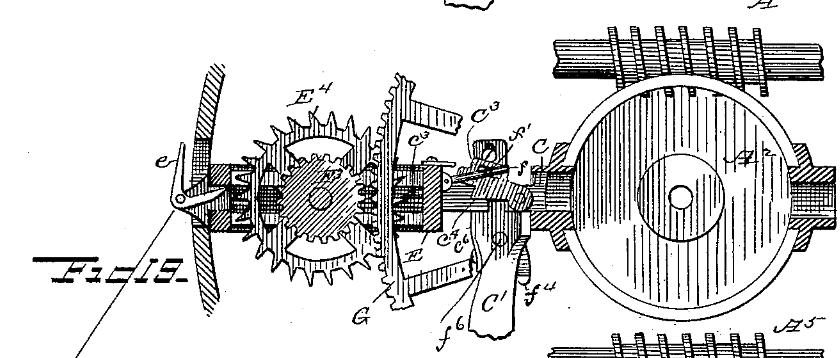


Fig. 18.



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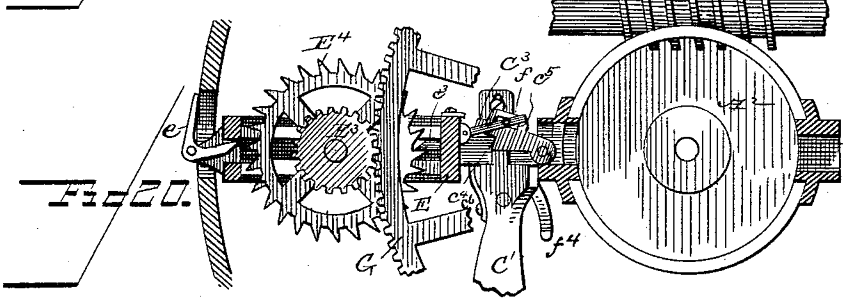

Fig. 20.

Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

Marcellus Bailey

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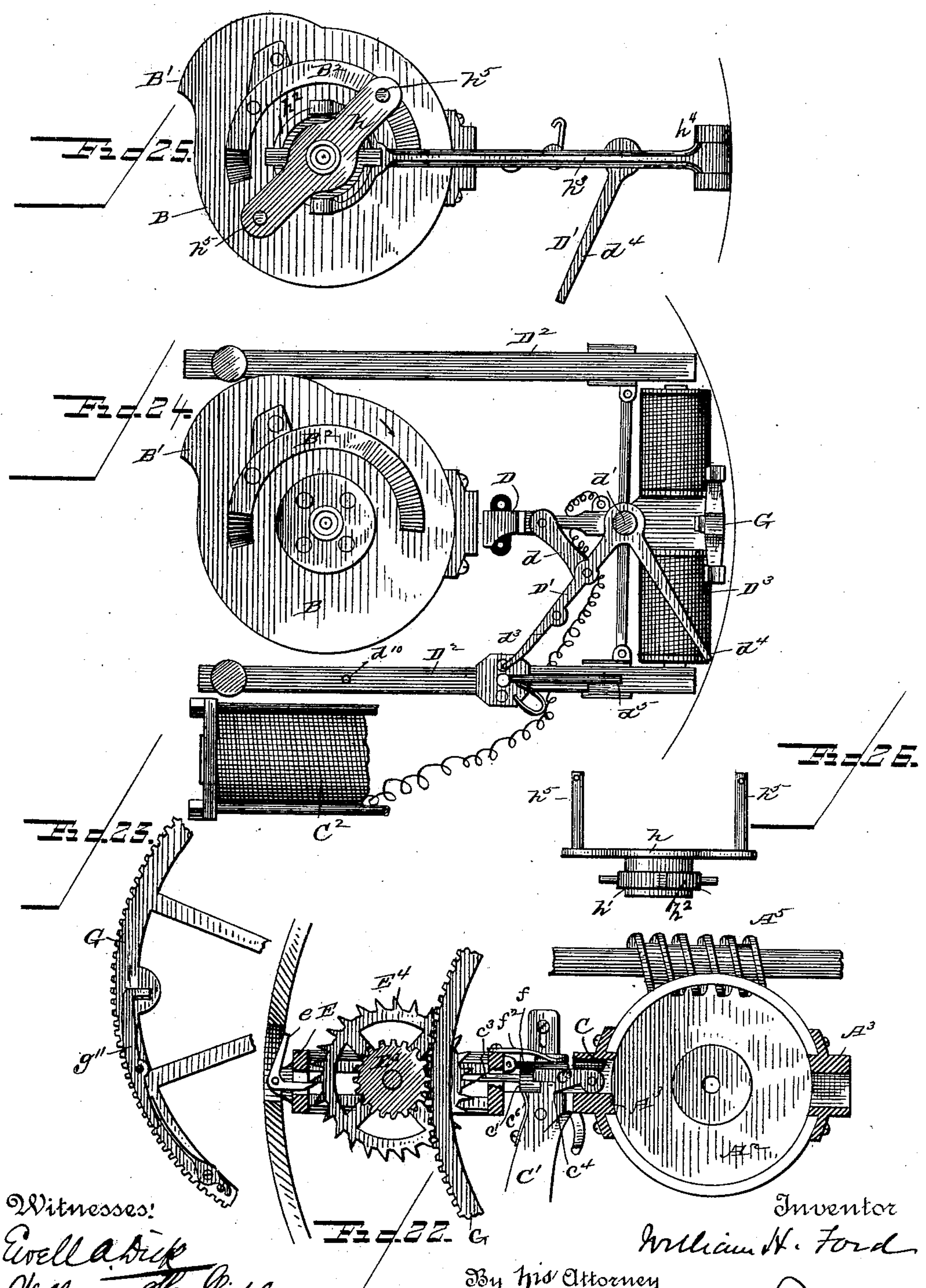
W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

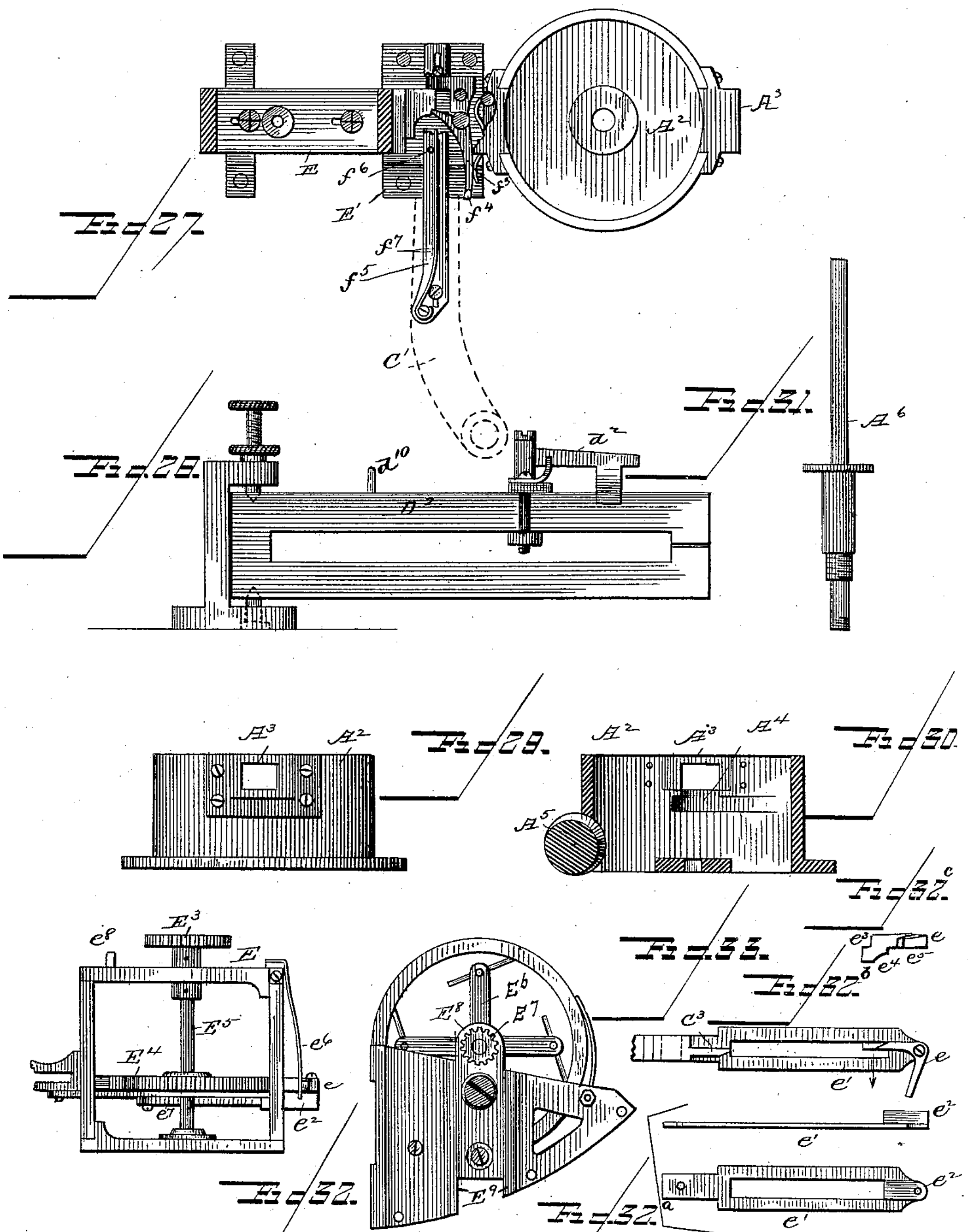
Marcellus Bailey

(No Model.) 27 Sheets—Sheet 8.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

Marcellus Bailey

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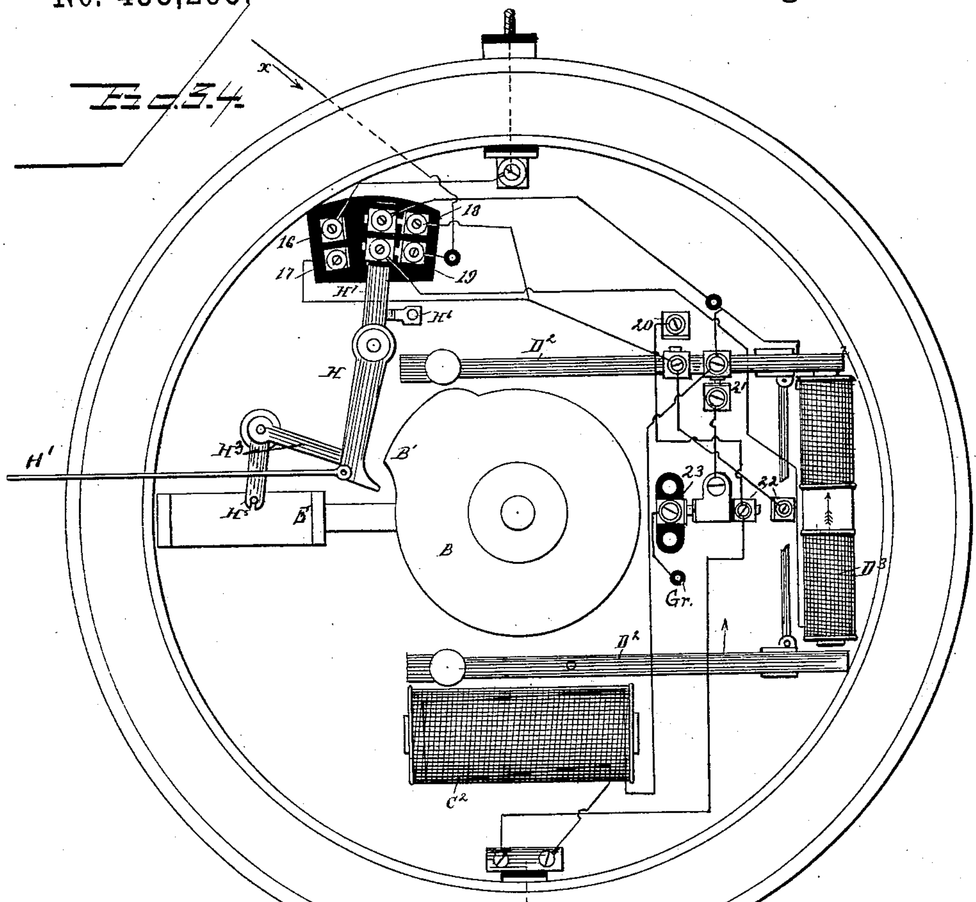
No. 435,295. Patented Aug. 26, 1890.

Fig. 34.



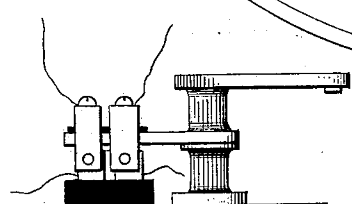


Fig. 35.

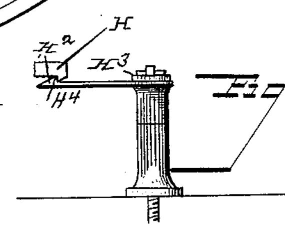


Fig. 36.

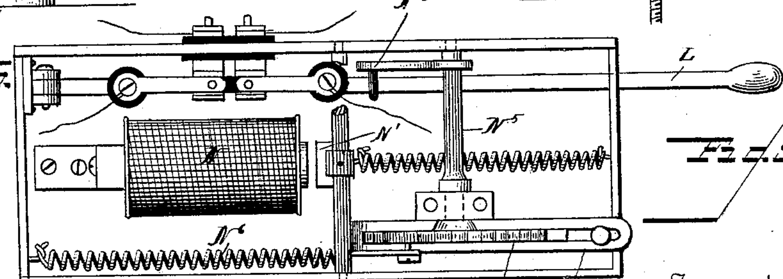


Fig. 50.a

Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorneys

Marcellus Bailey

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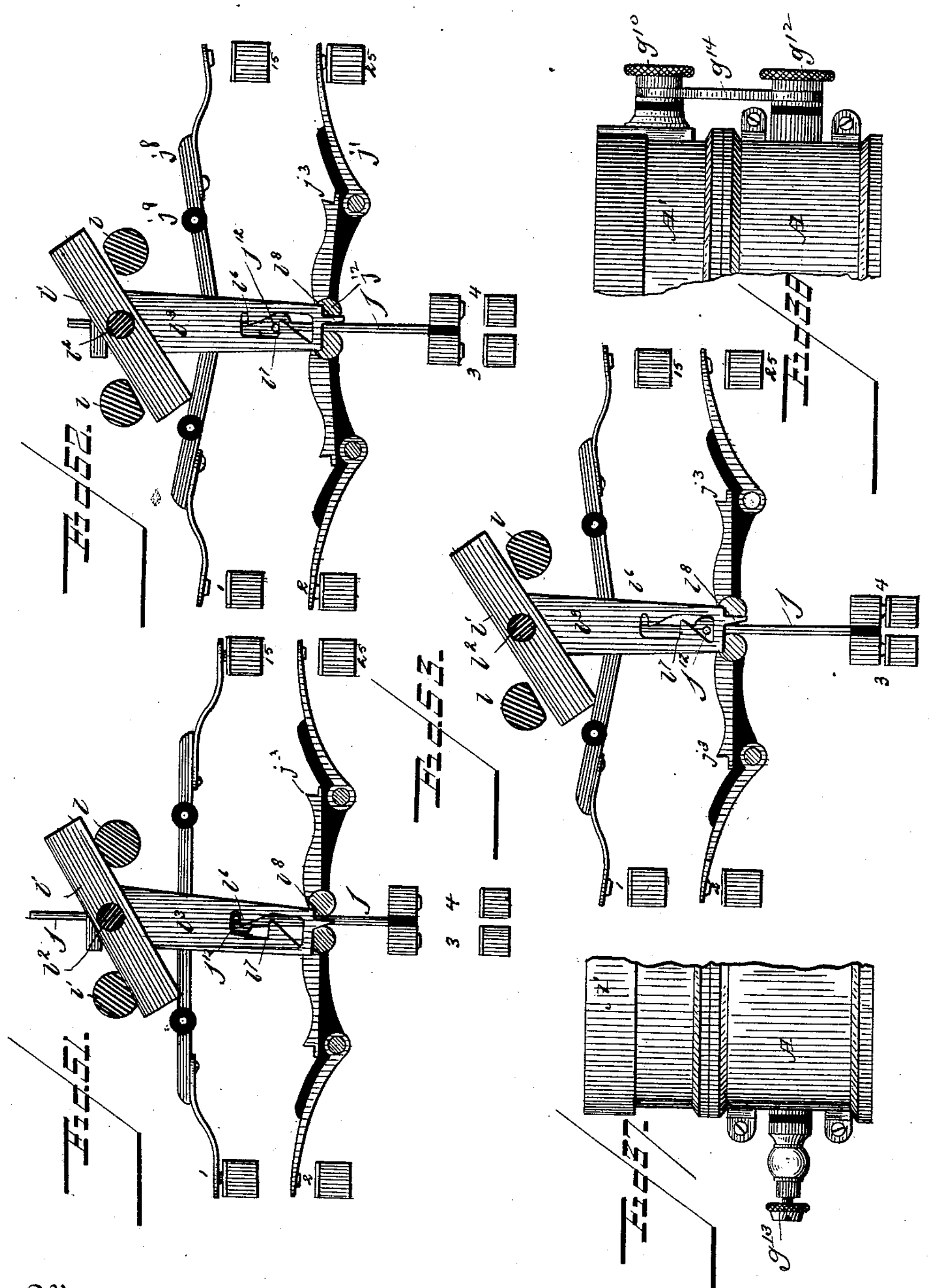
27 Sheets—Sheet 10.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

Marcellus Bailey

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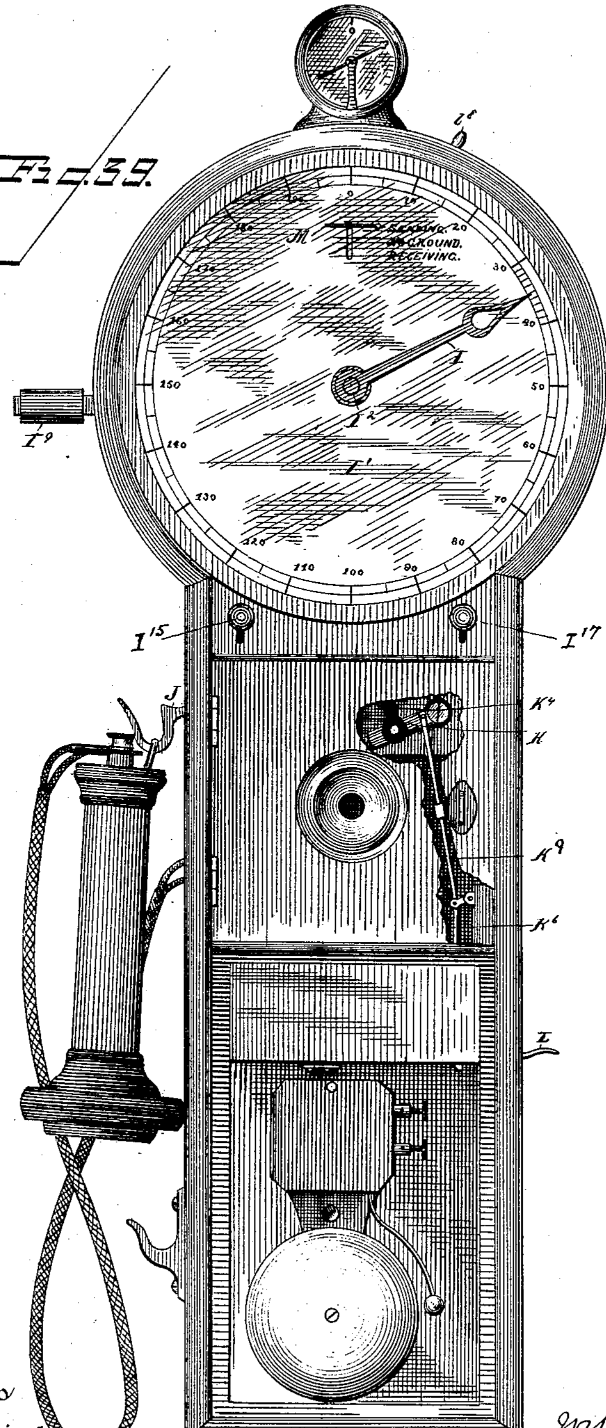
W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

Fig. 39.



Witnesses
Ewell A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

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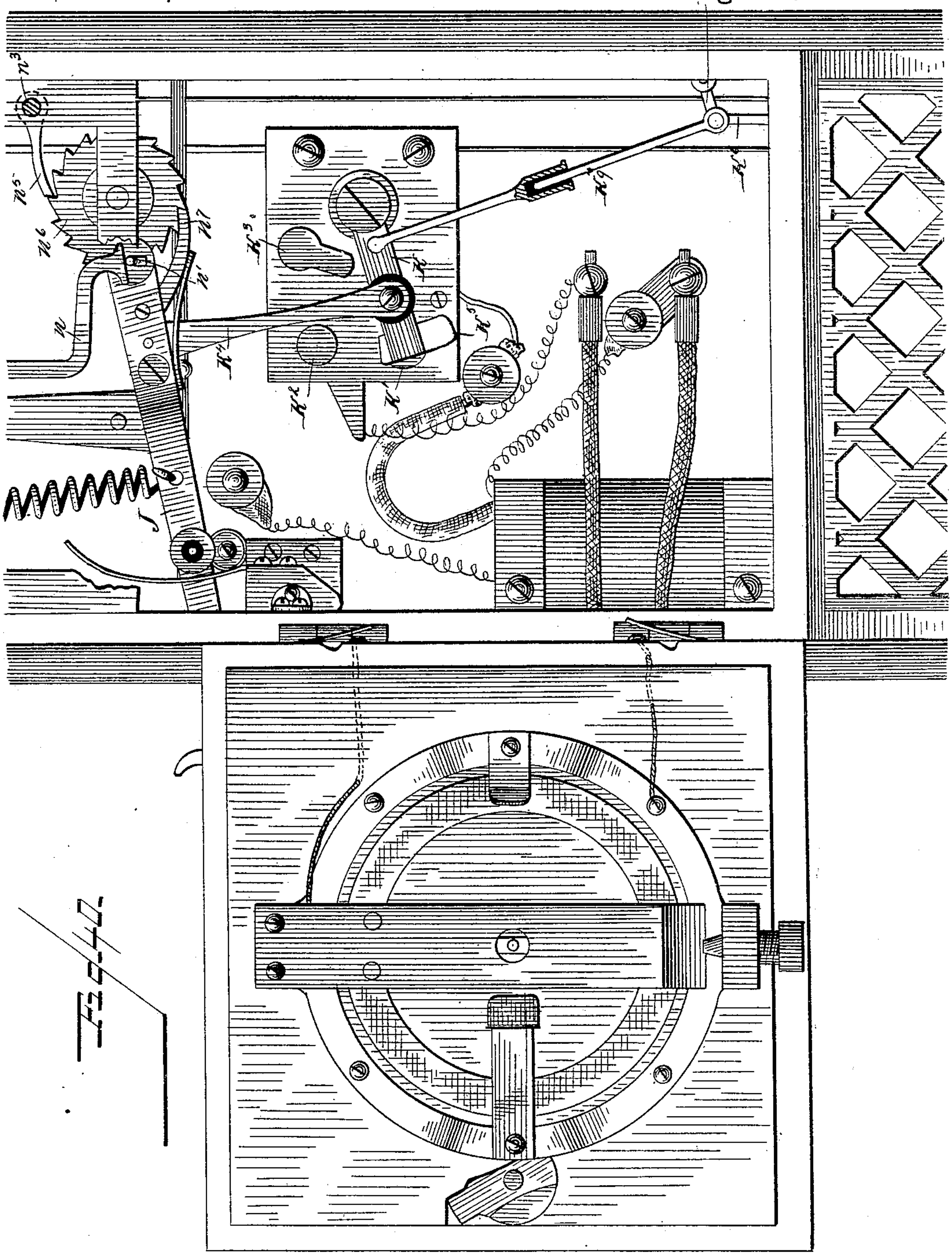

Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

Marcellus Bailey

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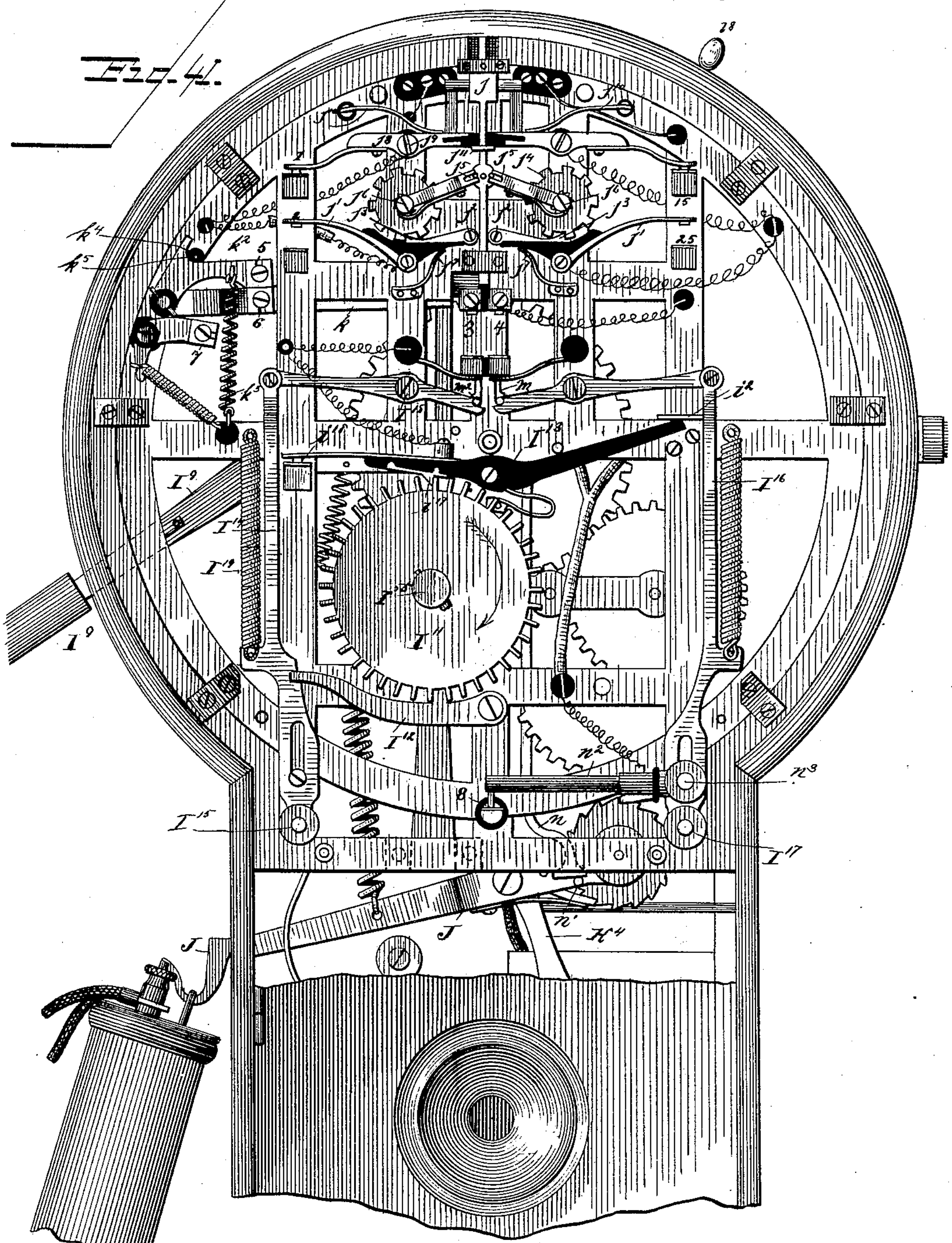
W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

Fig. 4.



Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

Marcellus Bailey

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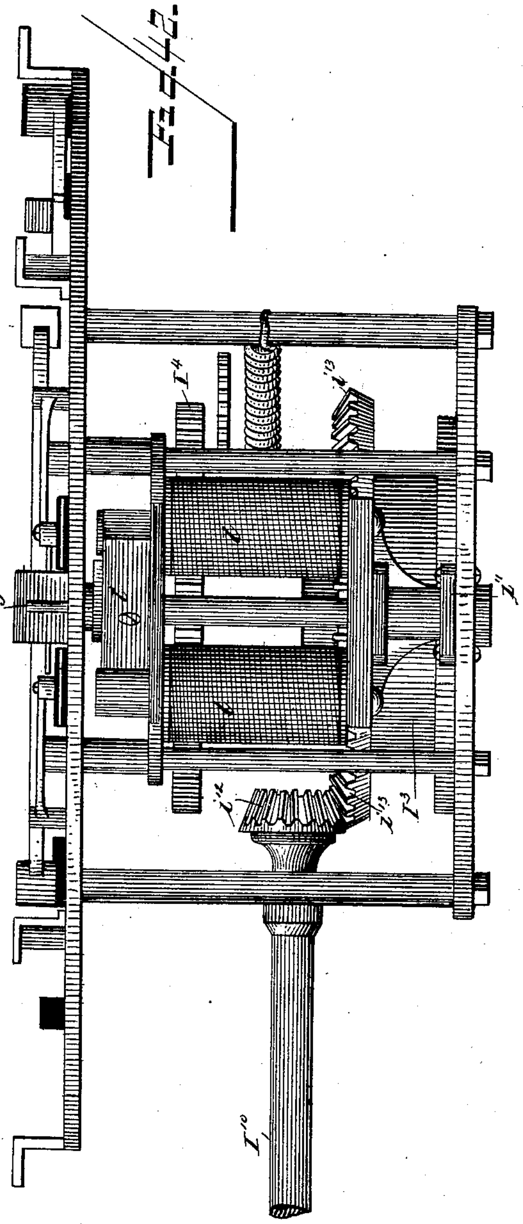
W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

Fig. 49.



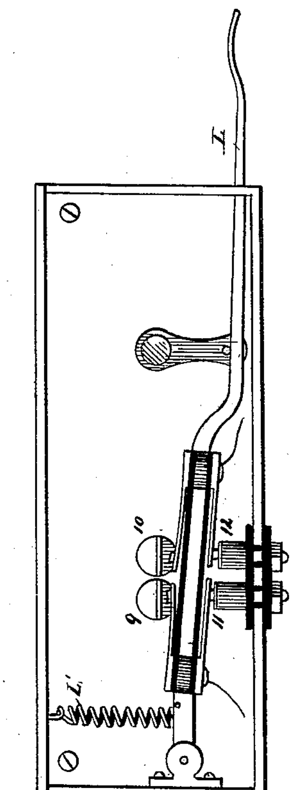


Fig. 50.

Witnesses
Ewell A. Dick
William H. Shipley.

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

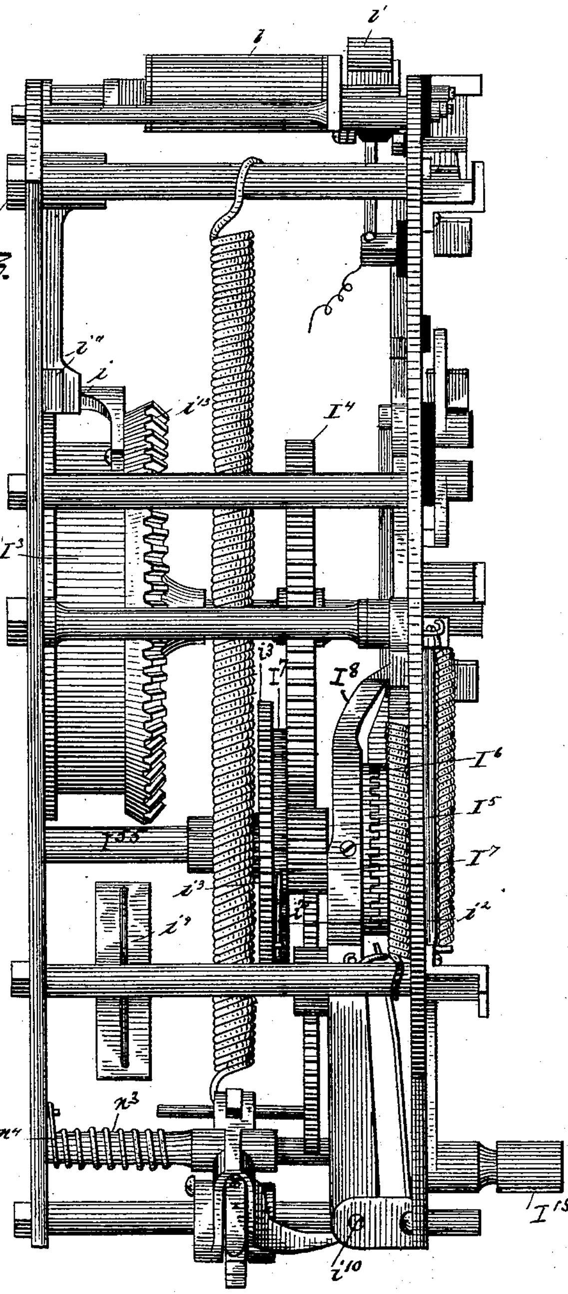
(No Model.) 27 Sheets—Sheet 15.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

Fig. 43.



Witnesses.
Everett A. Wick
William H. Shipley.

Inventor
William H. Ford
By his Attorney
Maurtus Bailey

(No Model.) 27 Sheets—Sheet 16.

W. H. FORD.

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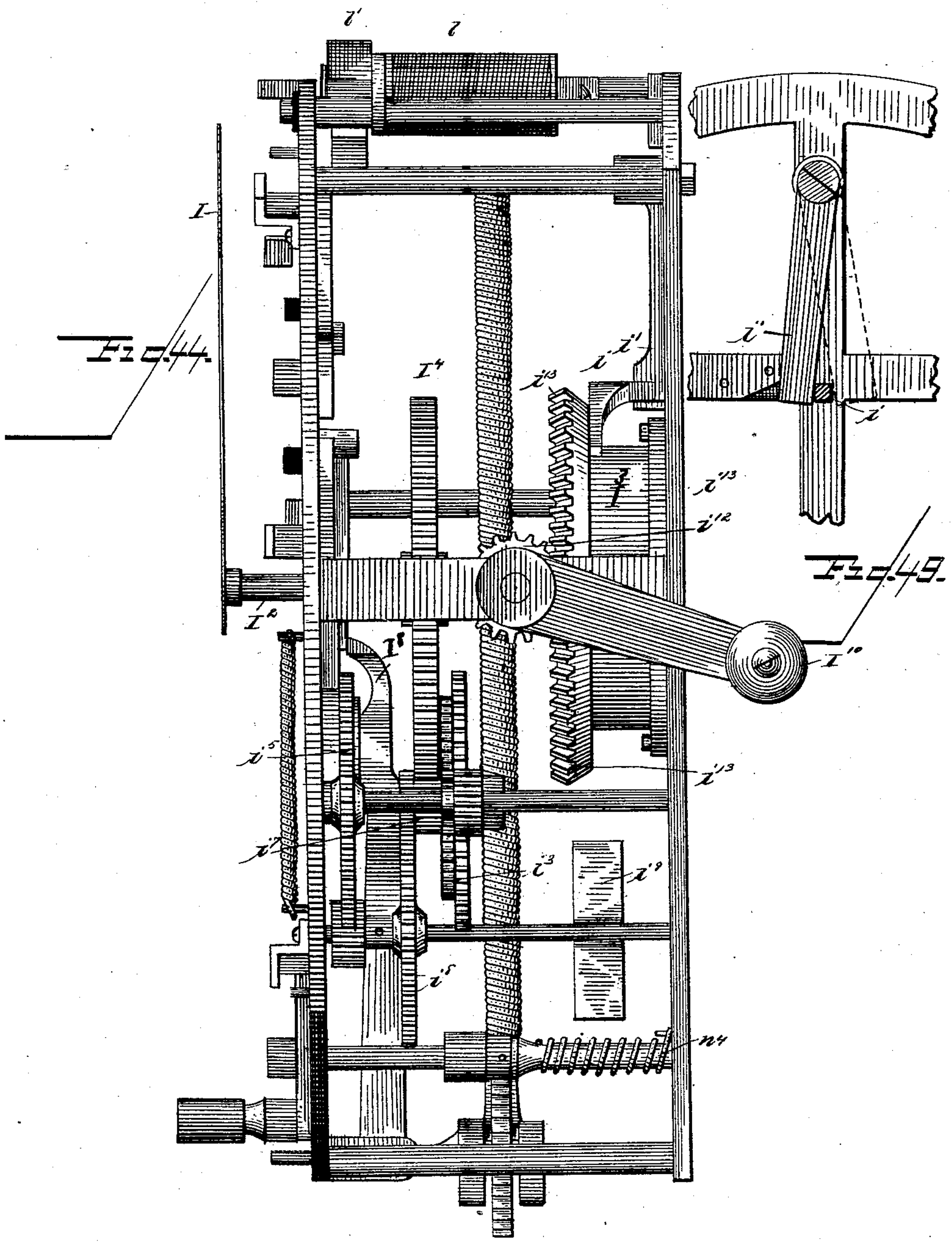

Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

Marcellus Bailey

(No Model.)

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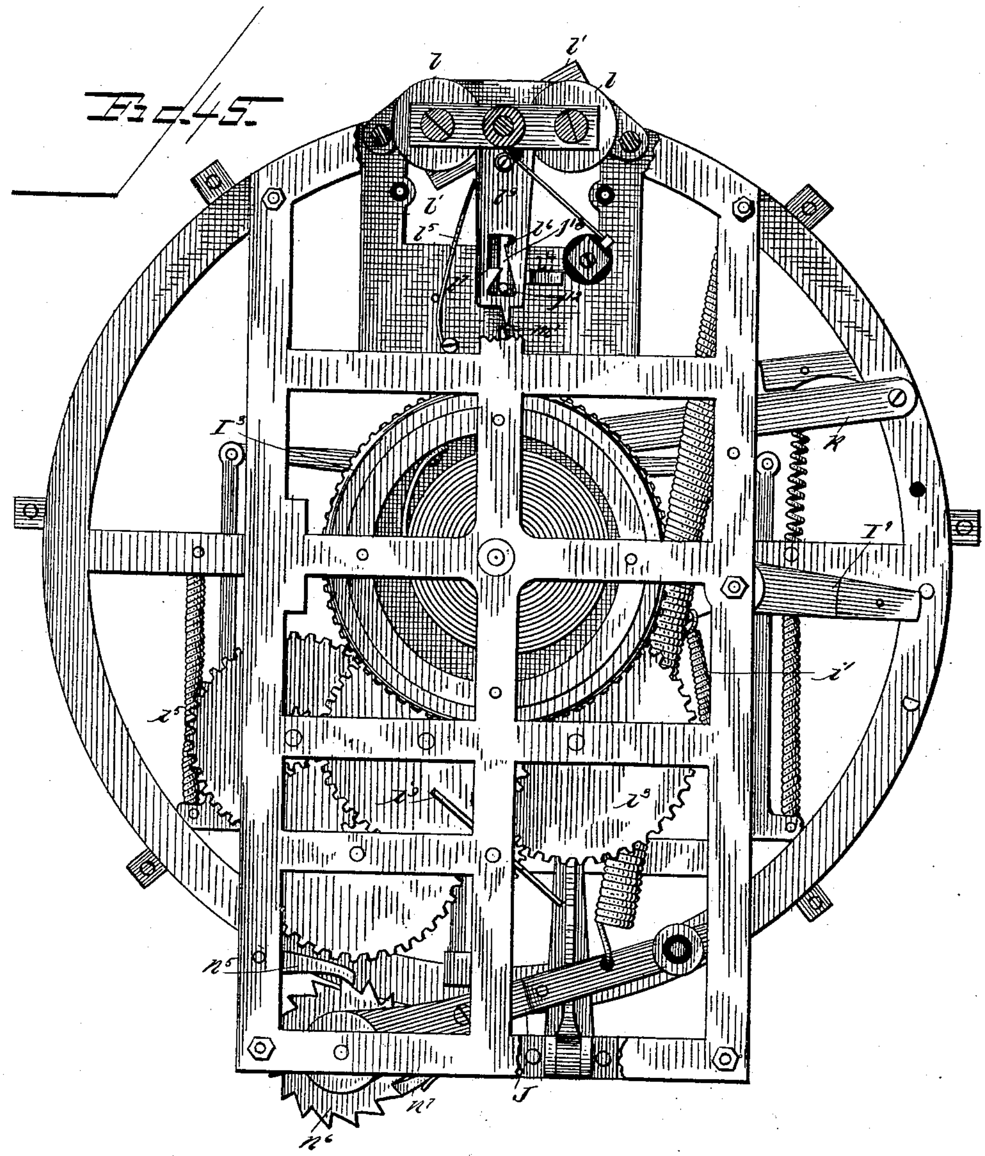
W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

Fig. 45.



Witnesses:

Ewell A. Dick

William H. Shipley

Inventor

William H. Ford

By his Attorney

Marcellus Bailey

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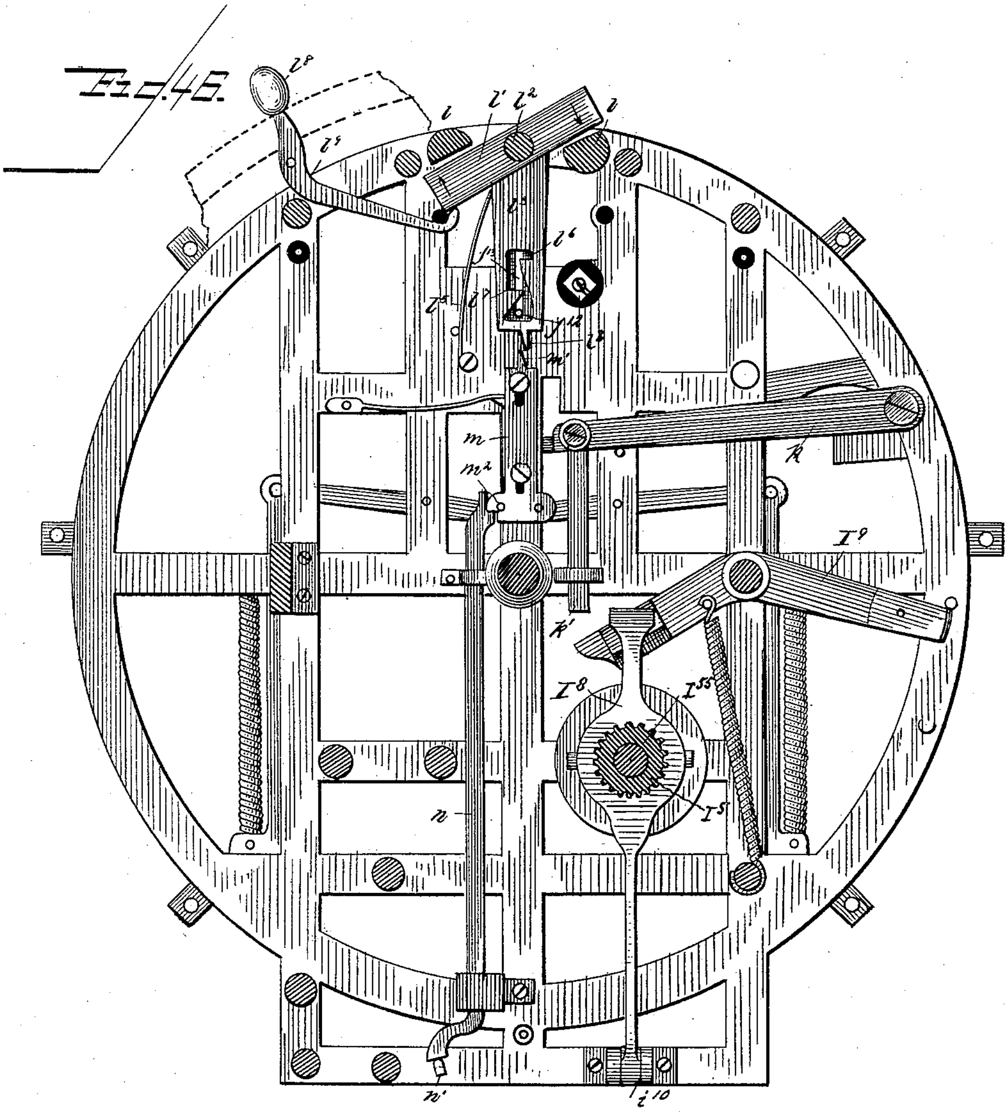
W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

Fig. 46.



Witnesses:
Ewell A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

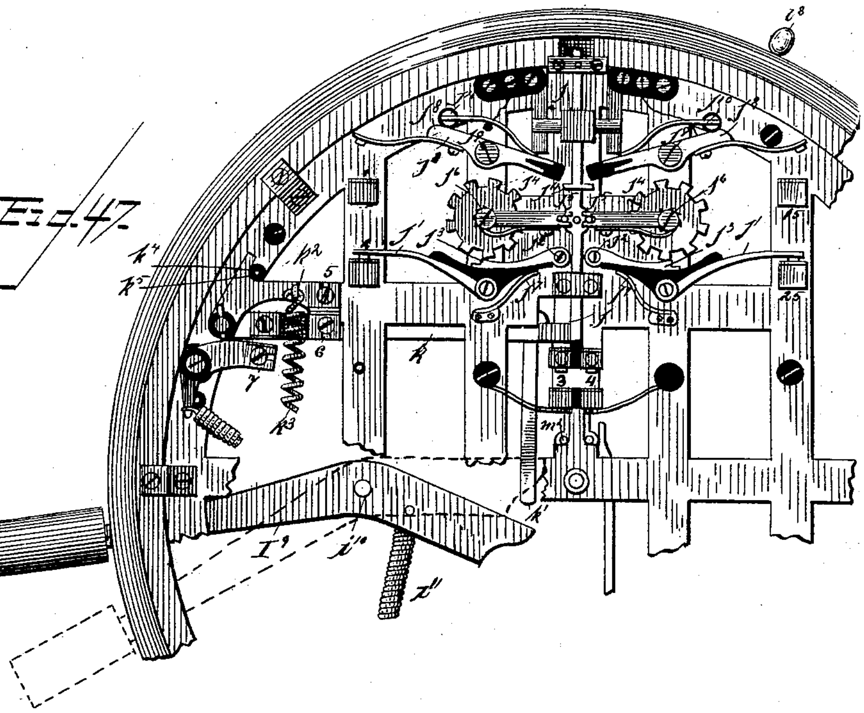
(No Model.) 27 Sheets—Sheet 19.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

Fig. 47.



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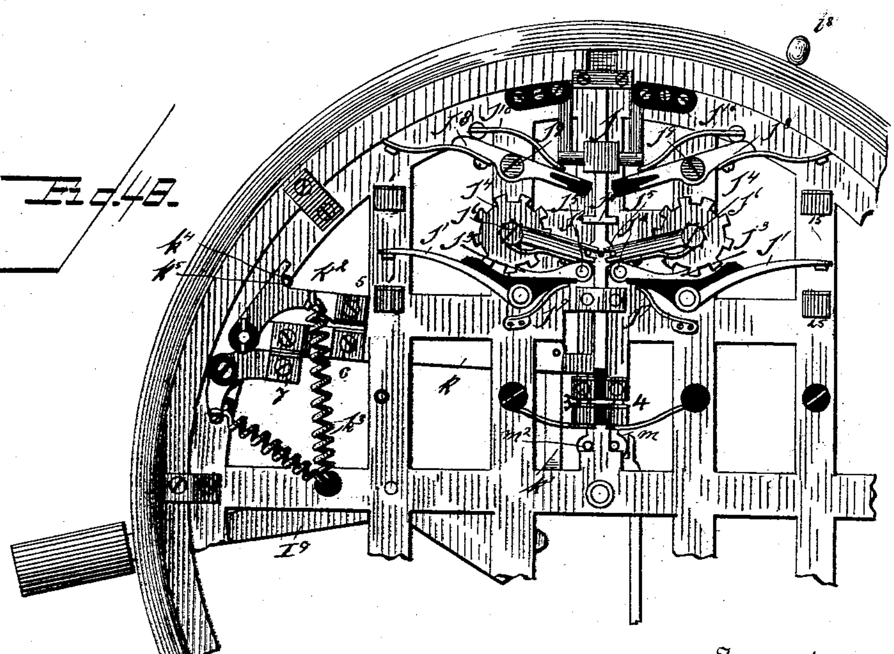

Witnesses:
Lowell A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

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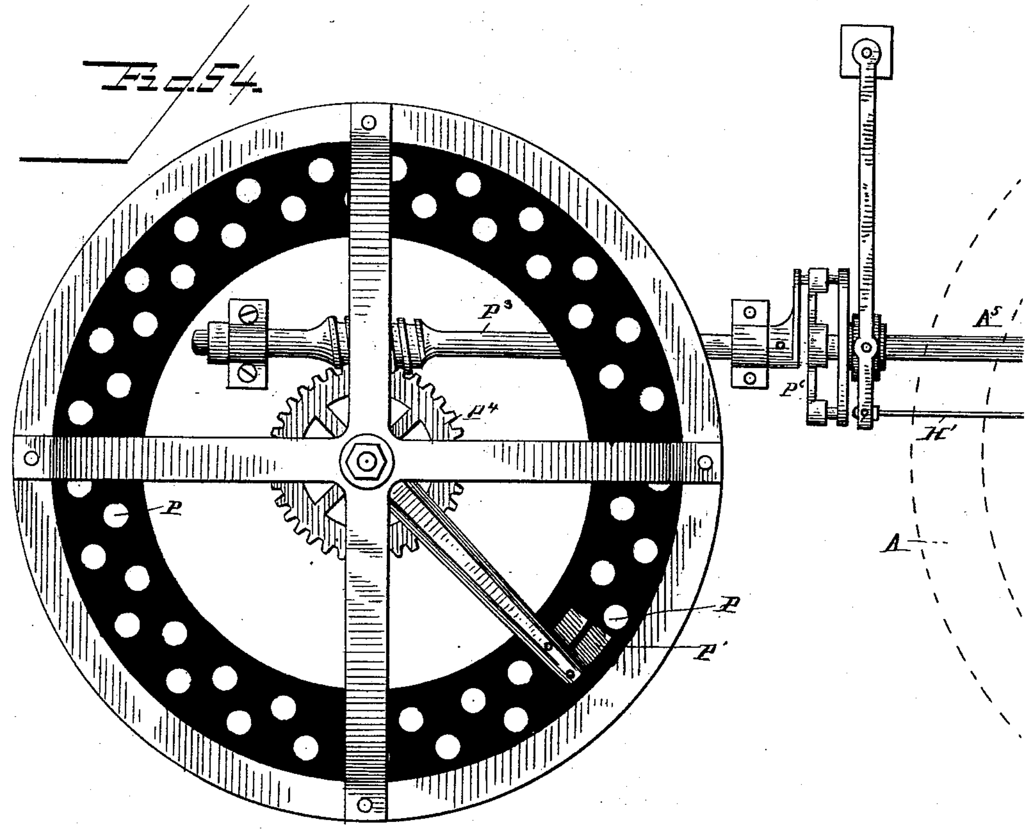
W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.

Fig. 54.



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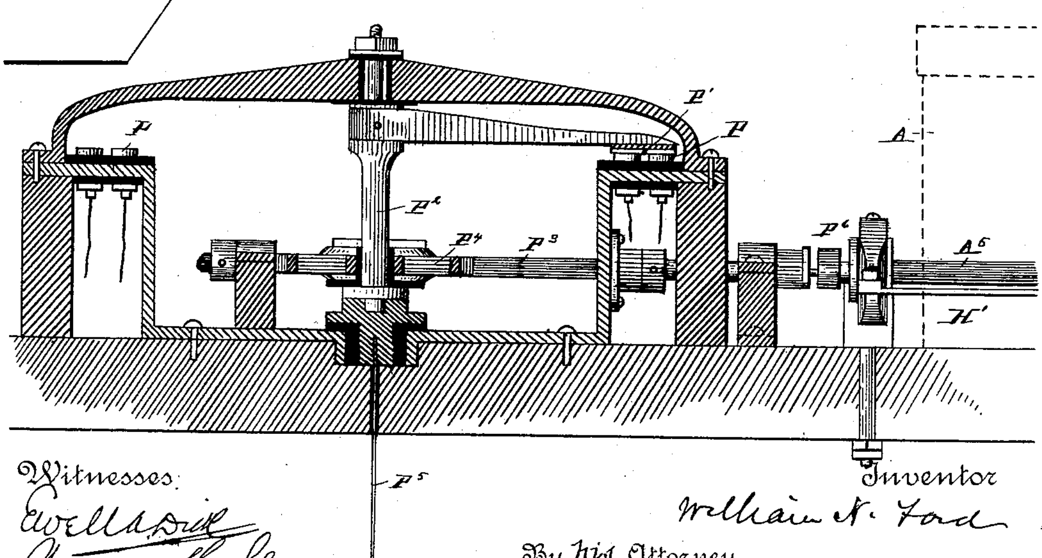


Witnesses:

Ewell A. Dick

William H. Shipley.

Inventor

William H. Ford

By his Attorney

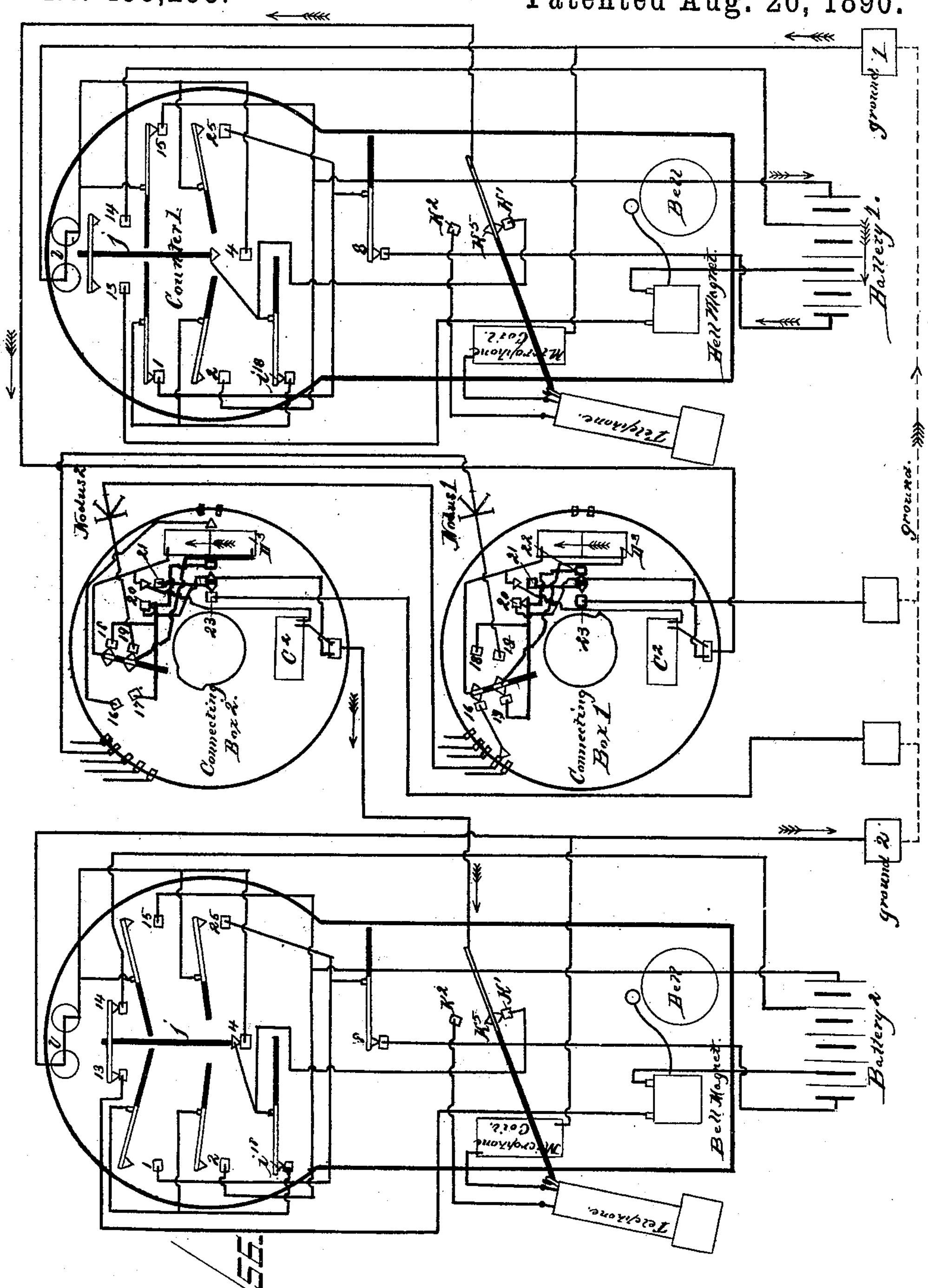
Marcellus Bailey

(No Model.) 27 Sheets—Sheet 21.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses:
Ewell A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

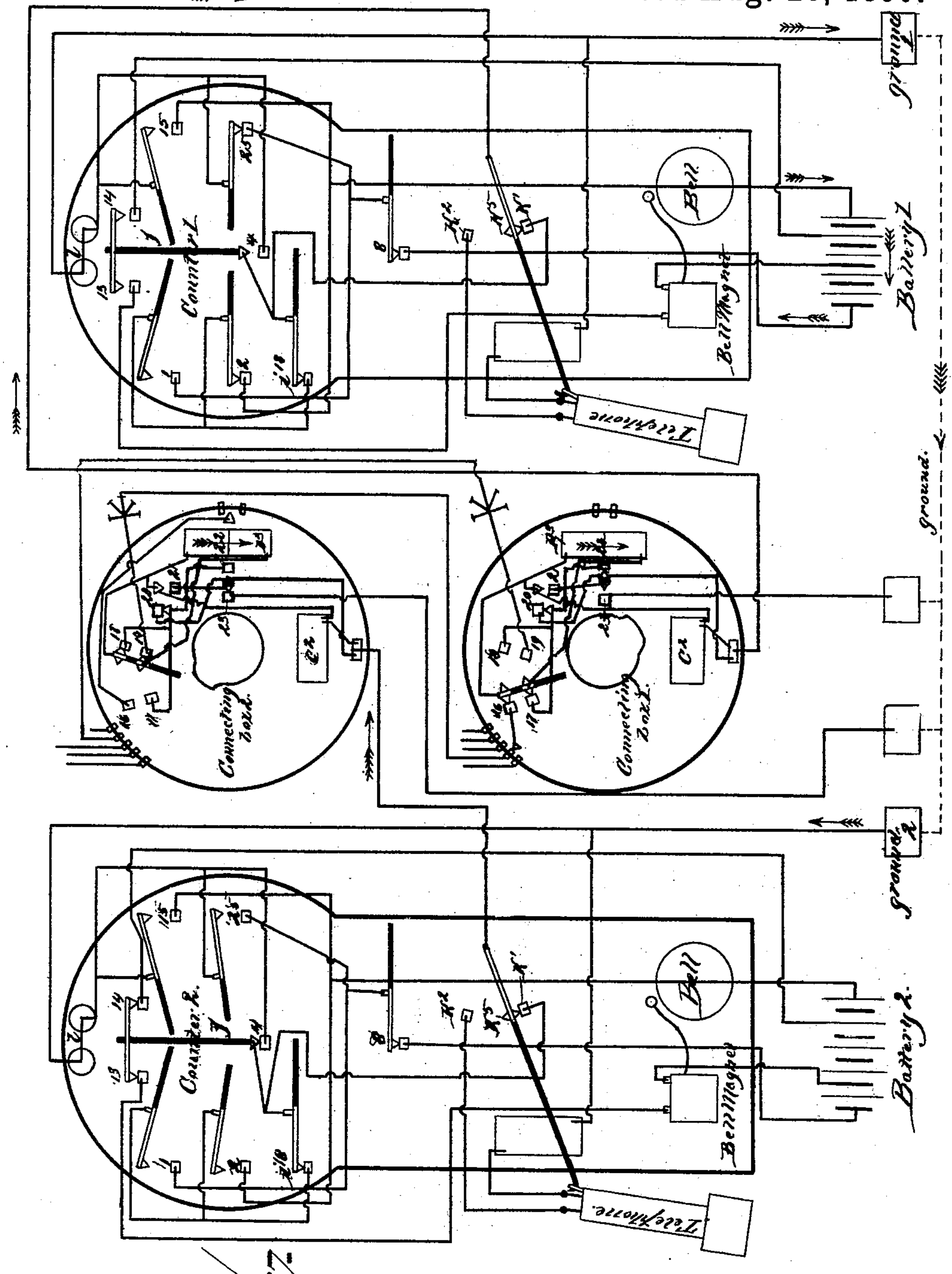
(No Model.)

27 Sheets—Sheet 22.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses:
Ewell A. Dick
William H. Shipley

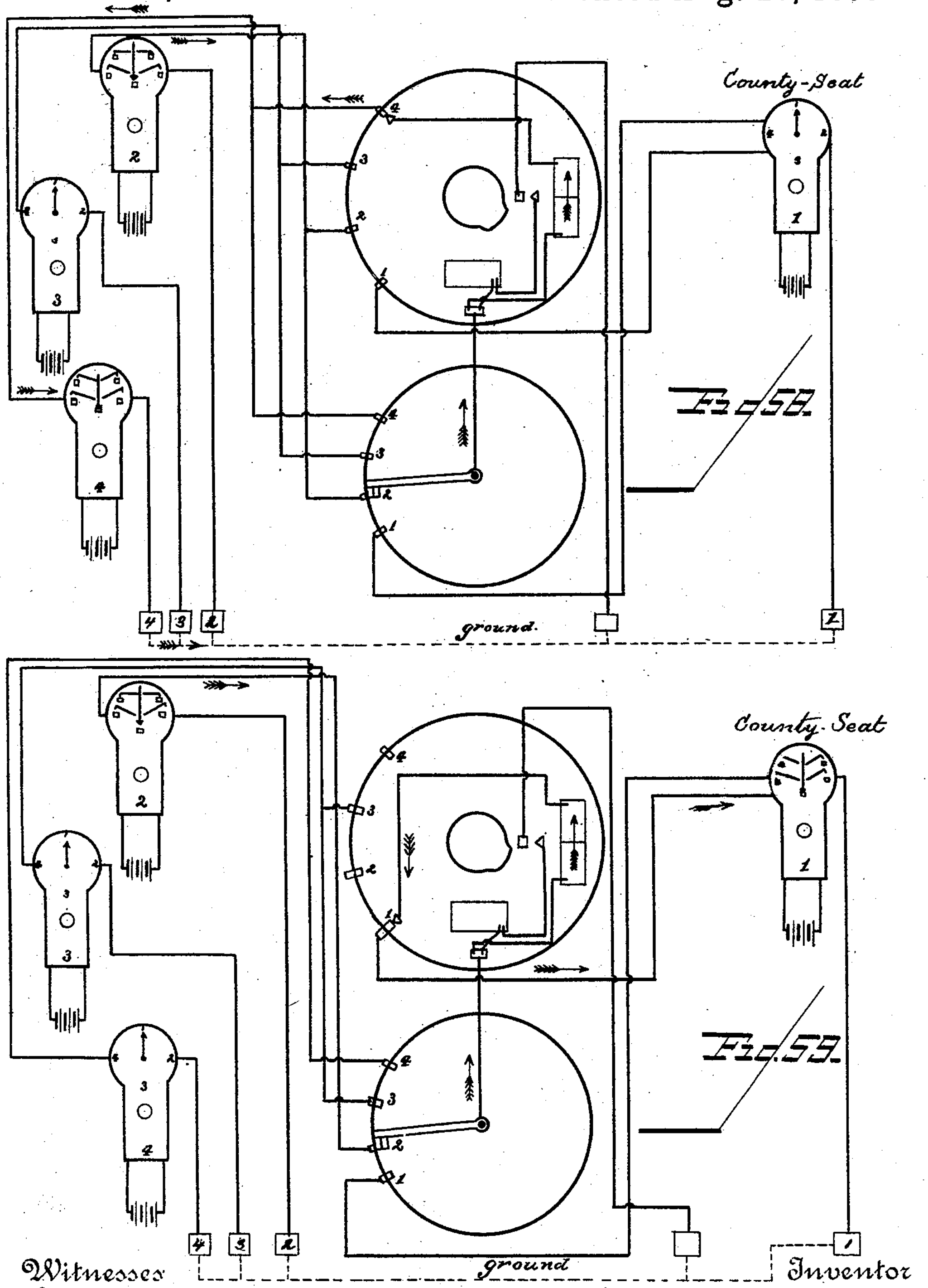
Inventor
William H. Ford
By his Attorney
Marcellus Bailey

(No Model.) 27 Sheets—Sheet 23.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses
Ewell A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

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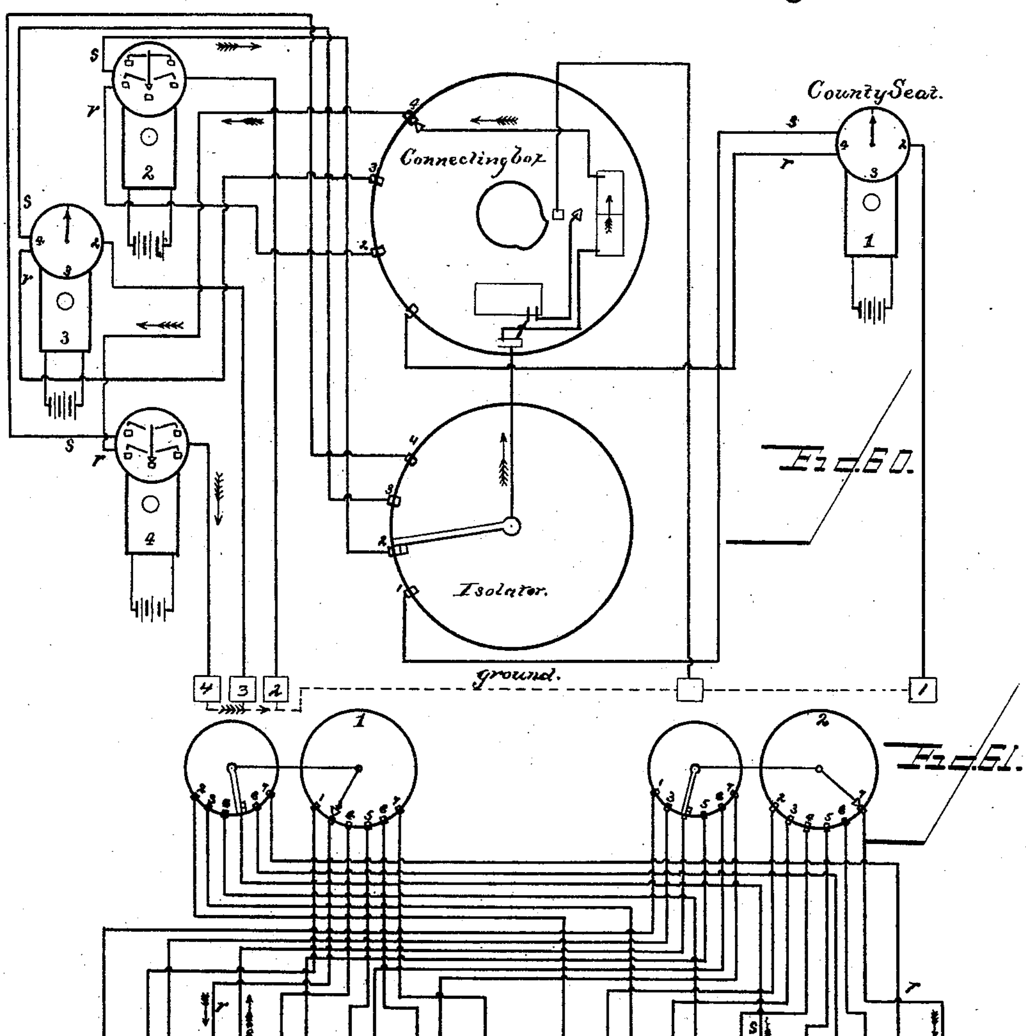
W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



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122	122	124	125	126	127
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162	163	164	165	166	167
182	183	184	185	186	187

Case 1.

2	3	4	5	6	7
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162	162	164	165	166	167
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Case 2.

Witnesses:
Ewell A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

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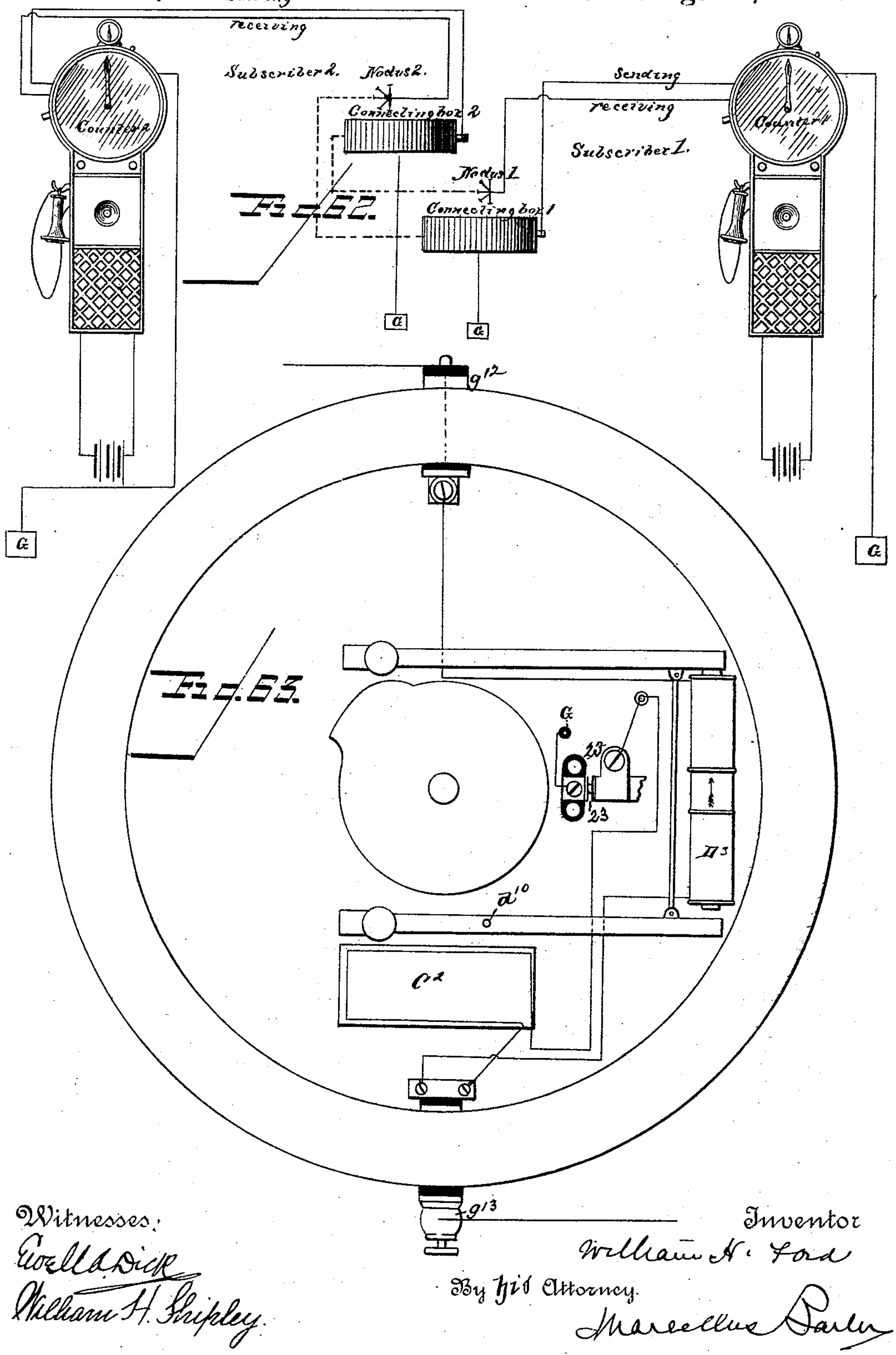
(No Model.) 27 Sheets—Sheet 25.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses:
Geo. W. A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney.
Marcellus Bailey

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

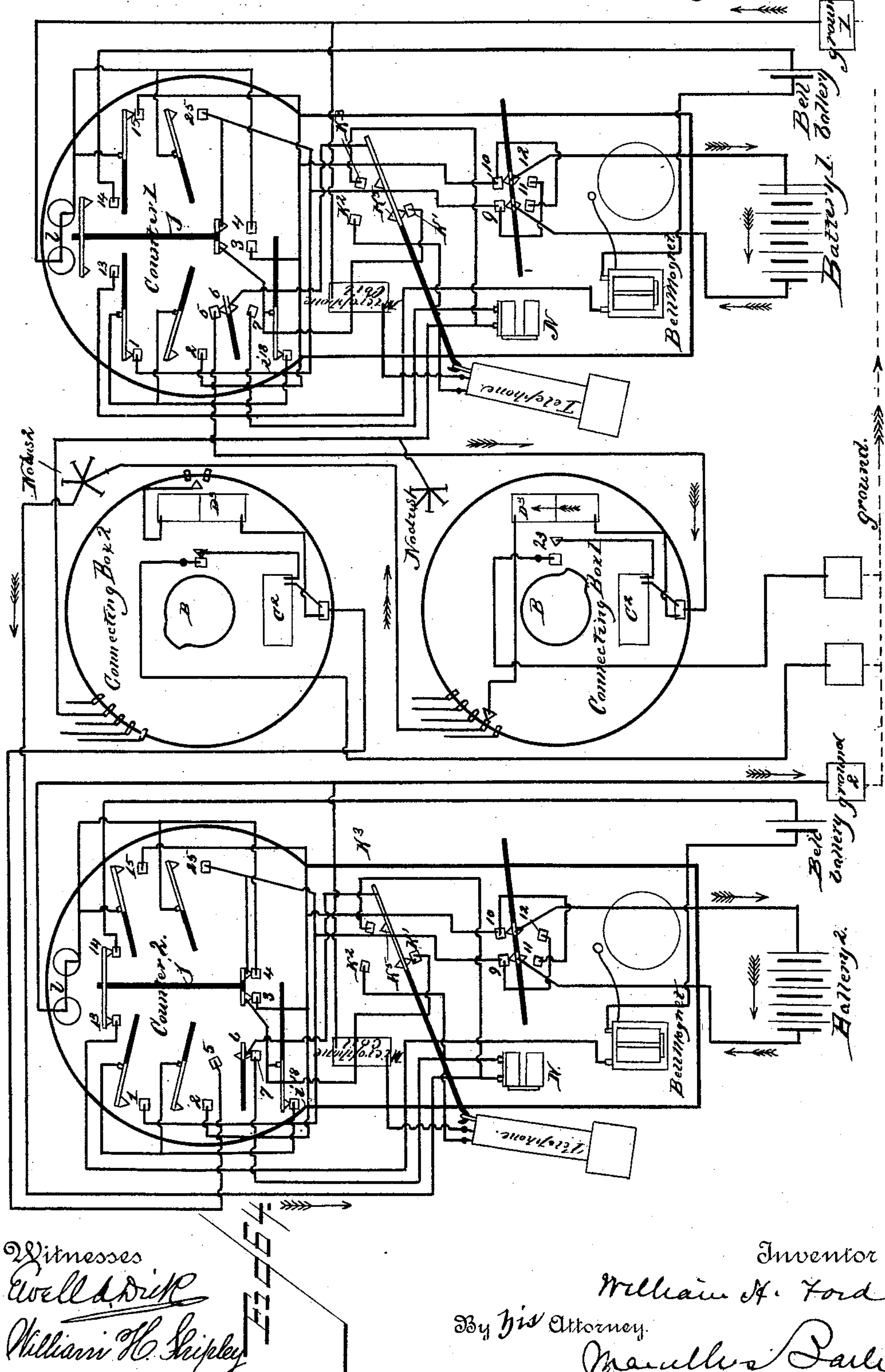
(No Model.)

27 Sheets—Sheet 26.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses
Ewell A. Dick
William H. Shipley

Inventor
William H. Ford
By his Attorney.
Marcellus Bailey

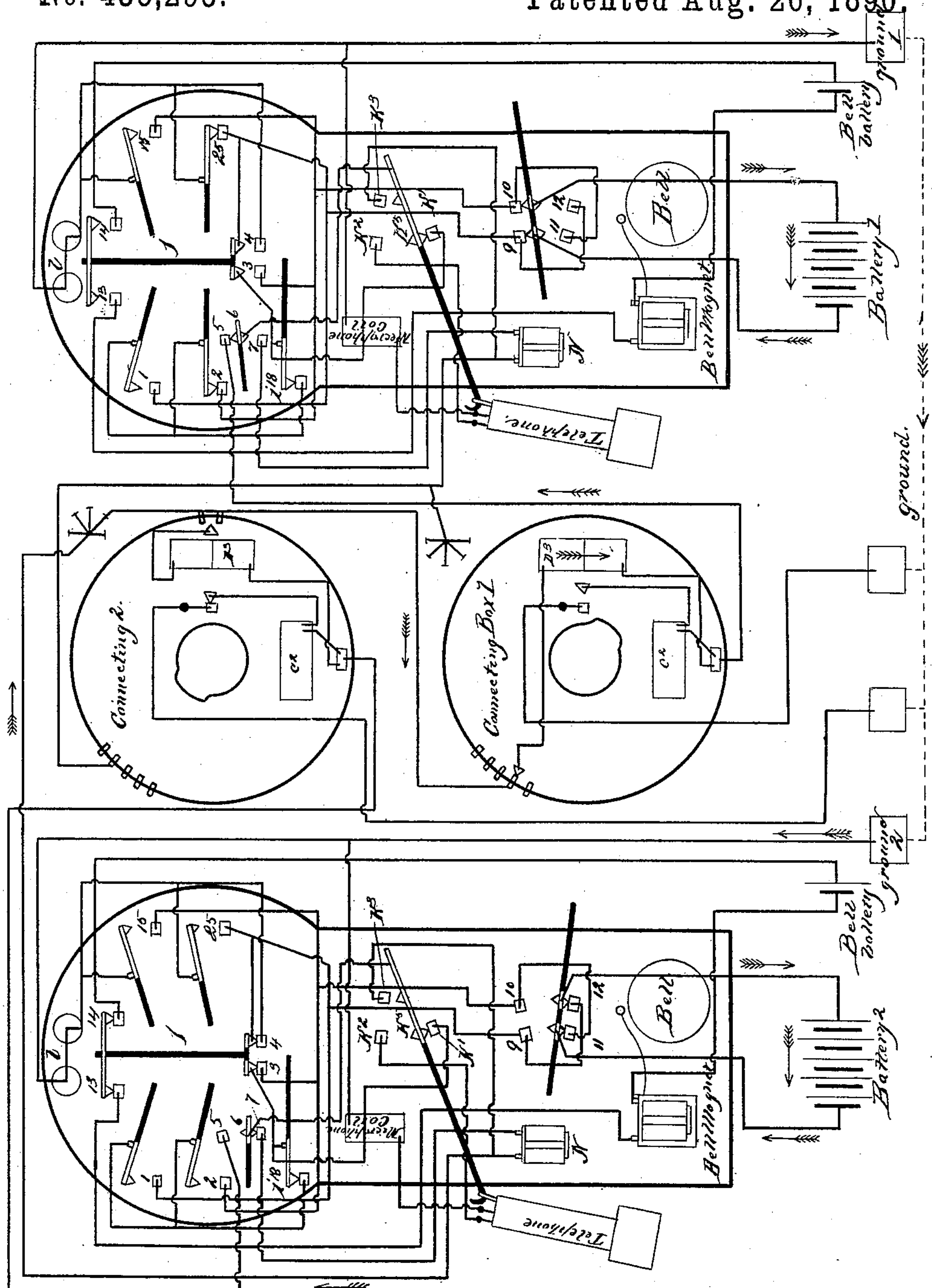
(No Model.)

27 Sheets—Sheet 27.

W. H. FORD.

AUTOMATIC TELEPHONE CONNECTOR.

No. 435,295. Patented Aug. 26, 1890.



Witnesses
Elvella Dick
William V. Shipley

Inventor
William H. Ford
By his Attorney
Marcellus Bailey

UNITED STATES PATENT OFFICE.

WILLIAM HUTSON FORD, OF ST. LOUIS, MISSOURI, ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO THE AUTOMATIC ELECTRIC EXCHANGE COMPANY, OF EAST ST. LOUIS, ILLINOIS.

AUTOMATIC TELEPHONE-CONNECTOR.

SPECIFICATION forming part of Letters Patent No. 435,295, dated August 26, 1890.

Application filed December 31, 1889. Serial No. 335,537. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM HUTSON FORD, a citizen of the United States, residing in the city of St. Louis, in the State of Missouri, have invented certain new and useful Improvements in Automatic Telephone-Connectors, fully described and represented in the following specification and the accompanying drawings, forming part of the same.

This invention relates to automatic telephone-connectors of that class in which successive electrical impulses derived from a battery are employed to effect the step-by-step movement of a suitable bar of metal capable of becoming a part of the circuit of the said battery along a certain pathway in which metallic plates or pins are placed in a regular series, each of which leads by a wire to the earth at a special point more or less remote from the locality of the said bar of metal and its pathway, to the end that any given number of successive electrical impulses shall always determine the contact of the said bar of metal with the same metallic pin or plate in continuity by a wire with a remote ground, and the possible passage of the said electrical current to the said ground by way of the circuit thus established.

The object of this invention is to automatize the acts necessary for holding telephonic communication, and incidentally thereto to diminish the number of wires leading to any general center by making one line do the work of many, thus saving the inconveniences of many lines of wire and the expense of maintaining them; to diminish or avoid the attendant service of telegraphic and telephonic exchanges by enabling a sender to connect his own line with another by his own act, thus also saving expense and obviating the effects of the indolence, ignorance, fatigue, or absence of the operatives as now employed; to enable subscribers to intercommunicate secretly and to know as promptly that a desired recipient cannot be reached as that he can and has been reached; to render telegraphic and telephonic communication more certain, secure, easy, and prompt, and to increase the capacity of telegraphic and telephonic exchanges as to the number of messages which may be simultaneously sent through them. To accomplish these results I employ a grounded battery and a line of wire passing from the same to another ground at the locality of the said circuiting bar or needle and the box containing the mechanism which controls its movements, with which box the said wire has definite electrical relations. This line of wire with the earth I denominate a "proximal" circuit. A circuit passing from a grounded battery to the said circuiting-needle and by its tip to a contact on the rim of the box aforesaid, and by a wire to another ground pertaining to a second box and circuiting-needle similar to the first-named box and needle, I denominate a "communicating" circuit. A circuit extending from a grounded battery through both of the said circuiting-needles or through one of them alone by a rim-contact on one of the boxes aforesaid through a wire directly to ground at a point remote from the locality of the said box or boxes I term a "distal" circuit. Now the method by which I accomplish electrical connection between two distant points consists in interrupting the communication of a proximal or communicating circuit with the earth by mechanical appliances regulated by the electrical current with a simultaneous or previous connection of the wire leading to the distant point with which communication is desired with the top of the first or second above-named circuiting-needle. Every act of connection as contemplated by this invention consists in the conversion of proximal or communicating circuits into distal circuits by the removal of the grounds of the first-named circuits at some central point where the mechanical appliances employed are conveniently placed. After such a distal circuit has been established by the mechanism I employ for that purpose, hereinafter to be described, a current sent through it may be interrupted as often as desired or wholly pretermitted, and the battery or batteries which may have been employed to establish it and all the electrical contacts and mechanisms similarly involved, excepting only such as are contained in the boxes aforesaid, may be eliminated from it without its disintegration for any length of time. Such a circuit so relieved of all the electrical appliances and resistances by means of which it was established would extend directly from the ground of the sender through the mechanism of one or of two boxes at the central point aforesaid to the ground of the recipient, and may be employed for the operation of any electrical devices whatsoever whose action is not inherently incompatible with the conditions determining the continuity of the said circuit for the conveyance of currents of greater or of less potentiality than that by which it was established and for the transmission of induced currents both directly and reversely through it, especially such currents as are excited by the action of a microphonic apparatus; but the essential condition of the establishment and maintenance of the distal circuit under my invention is that when a battery current of adequate potentiality and of a polarity opposed to that of the current by which such circuit was established is made to traverse it the said distal circuit will be broken, and the central ground-connections of the proximal or communicating circuits by whose agency it was established will be restored, and at the same moment all parts of the apparatus involved in establishing such a distal circuit will be caused automatically to resume their original or normal status and arrangement in the absence of appliances especially designed to prevent such an effect of an inverse current, as aforesaid, which appliances, however, are not herein shown, inasmuch as I design to make them the subject of an application for Letters Patent at some future time.

The features which essentially characterize my invention are two in number—the one mainly mechanical, the other electrical—viz:

First. The contacting of the circuiting needle or bar with its selected contact, through which the desired distal-circuit connection is made, is detetermined by a wheel or plate acting mediately or immediately upon said needle, which wheel or plate while stationary or idle during the interruptions of the electrical current by which the needle is brought step by step to position over its chosen contact is, after said interruptions have ceased and the current has become continuous, caused always to move or revolve in one and the same direction and invariably to the same extent, irrespective of and without reference to variations in the number of interruptions and changes in the position of the needle due to those variations.

Second. If either one of the circuits—proximal, communicating, or distal—be established to the exclusion of the others, then a subsequent break on that circuit in which a battery is active shall bring about a reversal of the direction of the current of said battery through part of the said circuit as soon as the latter is again restored. This reversal of the current attends and is consequent upon the restoration of the circuit after its interruption, as aforesaid, and is utilized to effect the automatic return of the parts of the apparatus to their original or normal position.

In carrying out my invention I make use of an apparatus or combination of apparatuses essentially comprising what I term a "connecting-box," containing the circuiting-wheel and needle or bar by which the distal circuit may be completed through any one of a number of separate contacts, and a combined interrupter and contact or pole-changing apparatus, which I term a "counter," and which is intended to be placed under the manual control of the individual subscriber. Under some conditions of electrical circuits I use in conjunction with these two devices a device termed by me an "isolator;" but, whether the isolator be present or absent, the counter and connecting-box are always present in combination in any system involving my invention.

The nature of my improvements and the manner in which the same are or may be carried into effect can best be explained and understood by reference to the accompanying drawings, in which I have illustrated fully the best form of apparatus now known to me for carrying my invention into effect and the circuits and circuit-connections which may be availed of in conjunction therewith for the establishment of systems of electrical intercommunication.

In the drawings, Figure 1 is a plan view of the connecting-box with a portion of the cover removed. In this figure the circuiting-needle is at zero, and the escapement-pinion is out of gear, and the fly-pinion is in gear, with the main circuiting-wheel. Fig. 2 is a plan of said connecting-box with the cover removed. In this figure the circuiting-needle has traveled watchwise a predetermined distance from zero and has been depressed upon a rim-contact, and the escapement-pinion is in gear, and the fly-pinion is out of gear, with the main circuiting-wheel. Fig. 3 is a plan of said connecting-box with the circuiting wheel and needle removed. The remaining parts in this figure are in the same position as that which they occupy in Fig. 1. Fig. 4 is a vertical central section of the said connecting-box with parts in normal position of rest—that is to say, the position represented in Fig. 1. Fig. 5 is a like section with the parts in the position they occupy when, for the purpose of transmitting a message, the circuiting-needle has traveled one hundred and eighty degrees from zero and is depressed upon a rim-contact. Fig. 6, Sheet 3, is a side elevation of the armature-lever of the counting-magnet and its supporting-standard detached from the connecting-box. Fig. 7, Sheet 3, represents in side elevation and plan, respectively, the spring and its sliding supporting-plate for acting upon the armature-lever of Fig. 6 at a predetermined time, as hereinafter specified, and also the wing (attached to the escapement-frame) by which said sliding plate is actuated. Figs. 8 to 33, inclusive, represent on enlarged scale, other structural details of the connecting-box, which will be hereinafter more particularly referred to. In Figs. 18 to 22, inclusive, I have represented in the positions which they consecutively occupy the escapement mechanism and the combination of parts which prevent the armature-lever of the counting-magnet, when moved by the first impulse of current, from actuating the devices which by subsequent impulses, it is caused to operate. Fig. 34 is a skeleton plan of the connecting-box, representing the wiring and the electrical connections of the parts when the box is employed in a system of electrical intercommunication, such as represented in Figs. 56 and 57, involving the use of one line-wire. Fig. 35 is an elevation of the receiving and sending contacts and their contact-bar shown in plan in Fig. 34. Fig. 36 is a side elevation showing in detail the spring-detent (actuated by the escapement-frame) for holding the said contact-bar. Figs. 37 and 38, Sheet 19, represent in side elevation the binding-screws and their connections upon the exterior of the connecting-box. Fig. 39 is a front elevation of the counter and parts attached thereto, a portion of the front of the case being broken away to expose part of the switch-lever actuated by the telephone-bar and of the rod operated by said switch-bar, for purposes hereinafter explained. Fig. 40 is a front view, on enlarged scale, of that portion of the counter devoted to the telephonic appliances, the telephone-bar, and the parts operated thereby, the door of this portion of the counter-case (which carries the microphone) being thrown open to expose the parts within. Fig. 41 is a front view of the counter proper with the dial and index-hands removed. Fig. 42 is a plan or top view of the counter mechanism removed from the case. Fig 43 is a side elevation of the counter mechanism looking at it from the left of Fig. 41. Fig. 44 is a like elevation of the counter mechanism looking at it from the right of Fig. 41. Fig. 45 is a rear elevation of the counter mechanism, a portion of the back skeleton frame being broken away at top and bottom to expose some of the working parts. Fig. 46 is a rear elevation of the front skeleton plate of the counter, together with the parts attached thereto, the large gear-wheels being omitted in order not to obscure the said parts. Figs. 47 and 48 are front elevations of a portion of the counter with the dial removed, designed, in connection with Fig. 41, to show the three positions successively assumed by the pole-changing contacts. Fig. 49, Sheet 15, is a front elevation of the swinging stop which is attached to the front of the back skeleton plate of the counter-frame, and is designed to act in conjunction with a stop on the rotatory geared main spring-box of the counter, said last-named stop being shown in section in this figure. Fig. 50, Sheet 2, is a front elevation of a special reversal apparatus, which is a thing separate from the mechanism by which automatic reversal is thrown upon the line, as provided in the recital of the second main feature of my invention in the opening parts of this specification. This apparatus occupies that part of the counter-case between the bell below and the microphone-door above. (See Fig. 39.) Fig. 50^a, Sheet 9, is a top view or plan of said reversal apparatus. Fig. 50^b, Sheet 13, is a front elevation of said reversal apparatus with the magnets, armature, ratchet-wheel, and parts immediately connected therewith removed, so as to show the reversal contacts and their operating-lever. Figs. 51, 52, and 53 are views, mainly diagrammatic, representing, on enlarged scale, the three positions successively assumed by the pole-changing contacts of the counter and devices immediately associated with them. Figs. 54 and 55 are respectively a plan view and a vertical central section of the instrumentality termed by me "isolator," showing also in plan and side elevation the mechanism by which its movement is controlled by the connecting-box. Figs. 56 and 57 are diagrams of circuits, including two sets of counter and connecting boxes, one set at each of two stations. In these diagrams a single line-wire is used for both receiving and sending. In Fig. 56 the circuit and instrumentalities therein are shown adapted for sending a message from the right to the left station. In Fig. 57 the circuit and instrumentalities therein are shown adapted to send a current in a direction the reverse of that shown in Fig. 56. Figs. 58 and 59 are diagrams of a modified arrangement of circuit and circuit-connections adapted for a county-seat or suburban system. In this system I employ in part one line-wire and in part two line-wires. Fig. 60 is a diagram of a suburban or county-seat system, in which two line-wires are used throughout, one for receiving and one for sending. Fig. 61 is a diagrammatic view of an exchange where isolators and communicating boxes are used, in conjunction, of course, with connecting-boxes and counters, as contemplated by my invention. Fig. 62 is a diagrammatic view illustrating generally the mode of communicating between two distant points under my invention. Fig. 63 is a skeleton plan of the connecting-box representing the wiring and connections to be employed in case two line-wires are used, one for receiving and one for sending. Fig. 64 is a diagram of circuits in which two line-wires are used, the parts being arranged for sending. Fig. 65 is the same as Fig. 64, with the parts arranged to cause a reversal of the current from the direction in which it is shown in Fig. 64.

I shall now proceed to describe, first, the structural details and mode of operation of the electro-mechanical appliances which I make use of, and will then set forth the manner in which they may be connected in circuit for the purpose of effectuating the objects I have in view.

The connecting-box.—This appliance is fully represented in Sheets 1 to 8, inclusive, of the drawings. It is composed of a cylindrical metallic box A and a tightly-fitting cover A′. Within the box A and attached centrally to its bottom is a smaller cylindrical case A^2, which I term the "cam-box." (Shown in section in Figs. 4 and 5, and represented detached in side elevation, vertical central section, and plan in Figs. 29, 30, and 27, respectively.) Upon diametrically-opposite sides it is formed with apertures surrounded by guides A^3, which I term "plunger-guides." Directly beneath each aperture there is formed in the inner wall of the cam-box a recess or notch A^4, Fig. 30, which terminates abruptly at one end, and at the other end gradually lessens in depth until it merges into the general inner face of the cam-box. The cam-box at one side is cut away at or near its bottom to admit the thread of a worm-shaft A^5, which is supported in suitable bearings tangentially to the cam-box.

Passing axially through the cam-box is a rotatory spindle A^6, to which is fixed at or near its lower end a worm-wheel A^7, (see Fig. 9,) which engages and is driven by the worm-shaft A^5. This worm-wheel A^7, it may here be said, is the only wheel that is fixed to said spindle A^6. The worm-shaft is driven by any suitable motor, and is supposed to be in constant revolution, at least during the period the apparatus is in use for purpose of communication.

Fitting into the upper end of the cam-box and flanged so as to rest upon the top or annular margin of said box is the wheel or plate B, which is termed by me the "cam-plate," and which is the wheel or plate hereinbefore referred to for effecting the contacting of the circuiting-needle with the rim-contacts of the connecting-box. This plate (shown more particularly in section in Figs. 4 and 5 and in top plan in Fig. 24 and in bottom plan in Figs. 10, 11, and 12) is of general circular form, having on its periphery at one point a cam surface or projection B′ and upon its upper face a semicircular cam-rib B^2, concentric with the axis of the plate. It is by this latter cam B^2 that the circuiting-needle is depressed. The cam-plate is free to revolve upon the spindle A^6.

Between the cam-plate and the worm-wheel A^7 are located the instrumentalities by which rotatory motion at the proper time is imparted to said plate. For this purpose below the cam-plate is placed loosely upon the spindle A^6 a star-wheel A^8. This star-wheel is shown in top plan in Fig. 14, in bottom plan in Fig. 11, in side elevation in Fig. 9, and in axial section in Figs. 4 and 5. It is connected to the worm-wheel A^7 by a volute spring A^9, one end of which is attached to the star-wheel and the other end to the worm-wheel. The object of this yielding connection is to permit the star-wheel to be momentarily arrested while the worm-wheel continues to move.

Downwardly projecting from the star-wheel is a pin or stud A^{10} in the path of a boss A^{11} on the upper face of the worm-wheel A^7, Fig. 4, to which projection is attached one end of the volute connecting-spring A^9. When, after the star-wheel has stopped, the worm-wheel by winding up the spring A^9 revolves far enough to bring the boss A^{11} against the stud A^{10}, the star-wheel will be positively forced to resume its movement. The star-wheel A^8, as will be seen by reference to Figs. 9, 4, and 5, is in the plane of the plunger-guides A^3, hereinbefore referred to. The connection between the star-wheel and the cam-plate B is made at stated times by means of a radially reciprocating tooth B^3, which is mounted to slide on the under side of the cam-plate and is normally pressed outwardly by a spring B^4, Fig. 12, so as to be out of engagement with the teeth of the star-wheel. The star-wheel is in fact one part of a coupling or clutch, of which the coupling-tooth B^3 is the other. Manifestly the form of this coupling-wheel A^8 can be varied materially without departure from my invention, what is essential being that there should be a rotating coupling driven from the worm or main driving-wheel A^7. I can, for example, use in lieu of the star form of wheel shown in Fig. 14 a disk provided with projecting teeth fashioned like outwardly spring-pressed pawls, as seen in Fig. 15. I prefer, however, the form shown in Fig. 14, and find that such a form of coupling-wheel gives on the whole the best results in connection with the coupling-tooth. This tooth is shown in longitudinal vertical central section in Figs. 4 and 5. It is represented in inverted inner end and side elevation in Fig. 16 and in inverted outer end elevation and top plan in Fig. 17. In Fig. 9 it is represented as lifted above the cam-plate. It is provided with side flanges *b*, which fit the recessed segmental guide-pieces B^5, (shown enlarged in Fig. 13,) fixed to the under side of the cam-plate, as seen in Fig. 12, a tooth portion *b′*, to engage the teeth of the star-wheel, a base or butt b^2, against which the plungers (hereinafter described) operate, and a tail-piece or downward projection b^3, which is in the path of an outwardly spring-pressed pawl B^6, pivoted to the under side of the cam-plate, Fig. 11. By this pawl the tooth is pressed inward and held in engagement with the star-wheel so long as the pawl during the revolution of the cam-plate bears against the unrecessed inner wall of the cam-box. When, however, said pawl comes opposite either of the recesses A^4, it will move outwardly into the recess and thus permit the tooth to spring back out of engagement with the star-wheel unless at this moment the tooth be restrained by some other instrumentality. This instrumentality consists of two plungers C and D, which reciprocate in the plunger-guides A^3.

The plunger C, I term the "starting-plunger," because from this point the cam-plate always starts. The plunger D, I term the "returning-plunger." The cam-plate halts at that point only when the distal circuit is made, and it returns thence to the starting-point whenever that circuit is broken.

The starting-plunger C is shown in longitudinal vertical central section in Figs. 4 and 5. In Figs. 18 to 22 it is shown in plan with those portions of it removed which are in a plane above the pivoted latch carried by it. This plunger at its inner end c fits the plunger-guide in which it moves, and at the extreme of its inward movement this inner end is flush with the inner wall of the cam-box. As it is opposite the butt b^2 of the tooth B^3, it will when thus moved inward force the said tooth into engagement with the star-wheel A^8.

The outward movement of the plunger C is limited by a shoulder c', which brings up against any suitable stop, which in this case is the frame of escapement hereinafter described. It is further provided with a projection c^2, which is struck by the peripheral cam-projection B' of the cam-plate B at or near the conclusion of one complete revolution of the latter. The effect of this action is, first, to move the plunger outwardly until it abuts against the sliding escapement-pawl, (which will permit the tooth to disengage from the star-wheel,) and then, by the continuance of this outward motion, to force back the sliding escapement-frame, for a purpose hereinafter explained. Whenever the plunger is moved back to the escapement-frame a portion of it, fashioned into a pallet c^3, passes far enough through the frame to engage the escape-wheel of the escapement and thus to hold said wheel immovable. This action takes place whenever the plunger moves outwardly far enough to permit the tooth B^3 to be disengaged from the star-wheel. The normal reciprocation, however, of the plunger C is effected by other means and is only sufficient to cause the alternate engagement and disengagement of the tooth B^3 without in any way acting on the sliding escapement-frame. The means which I employ for causing this normal reciprocation consists of an armature-lever C', influenced by an electro-magnet C^2, which I term the "counting-magnet," and so connected with the plunger C that its vibratory movement shall impart reciprocating movement of proper range to the said plunger. The connection for this purpose between the armature-lever and the plunger is made through a toothed latch C^3, pivoted to the plunger. This latch is so pivoted that when swung in one direction its tooth c^4 will be in the path of the end of the armature-lever, in which event the said lever, when in vibration, will force the plunger inward against the tooth B^3, the movement of said plunger in the opposite or outward direction being due to the recoil of the spring B^4. When, however, the latch is swung in a direction to carry its notch or tooth c^4 out of the path of the armature-lever, the latter in its vibrations will have no effect upon the plunger. This swinging movement of the latch is brought about by means of mechanism more particularly illustrated in Figs. 18 to 22, inclusive, and also in Fig. 7, and which will now be referred to.

Pivoted on a vertical axis to the escapement-frame E is a wing f, the active part of which is a pin f', which passes down through a slot c^5 in an ear or lateral extension of the latch C^3. A spring f^2 tends to press this wing into a position in which the latch will engage the armature-lever. The movement of said wing in the opposite direction is caused by the cam B', which wipes against it at or near the termination of the revolution of the cam-plate B. The cam B' wipes successively against the plunger C and the wing f. At the time it wipes against the plunger the armature-lever is in engagement with the latch. Consequently said lever is forced outwardly along with the plunger beyond its usual range of beat, and in so moving a light spring c^6, with which it is provided, is compressed between it and the escapement-frame E. The cam B', before the plunger is released, then acts on the wing, swinging it and the latch connected with it far enough to one side to permit the notch or tooth of the latch to clear the armature-lever, as seen in Fig. 18, at which moment the spring c^6 acts to throw the armature-lever inwardly, where its end will bear against the smooth side of the latch, as seen in Figs. 19 and 20, in which position said armature-lever, while being free to vibrate without imparting motion to the plunger, prevents at the same time the return of the latch to its normal position.

It is desirable to hold the sliding escapement-frame E in the outward position to which it is brought by the cam B' at the conclusion of the revolution of the cam-plate B. To this end I pivot upon a stationary part of the cam-box a spring-controlled detent-lever f^3, normally influenced by its spring in a direction to cause its detent end to spring into a notch on the front of the escapement-frame, as seen in Fig. 27, when the escapement-frame is moved back, said frame being thus held in its retracted position. The other or trigger arm f^4 of the detent-lever is so shaped and located that when the detent is in the position represented in Fig. 27 it (the trigger-arm f^4) will be in the path of movement of the armature-lever C', so that when the latter thereafter moves it will strike the trigger-arm and thus vibrate the detent-lever in a direction to disengage it from the escapement-frame, consequently permitting the latter to move inward again, which inward movement causes it to re-engage the toothed circuiting-wheel G, hereinafter referred to. This escapement-frame, it may now be said, is mounted upon a foot-piece E', Fig. 8, on which it can slide, and is pulled inwardly by a spring E^2.

To return now to the armature-lever C', this lever has a slight play in the longitudinal horizontal slot in the plunger in which the latch is located. It (the lever) is unprovided with the usual retracting-spring and back-stop of the ordinary armature-lever used in telegraphy. When it engages the latch, its normal outward movement is due to the tooth-spring B^4. When, however, it falls behind onto one side of the latch, as in Figs. 19 or 20, for instance, some means must be provided for giving it at this time outward movement when released from the influence of its magnet, and I therefore provide a retracting-spring for the armature-lever which shall be operative only when the lever is in the position last above referred to—a position which it always occupies when the first impulse of current through the counting-magnet C^2 occurs. To this end I place below the armature-lever, and extending parallel with and longitudinally of the said lever, a longitudinally-sliding plate f^5, supported on standards to which it is secured by studs passing through longitudinal slots in said plate, as indicated in Fig. 7, which represents the said plate in side elevation and plan, and also in Fig. 27, where the plate is represented in plan, (partly broken away between its end,) with the armature-lever represented in dotted lines above. From the under side of the armature a stud f^6 projects downward, Fig. 6, and upon the plate f^5 is a spring f^7, which can be brought into the path of that stud. In the plate is a cross-slot f^8, which is engaged by the pin f' of wing f, said pin being made long enough for the purpose. The sliding movement of the plate f^5 is brought about by the wing. Normally the spring f^7 is out of the path of the armature-lever stud f^6. When, however, the wing is swung outwardly to one side, (to the position shown in Figs. 18, 19, and 20,) it acts to slide the plate f^5 in a direction to bring its spring in front of the armature-lever stud f^6, and thus when the armature-lever moves inward under the attraction of its magnet it deflects spring f^7, which by its recoil retracts the armature-lever as soon as the latter is released by its magnet. When the wing returns to normal position, it acts to remove from the path of the armature-lever the spring f^7, whose services are no longer required.

The escapement hereinbefore referred to which is carried by the sliding escapment-frame E is intended to control the rotating movement of the circuiting-wheel and its needle, said circuiting-wheel being driven by spring-power derived from a coiled spring, (similar to that of a clock-movement,) which is wound up periodically and at each revolution of the cam-plate B.

The spindle A^6, which passes axially through the cam-box and has loosely mounted upon it the cam-plate B, is shown detached in Fig. 31. Surrounding this spindle above the cam-plate is a sleeve g, Figs. 4 and 5, whose flanged base g' is let into and fastened tightly to the top of the cam-plate, so that the sleeve will revolve therewith. The sleeve at its top screws into and is rigidly secured to the hub of a disk g^2, which forms the independently-rotatory bottom of a spring-box, whose cylindrical body g^3 is secured to the toothed circuiting-wheel G. In the spring-box is a spring g^4, coiled like a watch or clock spring, having one of its ends secured to the part g^2 and the other to the circuiting-wheel or to the part g^3. Under this arrangement, manifestly, if the circuiting-wheel G be held stationary and the cam-plate B be revolved in the proper direction, the spring g^4 will be wound up, and will then act to rotate the wheel G when the latter is released.

Attached to the circuiting-wheel is the circuiting needle or bar G′, which is hinged on a horizontal pivot g^5 to the circuiting-wheel, as seen in Figs. 1, 2, 4, and 5, so that while standing normally away from the rim-contacts G^2 of the connecting-box it may be depressed to make electrical connection with any selected one of said contacts over which it may be brought by the movement of the circuiting-wheel G. The rim-contacts are insulated each from the other and may be of any desired number. Each rim-contact has its own separate line-wire, with which it is connected to the distant point to be communicated with. The hinged circuiting needle or bar by wire g^6 is connected to an insulated hub g^7, mechanically secured to the circuiting-wheel so as to revolve therewith. Upon the periphery of this hub bear brushes g^8, Figs. 4 and 5, which are the terminals of the conducting-bar g^9, Fig. 1, leading from binding-screw g^{10} on the exterior of the connecting-box. The parts g^8 g^9 g^{10} are attached to the body of the connecting-box, but are of course insulated therefrom. The circuiting-wheel, during its movement from the starting-point toward the selected or desired rim-contact, is controlled by the escapement, which, by the inward sliding of the escapement-frame at the commencement of said movement, is thrown into engagement with the circuiting-wheel, this engagement being effected by the meshing of the escapement-pinion E^3 with the circuiting-wheel.

The escapement is of the kind known as a "chronometer-escapement" and is simple in construction. It consists of the pinion E^3 and the scape-wheel E^4, both of which are mounted upon the vertical arbor E^5. The pallet for the escapement is shown at c^3 attached to the starting-plunger C, and has already been described. The stop is furnished by an angle-arm e of peculiar form, best shown in Figs. 18 to 22 and in Figs. 32, 32^a, 32^b, and 32^c. Fig. 32 is a side elevation of the escapement and its supporting-frame. Fig. 32^a shows the stop-carrying plate in side elevation and in bottom plan. Fig. 32^b is a top plan of the plate. Fig. 32^c is a side elevation of the stop. The stop is pivoted at its angle to a plate e', which is attached to the outer end of plunger C and extends out through the frame under the scape-wheel, being slotted to straddle the arbor E^5, and having on its under side a steadying guide-lug e^2 at its outer end, where it passes through the outer portion of the escapement-frame. Said frame above this point is cut away, so as to allow the angle-stop piece to play through and in it. The angle-stop consists of the stop proper e^3, a downward projection e^4, and an angle-arm e^5. The projection e^4 extends down through the slot in plate e', and is influenced by a spring e^6, which tends to press the stop in the direction of the arrow in Fig. 32^b so far as permitted by the slot. A spring e^7, acting on the angle-arm e^5, tends to rock the stop in the same direction. Either spring can be used to the exclusion of the other. I use both in order to get re-enforced action. Under this arrangement, when the plunger recedes and the pallet c^3 engages the scape-wheel, the stop will be out of engagement with said wheel, and by its spring or springs will be rocked in a direction to incline it toward the interval between the next pair of teeth in the scape-wheel, as indicated in Fig. 20. When the plunger advances and the pallet moving with it quits the scape-wheel, the stop will enter between this next pair of teeth, and by the spring action of the clock-work of the circuiting-wheel will be vibrated until it moves a distance of one tooth, at which time it will bring up against the side of the slot in its supporting-plate, and so on. Thus the escapement movement takes place only when the plunger advances, and this movement is equivalent to that which will carry the circuiting-needle from one rim-contact to the next.

For the purpose of arresting or locking the circuiting-wheel when the escapement is in its outward position and disengaged from said wheel, I place on the top of the escapement-frame a stud or abutment e^8, Figs. 4, 5, and 32, which, when the escapement is in said position, is thereby brought into the path of a stop g^{11}, Fig. 23, on the under side of the circuiting-wheel, which stop abuts against stud e^8 when the circuiting-wheel reaches the zero or starting point. As soon, however, as the escapement-frame is released and is drawn in by its spring E^2 far enough to put the escapement in gear with the circuiting-wheel the stud e^8 is thereby removed from the path of the stop g^{11} on said wheel.

For the purpose of preventing the too sudden return of the circuiting-wheel to zero position, I prefer to employ a fly-wheel E^6, having its vertical arbor provided at the top with a pinion E^7 to mesh with the circuiting-wheel, said arbor being supported in a frame E^8, arranged to slide between guides E^9 to and from the circuiting-wheel, as seen in Fig. 1. The fly-frame and its guides are shown detached in enlarged plan view in Fig. 33. This fly-frame is connected to the escapement-frame by a straight or walking-beam lever E^{10}, pivoted at its center to that one of the guides E^9 which is between the two frames, with its ends connected to the two frames in such manner that a movement of the escapement-frame in one direction shall cause a movement in the opposite direction of the fly-frame. Then when the escapement is thrown out of gear with the circuiting-wheel the fly will be thrown in gear with said wheel, and vice versa.

In the plane of the cam-plate B is pivoted to a standard in the connecting-box a lever H, Fig. 3, the toe of which is in position to be operated on by the peripheral cam projection B′. To this lever is jointed a connecting-rod H′, which leads out from the connecting-box and may be used to operate any appliance which may be used in connection with the apparatus—for example, to control the isolator (hereinafter referred to) to throw on and off the motor for the cam-wheel or the battery for the connecting-box, &c. The last act of the cam B′ in returning to its zero or normal position is to push out this rod. The rod is held in this position by a spring-latch H^2 on a pivoted angle-lever H^3, which engages a notch H^4 on the under side of the lever H, Fig. 36, said angle-lever having at its other end a pin-and-slot connection H^5 with the sliding escapement-frame E, Fig. 34. The outward movement of the escapement-frame causes the latch H^2 to be brought to position to engage the notch H^4 of lever H when the latter is pressed back by the cam B′. As soon as the escapement-frame moves inward the latch H^3 thereby is disengaged by lateral movement from lever H, and the latter, when thus released, is at once thrown inward by a spring H^6, which acts upon the tail H^7 of said lever.

In using the connecting-box in an electrical system involving the employment of a single line-wire for both receiving and sending I can conveniently make use of this lever H for controlling contacts by which the circuits through the box may be changed for the purpose. To this end I attach to the tail of the lever the movable contacts for four fixed contacts 16 17 18 19, each of which is insulated from the other, as seen in Fig. 34, and upon the vibratory armature-frame of the polarized magnet I mount the movable contacts for two fixed contacts 20 21, closed and opened by the movement of the armature-frame, and arranged so that when one pair is open the other pair is closed; and finally I provide still another pair of contacts 22, the movable one of which is attached to the same piece which carries the movable contact of the "central-ground" contacts 23 of the connecting-box, (hereinafter referred to,) the arrangement being such that when the ground-contacts of the connecting-box are open the contacts 22 are closed, and vice versa. When lever H is pushed out by the cam, as in Fig. 34, contacts 18 19 are closed, this being the position for receiving. When, on the other hand, the lever is released, it is thrown over by spring H^6 to close contacts 16 17, this being the sending position. These shifting contacts are used in the box only in a single-wire system, as above stated. In a two-wire system—that is to say, a system having two line-wires, one for receiving and one for sending—they are unnecessary.

Having described the instrumentalities which are grouped around what may be termed the "starting-point" of the instrument, I now proceed to a description of those devices which are connected with and grouped around the "returning-plunger" D, and best seen by reference to Figs. 1 to 5, 9, 24 to 26, and 28. This plunger has an inner end precisely like that of the starting-plunger C, and its normal position is one in which this inner end is flush with the inner wall or face of the cam-box. It is intended to permit the disengagement of the tooth from the star-wheel only when and so long as the circuit through the circuiting-needle is made. It is operated by means of an angle-lever D′, having a fixed pivot at d' and connected with the plunger by a link d, which makes with the lever a sort of toggle-joint. In Fig. 24 I have shown a plan view of this lever system in turned-back position, (a position it never occupies in practice, but which is here shown in order to more fully illustrate the construction of the parts,) with the plunger wholly withdrawn from its guide and the cam-box. By a spring d^2, Figs. 2 and 3, the angle-lever D′ is normally held in a position in which the plunger is in its innermost position. In this position the arm d^3 of the angle-lever overhangs the cam-plate B and is in the path of a cam projection B′ thereon. The other arm d^4 of said lever is a detent intended to operate in connection with a shoulder or projection d^5 of the vibratory stop-frame D^2, which is or has connected with it the permanently-magnetized armature of the polarized magnet D^3.

When the angle-lever D′ is operated by its cam to withdraw the plunger D, its detent-arm d^4 is in the position shown in Fig. 2. In this position, if the circuit through the depressed circuiting-needle be complete, the magnet D^3 will thereby be energized and the polarized frame D^2 will be moved into the position shown in said Fig. 2, with its stop d^5 in the path of the detent-arm d^4. Consequently when cam B′ leaves the arm d^3 the lever will be held in outward position with the plunger withdrawn, thus permitting the tooth B^3 to spring outwardly into the plunger-guide left unobstructed by the plunger D, thereby disengaging the cam-plate B from the star-wheel A, and bringing said cam-plate to a standstill after completing one-half a revolution. The cam B′ is slightly in advance of the tooth B^3, so that it will act on the lever D′ and give time to the polarized magnet system to act (assuming the circuit to have been completed through the circuiting-needle) before the tooth reaches the plunger-guide of plunger D. The cam B′ also leaves or passes the angle-lever D′ sufficiently in advance of the tooth to permit that lever as well as the plunger D, in event of there being no circuit through the circuiting-needle, to return to normal position before the tooth reaches the plunger-guide. In this event the plunger prevents the disengagement of the tooth B^3 from the star-wheel, and consequently the cam-plate B continues its revolution back to starting-point, where it is stopped in the manner hereinbefore indicated.

The connection with the central ground hereinbefore referred to is completed through a pair of contacts 23, Figs. 4 and 5, the movable contact being carried by the plunger D, and the arrangement being such that whenever the plunger is withdrawn the contacts will be separated and the ground-connection will be broken, as indicated in Fig. 5. In addition to these contacts for the central ground I, as hereinbefore stated, make use of a second pair of normally-separated contacts 22, Fig. 34, (the movable one of which is also carried by the plunger and is brought against its fellow-contact when the plunger is withdrawn,) which, however, are to be employed only in connection with a single-wire system having the contacts 16 17 18 19, hereinbefore referred to, and shown also in said Fig. 34.

It remains now to describe the mechanism for depressing the circuiting-needle upon the selected rim-contact. This mechanism can best be seen in Figs. 1, 2, 4, 5, 25, and 26. Fig. 25 is a plan view of the mechanism. Fig. 26 is a side elevation of the needle-operating plate detached. Between the cam-plate B and the spring-box of the circuiting-needle is located a plate h, having a peripherally-grooved hub h' loosely encircling the sleeve. In the groove of this hub is a loose-fitting annulus h^2, which is trunnioned to the free inner end of a forked spring-depressed lever h^3, the outer end of which is pivoted to the case of the instrument at h^4. Upon the upper face of the plate h are two pins h^5, which extend up alongside of the spring-box and through the circuiting-wheel and are jointed to the inner end of the arm of the hinged circuiting-needle at h^6, Figs. 1 and 2. The cam-rib B^2, when the cam-plate revolves, passes beneath the lever h^3, and thereby lifts plate h, causing its pins h^5 to tilt the circuiting-needle in a direction to depress the latter upon the rim-contacts. The plate h is shown lifted in Fig. 5 and lowered or depressed in Fig. 4. In order to make sure that the armature-frame D^2 of the polarized magnet shall always be returned to normal position, I place upon one of the bar-magnets a pin d^{10}, which is so placed thereon that if said frame is not already in normal positon it (the pin) will be struck by the wiper-cam B′, as the cam-plate, after passing through one hundred and eighty degrees, returns home to starting-point, and the frame D^2 will thereby be returned into the desired position. As before stated, each rim-contact has its own separate wire. The sides of the connecting-box, as seen in Figs. 4 and 5, are made hollow for reception of these wires, which, through holes formed in the exterior shell, are taken out at the desired point or points. This completes the description of the mechanical details of the connecting-box. In order to better comprehend its mode of operation, a brief recital of the circuit-connections is requisite. These connections can conveniently be traced by reference to Fig. 63, Sheet 25, and Figs. 37 and 38, Sheet 19. The current enters through binding-screw g^{13}, Fig. 37, and divides, one branch going through the counting-magnet C^2 to central ground through contacts 23, the other branch going through the polarized magnet D^3, thence out through the box to binding-screw g^{12}, Fig. 38, connecting-bar g^{14}, and binding-screw g^{10}, and thence by bar g^9 and brushes g^8, Figs. 1 to 4, to the circuiting-needle, and thence to the line of that rim-contact with which the needle co-operates.

The instrument is shown in Fig. 1 in its normal position of rest. In Fig. 2 it is shown with the parts in the position they assume when the needle has counted and has been depressed upon its selected rim-contact with the circuit completed through that contact to the distant point with which communication is desired. In the normal position of rest at starting-point the escapement is out of gear with the circuiting-wheel, as seen in Fig. 1. If, now, we suppose the battery to be put on, this will energize the counting-magnet C^2 and will draw forward the armature-lever C′, with the effect of operating the trigger f^4 and releasing the retracted escapement-frame. This will be understood by reference to Fig. 19, where the lever is represented in the act of striking the trigger. This releases the escapement-frame and permits the escapement to spring inward into engagement with the circuiting-wheel, as seen in Fig. 20. If, now, we have in the circuit through the counting-magnet a circuit breaker and maker—a manually-operated key, for example—then by depressing the key so as to break this circuit the armature-lever C′ will be released, and by the temporarily active spring mechanism already described with reference to Fig. 7 will be retracted and will fall behind the latch, as seen in Fig. 21. Upon releasing the key the circuit will be restored, the counting-magnet will be again energized, and the armature will be attracted, and in so moving will advance the starting-plunger, thus forcing the coupling-tooth inward and permitting the escapement to make one beat and the circuiting-wheel to make a corresponding movement of partial revolution equivalent to the distance separating the first rim-contact from zero-point. The break and make of the manual key is momentary, not sufficient to cause the coupling-tooth to engage the star-wheel, and by continuing this series of breaks and makes in rapid succession the circuiting-needle by step-by-step movement of rotation can be brought over the desired rim-contact. As soon as this point has been reached the manipulation of the key ceases and the current ceases to be intermittent and becomes continuous. The effect of this is to hold the starting-plunger in its forward position, and thus to project the coupling-tooth inward and to hold it in that position until the rotating power-driven star-wheel engages it. The cam-plate is thus coupled with the star-wheel and revolves with it. It first acts by its cam-rib B^2 to depress the circuiting-needle upon its selected rim-contact, and then by its cam projection B′ to withdraw the returning plunger D and to throw the detent-arm into a position to engage the stop on the armature-frame of the polarized magnet. All this is done before the coupling-tooth comes opposite to the guide-opening in which the plunger D moves. The effect of the withdrawal of the plunger D is of course to interrupt the branch circuit through the counting-magnet, and this interruption should not take place until after the circuiting-needle has been depressed upon its rim-contact. If, now, the circuit through that rim-contact be complete to the distant point, then as soon as the counting-magnet branch circuit is broken current will pass over the polarized magnet branch with the effect of swinging the stop-frame D^2 into the path of the detent-arm of the angle-lever which controls the returning plunger. Under these conditions the returning plunger will be held retracted, so that the coupling-tooth as it comes around can spring out into the recess left by the retracted plunger, thus bringing all parts of the instrument to a standstill with the distal circuit complete. The parts in this position are shown in Fig. 2, and they will thus remain indefinitely without reference to any after breaks or intermissions in the distal circuit. By sending, however, a reversed current through the polarized magnet the returning plunger will be released and at once returned to normal position. In so returning it will force inward the coupling-tooth, and will thus start again the cam-plate B, which returns to normal position. In so returning it first of all permits the depressed circuiting-needle to rise. This needle and its wheel, however, remain stationary, being so held by the escapement until the cam-plate forces back the escapement out of engagement with the circuiting-wheel. As soon as this takes place the released circuiting-wheel is at once returned to normal position by its spring-box, the spring of which had been wound up by the previous revolution of the cam-plate.

With respect to the reversed current above mentioned for releasing the returning plunger after communication with the distant point has been accomplished, means for throwing the reversal upon the line will be hereinafter described in connection with the counter.

The foregoing description of the mode of operation assumes that the distal circuit is complete upon depression of the circuiting-needle. If, however, no distal circuit be thereby established, then the polarized magnet will not be energized, the stop-frame will remain out of position to engage the detent-arm d^4, and the returning plunger D will be withdrawn but momentarily, and will, after the cam B passes, be brought back to normal position before the coupling-tooth reaches it. Under these conditions the tooth will be forced to continue in engagement with the star-wheel, and the cam-plate will consequently continue its movement to starting-point, where it will stop, having made one complete revolution without cessation. During this movement it will have operated upon the other parts precisely as it did in the case first above supposed.

In the description of the mode of operation of the connecting-box thus far I have assumed, for the sake of simplicity, that the breaks and makes required for counting, &c., are made manually by a key. As a matter of fact, however, I use for this, among other purposes, a specially-devised instrument termed by me the "counter."

In the opening portion of this specification I have pointed out what seem to me to be the two chief features which characterize my invention. One of these features—viz., the mechanically-operated cam wheel or plate—has been described in connection with the connecting-box, of which it forms part. The other feature—viz., the reversal of the circuit consequent upon a break in the circuit if the communication has once been established—will appear in the course of the description of the counter, which I shall now proceed to give. The purpose of that reversal and its effect upon the polarized magnet of the connecting-box have already been indicated.

The counter.—This instrument, in the form in which I now prefer to make and use it, is shown in a general way in Fig. 39. In the upper part of the case are contained both the mechanical rheotome or circuit maker and breaker and also the contacts and mechanical devices connected therewith, whereby when a brake is made in an already established distal circuit the subsequent restoration of said circuit (which is a mere temporary restoration) will have the effect of causing the current to flow in reverse direction through the polarized magnet of the connecting-box, with the result of causing the mechanisms of that box to return at once to their normal position of rest, as already explained. At the same time that this takes place the devices of the counter itself also are caused to return to the normal position of rest from which they start. When the distal circuit is not established, then, as hereinbefore indicated, the connecting-box takes care of itself without extraneous aid, and in this latter case the contacts of the counter and their connected devices act simply to return all of the counter devices to zero or normal position.

Immediately below the devices of the counter proper in Fig. 39 are the telephonic appliances, by which communication may be had over the distal circuit. Next below the telephonic appliances is located the special reversal apparatus illustrated in Figs. 50, 50ª, and 50ᵇ, the uses of which will be hereinafter described, and last of all is the call-bell for the recipient, which automatically rings upon the establishment of the distal circuit.

The mechanical rheotome will first be described without reference to the electrical system. It consists of an index or hand I, revolving over the face of a dial I′, the subdivisions of which (two hundred in the present instance) correspond to the rim-contacts of the connecting-box. The hand I is fixed to a shaft I^2, on which is also fixed the spring-box I^3 of an ordinary clock-movement, Fig. 44. On this box is a finger i, which brings up against a stop i' on the frame, so as to hold the hand normally at zero. The stop i' is pivoted (see Fig. 49) so as to be capable of a swinging movement, as indicated by dotted lines in said figure, this being for the purpose of permitting the index or hand I (which, when being revolved by hand to the desired number, moves watchwise) to be brought to numbers approximating two hundred without being restrained by the bringing up of the finger i against a fixed stop. In any such case the stop i' will give to the pressure of the finger i, so as to permit the hand to be brought over even the number 199 without impediment. On main shaft I^2 is the main gear I^4, which meshes with a broad-faced pinion I^5, loose on an arbor I^{55}. The pinion is attached rigidly to the sliding part I^6 of a clutch, the other part of which is fixed to arbor I^{55}, and to the pinion is also fixed a ratchet I^7, engaged by spring-pawls i^2 on a gear-wheel i^3, which meshes with and is intended to drive the system of gears and pinions i^4 i^5 i^6 i^7 i^8 for driving the shaft on which the fly-wheel i^9 of the movement is mounted. The clutch part I^6, broad-faced pinion I^5, ratchet I^7, and gear-wheel i^3 all slide together on the shaft and are actuated so to move by a lever I^8, which by pins engages a peripheral groove in the sliding clutch part I^6 and is pivoted at i^{10} to the frame of the instrument. At its upper and free end the lever is provided with an inclined portion, which passes up loosely through a slot in the inner end of a pivoted lever-handle I^9. (See Fig. 46.) By pulling down the outer end of this lever-handle its inner end will be raised and caused to act upon the clutch-lever I^8 in such manner as to slide the clutch part I^6 and parts connected therewith far enough to disengage the two parts of the clutch. When the handle I^9 is released, a spring i^{11} pulls its inner end down, and thus causes the two parts of the clutch to again engage. The ratchet-and-pawl connection between wheel i^3 and the pinion I^5 is to permit that pinion to revolve independently of the said gear-wheel and the fly-train, which it engages when the main-spring is being wound up.

The winding up of the mainspring is effected by a crank-handle I^{10}, which carries a beveled pinion i^{12}, that engages beveled teeth i^{13} on the spring-box. In operating this mechanism the handle I^9 is first pulled down and then the crank-handle is turned, thus setting the index or hand to the desired point and simultaneously winding up the mainspring. In Fig. 39 the hand is represented as having been thus set to 35, this number corresponding to rim-contact 35 of the connecting-box. When the hand has thus been set, the lever-handle I^9 is released, thus throwing all the movement again into gear. If, after doing this, the crank-handle I^{10} be released, the hand, unless otherwise restrained, will travel back to zero at once. In order to restrain it from movement until the proper time arrives, I mount upon the shaft or arbor I^{55}, a wheel I^{11}, termed by me an "interrupting-wheel," Fig. 41, in connection with which I have a spring-pulled locking-lever I^{12}, which engages and locks said wheel, except when it is pulled away by a knob I^{15}, attached to a sliding rod I^{14}, connected to the lever, said rod being upwardly pulled by a spring I^{19}, by which the lever, except when pulled down by hand, is held up in engagement with the interrupting-wheel. This interrupting-wheel I make use of in order to interrupt the circuit the desired number of times, when the index, after the clock-work is released, travels back to zero. To this end the interrupting-wheel has such a number of teeth and is so geared down that in its travel each tooth, or rather the distance between each two contiguous teeth, will be the equivalent of one subdivision of the dial. I may here remark that in practice it is desirable to give the clutch the same number of teeth as the interrupting-wheel. In conjunction with this wheel I use a vibrating spring-pressed lever I^{13}, provided with a tooth i^{17}, which enters the spaces between the teeth of the wheel, and is so shaped that as the wheel revolves it will ride up over each approaching tooth and then drop into the space beyond, thus deriving a vibratory movement from the interrupting-wheel. On this lever is carried the movable contact of a pair of insulated contacts i^{18}, which, it is sufficient at present to say, are in the circuit of the counting-magnet of the connecting-box. Thus, supposing the hand to be set to the number 35, then if the locking-lever I^{12} be pulled down the hand or index will return to zero, and in so doing thirty-five interruptions in the circuit of the counting-magnet will occur in rapid succession, with the effect of bringing the circuiting-needle of the connecting-box over the thirty-fifth rim-contact.

For the purpose of operating the locking-lever, I connect it, as before said, with a vertically-sliding rod I^{14}, Fig. 41, provided with a button I^{15}, which projects through a slit in the front of the case, Fig. 39, in position to be pulled down by hand. A spring I^{19} pulls this rod in upward direction, and so holds the locking-lever normally in engagement with the interrupting-wheel. I here remark that a vertically-sliding rod I^{16}, with a button I^{17}, similar in all respects to the rod I^{15} in construction and general arrangement, is placed on the right of the interrupting-wheel in Fig. 41. It is provided with a pin i^2, which, when the rod is pulled down, depresses the tail of lever I^{13}, and so separates the contacts i^{18}, without, however, releasing the interrupting-wheel. The function of this last-named rod will be hereinafter referred to. It is sufficient now to say that it can be used as a manual counter or interrupter.

In addition to the instrumentalities already described, the counter contains several sets of electrical contacts, which, with their operating devices, will now be described. The chief sets of contacts are numbered 1 15 2 25 3 4 and 5 6 7, Fig. 41. The contacts 1 15 and 2 25 are pole-changing contacts. When the one set is closed the other set is opened, and each set gives a current the reverse of the other. The contacts 1 15 are what I term, for convenience sake, the "direct contacts"—that is to say, the contacts through which the direct current passes upon establishment of the circuit through them. Contacts 2 25 are what may be termed the "reversal contacts," which act to throw a momentary reversal upon the line for the purpose, among other things, of actuating the polarized-magnet system of the connecting-box to release the returning-plunger D, in addition to which the reversal thus occasioned works the separation of the reversal contacts themselves and causes all of the contacts to assume their normal position in the counter. The two pairs of contacts 3 4 are what I term "relay-contacts," by means of which the battery at the receiving-station is caused to re-enforce the current from the battery at the sending-station, thus putting both batteries in the distal circuit whenever that circuit is established. Contacts 3 complete the circuit to the recipient's battery, and contacts 4 complete the circuit from that battery, the current from the distant sending-station entering the recipient's counter and passing through contacts 3 of that counter to and through the recipient's battery in the direction required to cause the battery to re-enforce the current, thence to contacts 4, and thence, finally, back to the distant sending-station. In addition to this function, contacts 4 are used to close the circuit through a bell or other call, which notifies the recipient that communication with him is desired. Contact 6 is a double contact which plays between contacts 5 and 7. When it closes upon contact 5, it is in position for sending, and when it closes upon contact 7 it is in position for receiving. The latter is its normal position when the counter is inactive and at rest. I may remark here that the counter-contacts 5, 6, and 7 are the equivalents of the connecting-box contacts 16 17 18 19, Fig. 34. When one set is used the other is not. The former I use in a two-wire system, and the latter in a one-wire system. These contacts are arranged upon the front plate of the frame of the counter, just behind the dial. The movable contacts of the pairs 3 and 4 are attached to and move with a vertically-sliding bar j, mounted in suitable guides on the frame. The movable contacts of the reversal set 2 25 are carried by levers j', pivoted at j^2 to the frame, each lever being provided on its upper edge with an incline or wedge-shaped tooth j^3, which is acted on or wiped in the direction required to depress the lever by a toothed wiper-wheel j^4, loose on a stud attached to the frame and connected with a vibratory lever-arm j^5, mounted at one end, also, on said stud by a pawl-and-ratchet connection j^6, by which the wiper-wheel is caused to turn only when the lever moves downward. The inner ends of the lever-arms j^5 have a pin-and-slot connection with the bar j, as shown, and thus derive their movement from the bar. Springs j^7 press the reversal contact-levers upward, so as to hold the reversal contacts 2 25 normally open. The movable contacts of the direct set 1 15 are also carried by levers j^8, pivoted at j^9 to the frame, with their inner ends pressed by springs j^{10} in a direction to separate or open the contacts, this being their normal position when the instrument is inactive. These inner ends of the levers are in the path of a collar j^{11} on the vertically-reciprocating bar j, by which, when the bar is raised, the contacts 1 15 are caused to close. Contact 6 is attached to and moves with a vibrating arm k, (seen in rear elevation in Fig. 46,) pivoted at its outer end to the frame. This arm k at its free inner end enters and engages a slot in the sliding bar j, and thus serves to impart movement to the latter also. The arm k is actuated by the lever-handle I^9, the inner end of which is beneath a vertical plunger-rod k', jointed to the arm k, and at its lower end playing through a suitable guide on the frame, as seen in Fig. 46. When the lever-handle is pulled down, it consequently will lift both the arm k and the bar j, and will thus operate all of the contacts controlled by the bar and arm, respectively. The contact-carrying bar j occupies successively three positions, the first being the one to which it is lifted, which is its uppermost position, the third being the one to which it ultimately returns after having been lifted, which is its lowermost position, or the position it normally occupies when the instrument is inactive and at rest, and the second being an intermediate position occupied by it only momentarily in passing from the first to the third position, this intermediate position being one in which the reverse contacts meet to throw a reversal upon the line. Inasmuch as the circuit over which this reversal passes is completed through the contacts 5 and 6, it is therefore necessary that these contacts during the descent of the arm k and bar j should remain closed until after the reversal contacts have done their work. To this end the sending-contact 5 is attached to a lever k^2, which is downwardly pulled by a spring k^3 and has a vibrating play of short range determined by a pin k^4 on the frame, which extends into a slot or recess k^5 of the proper width in the lever. When arm k is lifted to its full extent, contact 6 bears up against and raises the sending-contact 5 as far as is permitted by pin k^4. This will allow the lever k^2 a slight downward play when released, and consequently when the arm k swings downward lever k^2 will follow suit, and thus the two contacts 5 6 will be maintained still closed until after the bar j has reached the second position. When the bar j leaves that position for the third, the contact 5, being incapable of further downward movement, is quitted by the contact 6, which then closes upon the lower contact 7. As soon as the lever-handle I^9 is released the bar j will at once drop unless restrained. It becomes necessary, therefore, to provide a means by which the bar shall be sustained in the position to which it has been lifted after the return of the lever-handle to its normal position of rest. This means is provided by an electro-magnet l, (known as a "twisting magnet,)" having its armature l' inclined to but in a plane parallel with the poles of the magnet, and pivoted on an axis l^2, intermediate of but parallel with the axes of the magnet-cores. The direction of movement of the armature under the influence of its energized magnet is indicated by arrow in Fig. 46. Rigidly attached to the armature is a downwardly-extending arm l^3, which is held between a stop l^4, Fig. 45, on one side and a light spring l^5 on the other, which spring tends to move it in a direction opposite to that in which it is moved by the armature when the latter is attached by its magnet. In this arm is a slot which is entered by a pin j^{12} on the rear face of bar j, which pin first passes through a straight vertical slot j^{13} in the front plate of the frame. The slot in the arm l^3 is formed with two jogs l^6 l^7. The former is to support the pin j^{12} when the bar j is lifted to the first position. The latter is to support said pin momentarily when the bar drops from the first to the second or intermediate position. To this end the closure of the direct contacts l^{15}, when the bar is lifted to first position, closes a circuit which includes the magnet l, which consequently attracts its armature l', and thereby causes arm l^3 to swing in a direction to bring jog l^6 under pin j^{12}, as seen in Fig. 51, for example. So long as the magnet continues active the parts will remain in this position, and the bar j, consequently, will be maintained in the first position irrespective of the lever I^9. The moment the circuit is broken the magnet loses its energy, and the slotted arm l^3 by its spring is moved in a direction to carry jog l^6 out from under the pin j^{12}. The bar j is thus freed and allowed to drop; but at second position (in which it closes the reversal contacts 2) it is again arrested by the jog l^7, which is so positioned that it will be brought into the path of pin j^{12} when the jog l^6 is moved out of the path of said pin. The parts in this position are shown in Fig. 52. The arrest of the bar j in second position is, however, in practice but momentary, because the closure of the reversal contacts 2 re-establishes circuit through magnet l, and the armature l' thereby is attracted, causing the arm l^3 to move (against the stress of its spring) in a direction to carry the intermediate jog l^7 out of the path of the pin j^{12}, thus allowing the bar j to drop to third position.

The circuit in which the magnet l is included is one which includes also the counting-magnet of the connecting-box, hereinbefore referred to. Interruptions in this circuit are required in order that the circuiting-needle may be brought over the proper rim-contact. These interruptions are occasioned by the action of the interrupting-wheel I^{11} of the counter upon the contacts i^{18}, as already explained; and, finally, during the time this sequence of interruptions takes place the lever-handle I^9 of the counter must be released in order that the clock-movement of the counter (which includes the interrupting-wheel) may be thrown into gear with the main-spring of that movement; but, as an interruption of the circuit at this time (the lever-handle I^9 having ceased to sustain the bar j) would result in the de-energizing of the magnet l and the consequent drop of the contact-controlling bar j from first position, it becomes necessary to provide some means by which this bar shall be positively held in its uppermost or first position during the period of these interruptions. This result I attain in a mechanical way through the instrumentality of the rod I^{14}, Fig. 41, which operates the locking-lever I^{12}. This rod, by a pivoted lever I^{18}, is connected to a vertically-sliding plate m, which plate, in view of its function, I term the "current-guard." The connection between the lever and the current-guard is effected by bringing the inner end of the lever under a pin m^2 on the current-guard, so that when this end of the lever is lifted it will lift the current-guard also. This plate is mounted upon the back of that part of the front face of the frame on which the bar j moves, as seen in Fig. 46. It is provided at its upper edge with an upwardly-projecting tooth or point m', which, when the arm l^3 of the armature l' is swung in position to support the pin j^{12} of the bar on the upper jog l^6, is in such position that if the current-guard be lifted said point will pass up alongside of a similar point or projection l^8 on the under edge of arm l^3 in position to be a mechanical stop, which will prevent the arm l^3 from moving laterally under the pressure of its spring l^5. By pulling down rod I^{14} the interrupting-wheel will be released from the locking-lever I^{12} and will commence to move; but simultaneously with the disengagement of the locking-wheel the current-guard by the same movement of rod I^{12} has been raised into position to mechanically hold the arm l^3 in position to support the contact-controlling bar in its first position during the sequence of interruptions occasioned by the interrupting-wheel. When the hand or index returns to zero, the interruptions cease, the current becomes continuous, and the magnet l becomes again active. Consequently at that time the rod I^{14} can be released and allowed to rise.

I here remark that the manual counting or interrupting rod I^{16} is connected to the current-guard in the same way as the rod I^{14} and for the same purpose. Either rod I^{16} or I^{14} can operate the current-guard independently of and without influencing the other.

In illustration of my invention I have represented the counter and connecting-box as combined in a system intended to be used for telephonic intercommunication. To this end the telephonic appliances can be conveniently assembled and arranged in the counter and are so represented in the drawings. (See Figs. 39, 40, and 41.)

J is the usual hinged telephone-bar, which is depressed against the stress of its spring, as customary, by the weight of the telephone hung upon its outer end. So far as the telephonic circuit-connections within the box are concerned, they are or may be those of the ordinary Bell telephone.

Connecting with the telephone-bar are appliances used to operate both the current-guard and a pair of contacts 8, Fig. 41, respectively. The contacts 8 and the appliances for operating them are used only in a system employing one line-wire for receiving and sending—that is to say, a "one-wire system," as I have termed it. With a two-wire system they are not used. The appliance for operating the current-guard independently of the rods I^{14} and I^{16}, used in both the two-wire and the one-wire systems, is a rod n, which rests at its base on a pin or shelf n', Figs. 41 and 40, projecting laterally from the telephone-bar, thence passing up through suitable guides on the back of the front plate of the frame of the instrument, Fig. 46, with its upper end abutting against a notch or shoulder in or on the current-guard. When the telephone-bar is released and rises, the current-guard will be lifted. The contacts 8 in the single-wire system when separated make a break in the circuit, by means of which the bar j is precipitated from its first position. The movable one of these contacts is carried by a radial rod n^2, attached to a rock-shaft n^3, impelled by a spring n^4, Fig. 43, to turn in a direction to hold the contacts 8 together. Rigidly fixed to this shaft is a pawl-like arm n^5, Fig. 40, which engages a ratchet n^6, loose on the axis of the telephone-bar. A hinged pawl n^7 on the telephone-bar engages this ratchet. The arrangement is such that when the telephone-bar rises (owing to removal of the telephone) the pawl n^7 will ride over the ratchet without imparting movement to it; but after communication is over and the telephone is again hung on the telephone-bar the latter descends, and in so doing its pawl n^7 is forced against the ratchet-wheel, giving it a partial movement of rotation the distance of one tooth, thus causing the pawl-arm n^5 to ride over said tooth, and consequently rocking the shaft n^3 in a direction to momentarily separate the contacts 8.

To the telephone-bar J is connected a switch-lever K, which operates in connection with stationary contacts K′ K^2 K^3. Connection between the switch-lever and the telephone-bar is made by an insulated link K^4, jointed at one end to the lever and at the other end to the bar, as seen in Fig. 40. The switch-lever carries a contact K^5 of such length that before leaving K′ it will meet K^2 and K^3, and vice versa. The switch-lever, by a jointed connecting-rod K^9, is also connected to the rod K^6, Figs. 40 and 50, which operates the special reversal mechanism shown in Figs. 50, 50^a, and 50^b, and hereinbefore referred to as being located in the counter-case immediately below the telephonic appliances. At the point where the two rods K^9 K^6 meet they are both jointed to a link K^7, which at its outer end is also jointed to the frame of the instrument.

When the telephone-bar is down, as seen in Fig. 40, the switch-lever is also down, and in this position its contact is in connection with contact K′ only, thus closing the circuit at this point of the circuit through the battery of the counter proper. When, on the other hand, the telephone-bar rises to its uppermost position, the switch-lever rises also, quitting contact K′ and closing with contact K^2, which is in the telephonic circuit, and also with contact K^3, which is in a shunt around the electro-magnet of the special reversal apparatus. In this way, as will hereinafter be more clearly seen, I cut out of the telephonic circuit all material resistance in the shape of electro-magnets, &c., save only in the two-wire system the polarized magnet of the recipient's connecting-box and in the one-wire system the polarized magnets of the connecting-boxes of both the sender and the recipient, the resistance of which at the most is inconsiderable.

The special reversal mechanism shown in Figs. 50, 50^a, and 50^b is used only in the two-wire system. In the one-wire system it is dispensed with. The electro-magnet of this reversal mechanism is in the circuit of the receiving-wire only of the counter—that is to say, it connects with the receiving-contact 7. Consequently when the counter is used for sending, in which event the contact 6 is closed upon sending-contact 5, the electro-magnet of the special reversal mechanism of the sending-counter is, *ipso facto*, cut out. It is only the electro-magnet of the reversal mechanism which is contained in the recipient's counter, therefore, that remains in the circuit established between sender and receiver. The moment the recipient, in answer to the call, takes up his telephone the telephone-bar of his counter rises, lifting the switch-lever of that counter into connection with the shunt-contact K^3 and the telephonic contact K^2, thus cutting out the magnet of the reversal mechanism of his counter, and at the same time completing his telephonic circuit.

The reversal mechanism consists, primarily, as shown in Fig. 50^b, of four pairs of insulated contacts 9, 10, 11, and 12, the movable members of which are attached to and move with an intermediate lever L, the handle end of which projects out through the right-hand end of the counter-case, as seen in Fig. 39. This lever is upwardly pulled by a spring L′ to close upon the upper contacts 9 10, which correspond to the direct contacts 1 of the sender's counter, and this is the normal position of the parts when the circuit is established between sender and receiver and while communication is being carried on. The circuit under these conditions is represented in Fig. 64. When communication is ended and the distal circuit is to be broken, it is the duty of the recipient after hanging up his telephone to depress the lever L, breaking contact with the upper contacts 9 10 and closing upon the lower contacts 11 and 12, which correspond to and act in conjunction with the reversal contacts 2 of the sender's counter. The effect of this is, first, to interrupt the circuit, and then through the contacts 11 12 to throw upon the line a reverse current, as seen in Fig. 65, the result being that the break causes the bar *j* of the sender's counter to drop from its first or uppermost to its second or intermediate position, and the subsequent closure of the lever-contacts upon the reversal contacts 11 12 immediately following the break throws upon the line the reversal of current needed to allow the bar to drop from its second to its third or normal position of inactivity. It may be, however, that the recipient, after hanging up his telephone, will fail to depress the reversal-lever L. This fact will be indicated to the sender by an indicator stud or finger M, which is attached to bar *j* and projects to the front through a vertical slot in the dial of the counter, along which are marked the positions respectively assumed by the indicator when the bar is in its successive three positions, as seen in Fig. 39. Should the recipient fail to depress the reversal-lever, the sender's indicator will remain at the uppermost or first position. In order, therefore, to enable the sender under these conditions to himself operate the contacts of the recipient's special reversal mechanism, I provide each special reversal mechanism with an electro-magnet N, which is in the distal circuit and is the magnet hereinbefore referred to as being cut out by the shunt-contact K^3. This magnet has a spring-retracted armature-lever N′, to which is jointed a longitudinally-sliding frame or bar N^2, carrying an actuating-pawl N^3, which engages a ratchet-wheel N^4, mounted on an arbor N^5 and held normally in the position shown in Fig. 50 by a spring N^6, connected to it by an eccentrically-pivoted link. A stop-pawl N^7, hinged to the frame, is provided to hold the ratchet-wheel in the position to which it may be moved by the actuating-pawl N^3, which by the vibration of the armature has imparted to it a reciprocating movement. The arbor of the ratchet-wheel has upon it a crank-arm N^8, which, when the ratchet-wheel has revolved far enough, will bear down upon and depress the reversal-lever L. In order to effect this result, the crank-arm is so placed that the ratchet-wheel must revolve beyond its dead-center or more than a half-revolution before said arm reaches the reversal-lever. As soon as the ratchet-wheel passes its dead-center it is at once caused to complete its full revolution by the pull of its link and spring, and in so moving it rides over the pawls and causes the crank-arm to wipe over and momentarily depress the reversal-lever. The vibration of the armature is effected by the manual interrupter I^{16} of the sender's counter. The sender reciprocates this rod, and thus makes and breaks contact at i^{18}, with the effect of interrupting the distal circuit, consequently vibrating the armature-lever N of the recipient's counter and actuating the ratchet until the crank-arm of the latter depresses the reversal-lever and causes a break of the circuit with a subsequent reversal of current—a fact which will be announced to the sender by the fall of the indicator M of his counter to its normal position of rest.

In order that the ratchet may be always in normal position at the time the recipient communicates with the sender, the adjusting-rod K^6, hereinbefore referred to, is employed. This rod extends down past the stopping and actuating pawls of the ratchet N^4, and is provided with lugs K^8, which come under the tails of said pawls, as seen in Fig. 50, where this adjusting-rod is shown in the position it occupies when the telephone-bar is down. When the telephone-bar rises, it pulls up through the agency of the switch-lever the adjusting-rod K^6, and the latter is consequently caused to disengage the pawls from the ratchet, which latter as soon as released at once returns to its normal position, if it be not already in that position. The call-bell shown in Fig. 39 in the lowest part of the counter-case is in a local circuit, (as will hereinafter appear,) which is active only when the counter of that call-bell is in condition for receiving.

The isolator.—It remains for me to describe the instrument which I have hereinbefore termed the "isolator." In case each subscriber or user had his own individual connecting-box as well as counter the isolator is unnecessary; but it may be desirable at times, on the score of economy and for other reasons, that a number of subscribers shall make use of the same connecting-box, or, in other words, that there shall be but one connecting-box for a number of subscribers or users. In this event it becomes necessary to provide means by which the subscriber who desires to communicate shall be able to hold the connecting-box until he is through without being interfered with by the other subscribers who have the connecting-box in common with himself. It is to this end that I have devised the isolator, which, as its name implies, is intended to isolate the counter of the subscriber who has once gained access to the connecting-box from the other counters which may also be in the system to which that box is common. This instrument, which is a simple appliance, consisting of a number of stationary insulated rim-contacts, in combination with a revolving brush which contacts successively with each rim-contact, is shown in Figs. 54 and 55. The sending-wire of each of the counters of the system is connected to one of these rim-contacts. It is a shallow box of any suitable material containing individually-insulated rim-contacts P equal in number to the counters which are to have the single connecting-box in common. Over these contacts is a contact-brush P′, fixed to and moving with an upright shaft P^2, to which rotary movement is imparted by a worm-shaft P^3, that engages a worm-wheel P^4 on said shaft. The brush is electrically connected to its shaft, and the shaft in turn is electrically connected by a wire P^5, Fig. 55, to the binding-screw by which the circuit enters the connecting-box, said connecting-box being shown by dotted lines in Figs. 54 and 55. The main worm or driving shaft A^5 of the connecting-box is shown in full lines in these figures. The worm-shaft of the isolator is axially in line with the said driving-shaft of the connecting-box and is driven by it. The connection between the two shafts is effected by a clutch P^6 of suitable construction, which is connected with and operated by the rod H′ of the connecting-box, hereinbefore described by reference to Fig. 3. This rod, when the connecting-box is inactive, is pushed out, as has hereinbefore been explained, and when so pushed out it causes the two parts of the clutch P^6 to engage, and thus the worm-shaft of the isolator is driven by the like shaft of the connecting-box. As the connecting-box shaft is power-driven and is normally in continuous revolution, it follows that the contact-brush P′ of the isolator is also in continuous revolution so long as the connecting-box is inactive, and consequently the rod H′ is pushed out. If under these conditions any one of the subscribers of the system desires to communicate or to establish circuit through the connecting-box, he turns on the battery of his counter. After this has been done by him, then just as soon as the brush in its movement reaches that rim-contact with which the battery of the counter of the subscriber is connected circuit will be established from said battery through the brush and its shaft and connections to and through the connecting-box, with the effect, as hereinbefore explained, of releasing the escapement of the connecting-box, allowing it to spring forward into gear with the circuiting-wheel, and at the same time pulling inward the rod, thus disengaging the two worm-shafts and bringing the isolator-brush to a standstill over the rim-contact of the subscriber. The circuit is then established, and the subscriber can hold it to the exclusion of others until he is through, after which the rod will be again pushed out, the brush will again revolve, and the isolator will be ready for the next subscriber who may wish to use the connecting-box.

The foregoing form of isolator is simple and efficient and is the one which I prefer to use. Manifestly, however, the construction and arrangement of it may be widely varied by the skilled electrician, what is essential being that when one subscriber has established communication with the connecting-box other subscribers of that system shall not be able to interfere therewith.

Recurring for a moment to Fig. 39, there will be seen at the top a galvanometer, which in practice is included in the line between the twisting-magnet L and the ground of the counter. This affords a convenient means for ascertaining the nature and condition of the current on the line. To the right of the galvanometer in Fig. 39 is seen a small knob l^8. This knob is attached to a lever l^9, (shown in rear elevation in Fig. 46,) the end of which extends down under one end of the armature l', and is intended to influence that armature manually in the same direction as the latter is influenced electrically by its magnet l. This manual lever is a convenient means by which, upon failure to reach a distant subscriber, the sender can, by manipulating it, bring back the bar j, &c., of his counter to normal position.

I have now described all of the instrumentalities which I make use of in carrying out my invention. It remains for me to indicate the manner in which they can be used in circuit for the purpose of electrical intercommunication.

The system in its simplest skeleton form, absolutely divested of all detail, is represented in Fig. 62. Two subscribers' stations are represented, each provided with a counter and connecting-box, and with each counter two wires are employed, one for receiving and one for sending, the sending-wire of the sender being connected through his own connecting-box directly with the receiving-wire of the recipient, as indicated by the figure, in which the connecting-box of subscriber 1 is represented by the dotted line as connected with that branch of the nodus of the receiving-wire of the counter of subscriber No. 2, which has its terminal or rim contact in the connecting-box of subscriber No. 1. The circuit thus established is as follows: Starting at "ground" of subscriber No. 1, it passes up to and down through this subscriber's counter to his battery, which it enters, say, from the zinc side, thence up again through the same counter, out by the sending-wire to connecting-box 1, thence by dotted line to receiving-wire of subscriber 2, down through counter 2 to the zinc end of the battery of that counter, (which is thus in series with the battery of counter 1,) thence up again through counter 2 to the ground-wire of the latter, and from that ground back to the ground of subscriber 1. The wiring of the connecting-boxes in this two-wire system is shown in Fig. 63, and has already been explained.

Having indicated in a general way the organization of the system, I now proceed to a more particular description of the circuit-connections by reference to Figs. 64 and 65, which represent more in detail the same general system as that outlined in Fig. 62. In these figures the wiring of the two counters and connecting-boxes is clearly shown, and includes not only the wiring for the establishment of the distal circuit, but also the circuit-connections whereby the telephonic circuit may afterward be established by lifting the telephone-bars of the two counters, as already explained. I also show in these figures the local circuit for the bell or sounder of each counter. This, however, is a mere detail which forms no essential part of my invention, and is simply an accessory of the same general kind as is used in other systems of electrical communication.

Fig. 64 shows the various parts in the position which they assume after the distal circuit has been made and before the telephonic circuit has subsequently been established. Fig. 65 shows the same parts in the position which they assume when (for the purpose of restoring the circuit-connections, &c., to their normal position of rest or inactivity) a reversal of the current following a break has been established in the distal circuit.

Referring now to Fig. 64, counter 1 is the sending-counter, which, by the manipulation of the sender in the manner hereinbefore indicated, has been brought to the condition shown diagrammatically in the figure, with the effect of being thrown into communication with the receiving-wire of counter No. 2 through connecting-box 1. Counter 2 and connecting-box 2 remain in their normal position of rest. The ground-contacts 23 in connecting-box 1 are separated, thus breaking the proximal circuit, by whose controlling agency connecting-box 1 has been brought into communication with the receiving-wire of counter 2. Under these conditions the circuit is as follows, starting from the carbon end of battery 1, the arrows indicating the direction of current: from battery 1 to contacts 9, to direct contacts 1, to contacts i^{18}, to contacts K^5 K′ and switch-lever, (represented diagrammatically as part of the telephone-bar,) to contacts 5 6, out from counter 1 to connecting-box 1, through polarized magnet D^3 and circuiting-needle and appropriate rim-contact, to line and receiving wire of counter 2. In this counter it passes successively through magnet N of the special reversal mechanism, to receiving-contacts 6 7, to contacts K′ K^5 and switch-lever, to contacts 3, to contacts 10, to zinc of battery 2, from carbon of said battery to contacts 9, to contacts 4, through twisting-magnet l, out from counter 2 to ground 2, thence to ground 1, and thence again to counter 1, where it passes successively through twisting-magnet l, direct contacts 15, contacts 10, back to zinc end of battery 1. The distal circuit thus established can be used for any desired purpose. Interruptions occasioned in it will have no effect if the current-guard or a device similar to it be employed to lock the bar j in its uppermost or first position so long as the circuit is to be maintained. The current-guard may indeed be thus operated manually by the sender through the intermediary of the pull-rod I^{14}, which can be so arranged as to be locked in its pulled-down position; but in using my invention for any purpose I have arranged to leave as little as possible to the discretion or voluntary action of the subscriber, and to this end in using said invention to establish telephonic communication, for example, as represented in the drawings, I connect, as hereinbefore indicated, the "current-guard," so called, to the part (in this instance the telephone-bar) which establishes the telephone-circuit, so that when the subscriber takes off his telephone, and the bar consequently rises, the current-guard will thereby be automatically brought into position to maintain the bar j in its first or uppermost position notwithstanding the cutting out of the twisting-magnet due to the establishment of the telephonic circuit.

I have not diagramatically represented the completed telephonic circuit; but its course can readily be followed in Fig. 64, assuming the telephone-bars of the sender and receiver, and consequently the switch-levers K, to be lifted so as to bring K^5 into connection with K^2 and K^3, and it may be traced, under this assumption as follows: from ground 1 to microphone-coil of the telephone of counter 1, through said coil and the telephone to contacts K^2 K^5 and switch-lever, to contacts 5 6, out from counter 1 to and through connecting-box 1, to line and receiving wire of counter 2, to contacts K^3 K^5 K^2, to and through the telephone, and thence through the microphone-coil, thence out from counter 2 to ground 2, and thence back to ground 1. In this telephonic circuit all magnets of both sets of instruments are cut out, save the polarized magnet D^3 of connecting-box 1.

The local call-bell circuit of each counter can readily be seen. It includes two pairs of contacts 13 14, the movable ones of which are carried by the bar j, these contacts being closed when the bar is in its normal third or lowermost position, as in counter 2 of Fig. 64. When the bar j is raised above that position, the contacts 13 14 are separated, as seen in counter 1. The circuit is from one pole of bell-battery through bell-magnet, contacts 13 14, to other pole of bell-battery. I may here remark that a contact is connected to the armature-lever l' of the twisting-magnet l in such position as to close a break in the bell-circuit when the said lever is attracted by its magnet. At other times than the one just mentioned the break referred to is unclosed. This means for putting the bell-battery on and off I have not, however, deemed it necessary to show, as it is an expedient known in other systems and forms no essential part of my invention. If now, after telephonic communication has ceased and the telephones are hung up, it is desired to return all parts of the two subscribers' instruments to their normal position of rest and to permanently interrupt the distal circuit, the reversal-lever of the special reversing mechanism of counter 2 is depressed either by the manual act of the recipient or, in failure of that, by the act of the sender himself through the electrically operated or controlled devices connected with said lever, as already has been set forth. The effect of this act is to make a break in distal circuit followed at once by a re-establishment of that circuit, the bar j of the sender's counter (counter 1) dropping to its second or intermediate position, so as to open the direct contacts 1 15 and close the reversal-contacts 2 25. The parts thus positioned are represented in Fig. 65 with the contacts 11 12 of the receiver's special reversing mechanism closed. The circuit under these conditions is as follows: from carbon of battery 1 into counter 1, to contacts 9, to contacts 25, through twisting-magnet l, out from counter 1 to ground 1, to ground 2, into counter 2, through twisting-magnet l, to contacts 4, to contacts 12, to zinc of battery 2, from carbon of battery 2 to contacts 11, to contacts 3, to contacts K′ K^5 and switch-lever, to contacts 6 7, through reversal-magnet N, out from counter 2 to line, and thence to connecting-box 1, through polarized magnet D^3, (in a direction reverse to that in which it before traversed said magnet,) out from connecting-box 1 into counter 1, to contacts 5 6, to switch-lever and contacts K^5 K′, to contacts i^{18}, to contacts 2, to contacts 10, to zinc of battery 1. Thus immediately upon the re-establishment of the circuit, due to the depressal of the lever of the special reversal mechanism of the recipient, a current is thrown upon the circuit momentarily, which, by energizing the twisting-magnet l of the sender's counter, causes the precipitation of the bar *j* of this counter to its normal position of rest, and at the same time by imparting a reverse polarity to the magnet D^3 of the polarized-detent mechanism of connecting-box 1 releases the returning-plunger D of that box with the effect of causing the return of all of the connecting-box mechanisms to their normal position of rest and permanently interrupting the distal circuit between the two stations.

In Fig. 60, Sheet 24, I have represented an extension of the system involving the employment of a single connecting-box common to a number of subscribers in conjunction with an isolator. There are four subscribers' counters shown. The sending-wire of each counter is lettered *s*, and the receiving-wire *r*. Each sending-wire is connected, as shown, directly to its appropriate rim-contact of the isolator, and each receiving-wire is connected directly to its appropriate rim-contact of the connecting-box. In the figure, counter 2 is supposed to have established distal circuit with counter 4 to the exclusion of possible interruption by any of the other counters. The circuit is from carbon of No. 2 battery, through counter 2, out by its sending-wire to No. 2 contact of the isolator, thence to and through the connecting-box to the rim-contact of the receiving-wire of counter 4, by this receiving-wire to, through, and out from counter 4 to the zinc of the battery of that counter, from the carbon of said battery back to, through, and out from counter 4 to ground 4, to ground 2, to and through counter 2, to zinc of the carbon of battery 2. The construction of the instruments comprised in this system and their mode of operation have already been described and need not be repeated.

In the system represented in Fig. 60 the counters 2 3 4 are typical of a number of subscribers' counters located in proximity—say in a country neighborhood—which can intercommunicate between themselves, and also may communicate with a counter 1, located at a point miles away—as, for example, at a county-seat. The system illustrated in the figure contemplates the employment of two wires—sending and receiving—for each counter. In some instances, however, it may be found desirable or convenient to provide the country-neighborhood counters with one wire only for both receiving and sending, the county-seat counter still retaining its two wires. Such a modification of the system is represented in Figs. 58 and 59; but in order to comprehend the same it will be necessary to first explain the modifications in the wiring of the counter, &c., made necessary by a one-wire system of intercommunication. This explanation can best be made by reference to Figs. 56 and 57, which represent two stations similar to those in Figs. 64 and 65, save that one wire only is employed for receiving and sending—that is to say, the connection between each subscriber's counter and the connecting-box pertaining to that counter is made by a single wire as between two different connecting-boxes—the connections remain the same as heretofore described—viz., each rim-contact wire of any one box leads to the particular branch of the nodus of that other box with which it may be designed to communicate. It will be understood, therefore, that by the term "one-wire system" I intend only a system in which the counter and its connecting-box are connected by one and the same wire for both sending and receiving. In this one-wire system each counter has a system of contacts which differ somewhat from the system of contacts employed for the two-wire system. The difference can best be noted by comparison of counter 1 in Fig. 56 with counter 1 in Fig. 64. Similar letters of reference in these two counters designate similar contacts and other parts. The two counters have in common the contacts 1, 15, 2, 25, 4, i^{18}, K^2, K^5, K', 13, and 14. From the single-wire system counter, Fig. 56, are omitted, first, the contacts 5 6 7 of Fig. 64, the place of which is taken by the connecting-box contacts 16 17 18 19, Figs. 56 and 34, which are lacking in the double-wire-system connecting-box, Fig. 64; second, the contacts 3 and K^3; third, the contacts 9 10 11 12 of the special reversal mechanism, and, indeed, the whole of that reversal mechanism, the place of which is taken by the reversal-contacts 2 25, which in themselves suffice to produce the reversal which, under my invention, must follow a break in the distal circuit.

The contacts contained in the single-wire-system counter and connecting-box, Figs. 34 and 56, and not found in the double-wire-system counter and connecting-box, Figs. 63 and 64, are, first, the contacts 8, which contacts are operated from the telephone-bar by the means illustrated in Figs. 40 41, and, as already explained, act, when the telephone-bar drops, to first break and then make the distal circuit for the purpose of precipitating the bar *j* to second position by the break, and then by the make to permit to be thrown on the circuit the reversal needed to precipitate the bar from second to third or normal position; second, the contacts 20 21 22. In order that the function of these contacts may be appreciated properly, it should be stated that in the single-wire system the connecting-boxes of both the recipient and the sender are included in the distal circuit, whereas in the two-wire system the sender's box only is in said circuit. In the sender's box the ground-contacts 23 are always broken when the distal circuit is established, because with this circuit completed the returning-plunger is held outwardly in position to separate said contacts, as hereinbefore explained. In the receiver's box, on the contrary, the parts are in their normal position of rest, in which position the contacts 23 are closed. Consequently as the distal current enters the recipient's box and passes to the branched binding-screw, from which connection is made with the recipient's counter, it will, unless restrained, seek the shortest path or path of least resistance, and consequently in great measure, if not entirely, will pass through the receiver's counting-magnet C^2 to central ground instead of going to the counter. It becomes necessary, therefore, to provide means for breaking the central ground of the recipient's box, and such means are afforded by the contacts 20 21, as will be understood by reference to Fig. 34, in which the recipients's box is in normal position of inactivity or rest, with central-ground contacts 23 closed, and the receiving-contacts 18 19 also closed, contacts 20 22 open, and contacts 21 closed. If under these conditions the distal circuit be established, the current entering the box in direction of the arrow *x* will first of all pass through contacts 19, thence to and through polarized magnet D^3, and thence to central ground through contacts 21 23, thus establishing a circuit through polarized magnet D^3. This energized magnet immediately pulls its armature-frame in a direction to open contacts 21 and to close contacts 20. The central-ground connection being thus broken at 21, the circuit then will be from contacts 19 to and through polarized magnet D^3, to contacts 18, to contacts 20, to fixed contact 22, and thence out from connecting-box to counter. In this arrangement of wiring the counting-magnet C^2 is connected to central-ground contacts 23, not directly, as it is in the double-wire-system box, but indirectly through the contacts 21. Again, suppose the connecting-box is the sender's instead of the receiver's. Then the sender's current enters the box in the direction of arrow *y* through the counting-magnet and operates the circuiting-needle, &c., as already explained. The circuit at this time is through the counting-magnet C^2 to contacts 21, to contacts 23, to central ground. As soon as the circuiting-needle has completed the distal circuit the returning-plunger D, by its outward movement, breaks the ground-contacts 23 and simultaneously closes contacts 22, while the lever H has shifted so as to open contacts 18 19 and to close contacts 16 17. Under these changed conditions (which I have not deemed it necessary to represent graphically) the counting-magnet C^2 will be cut out by the breaking of its ground, and the circuit will be from binding-screw at arrow *y* to closed contacts 22, to the movable one of contacts 20, to contacts 17, to and through polarized magnet D^3, to contacts 16, and out to line. Magnet D^3, when thus energized, pulls its armature-frame in a direction to open contacts 21 and to close contacts 20; but this, however, has no electrical effect whatever upon the circuit. The separable contacts 22, like contacts 20 21, serve to guard against a ground which might at times otherwise be made, with the possible effect of short-circuiting or cutting out the counter.

Having described the wiring of the connecting-box for its one-wire connection with the counter, I proceed to describe the system illustrated in Figs. 56 and 57, in which two counters, &c., are represented as connected in system under the one-wire plan. In Fig. 56 it is supposed that the distal circuit between counter 1 and counter 2 has been established. The circuit is as follows: from carbon of battery 1, to contacts 8, to contacts 1, to contacts i^{18}, to contacts K′ K^5 and switch-lever, out from counter 1 to connecting-box 1, to contacts 22, to contacts 20, to contacts 17, to and through polarized magnet D^3, to contacts 16, out from connecting-box 1 by the appropriate rim-contact, to the nodus of connecting-box 2, which latter it then enters, passing to contacts 19, through polarized magnet D^3, to contacts 18, to contacts 20, through contacts 22, out from connecting-box 2 to counter 2, in which it passes successively to switch-lever and contacts K^5 K′, contacts 4, twisting-magnet *l*, out from counter 2 to ground 2, to ground 1, entering counter 1, in which it passes successively to twisting-magnet *l*, to contacts 15, to zinc of battery 1. It will be noted that in this arrangement of circuit-wire only the battery of the sender is used. The recipient's battery is cut out. With the distal circuit thus completed the telephonic circuit can be established precisely as described with reference to Fig. 64.

In Fig. 57 it is supposed that communication between the two stations has ceased and that the telephones have again been hung up. The sender, by hanging up his telephone, has depressed his telephone-bar, thus actuating the contacts 8 to first break and then remake the circuit. The bar *j* of counter 1 at the break drops from first position, Fig. 56, to second position, Fig. 57, with the effect of throwing the required reversal upon the circuit. The diagram Fig. 57 represents the circuit as it is at the time the reversal is thrown over it, and may be traced as follows: from carbon of battery 1 to contacts 8, to contacts 25, to twisting-magnet *l*, out from counter 1 to ground 1, to ground 2, to counter 2, in which it passes successively to twisting-magnet *l*, contacts 4, contacts K^5 K′, and switch-lever to connecting-box 2, in which it passes through the same made contacts as in Fig. 56, but in an opposite direction, so as to impart reverse polarity to the polarized magnet D^3, (thus bringing the armature-frame of that magnet back to normal position and restoring the central ground,) out from connecting-box 2 to connecting-box 1, in which it passes through the same system of made contacts as in Fig. 56, but in the opposite direction, thus restoring the parts of this box to normal position, out from connecting-box 1 to counter 1, in which it passes successively to switch-lever and contacts K′ K^5, to contacts i^{18}, to contacts 2, to zinc of battery 1. By this momentary reversal the sender's twisting-magnet acts to permit the drop of bar *j* to normal or third position, as already explained.

Figs. 56 and 57 represent counters and connecting-boxes which are designed to be used in a telephonic or telegraphic exchange system in which each subscriber has his own counter and connecting-box; but in cases where subscribers are content to use a connecting-box common to all, then this box may be wired as described for the double-wire system, whether the counters themselves are one-wire or two-wire. A mixed single and double wire system organized on this plan is represented in Figs. 58 and 59. The system embraces a connecting-box and isolator common to all the counters and four counters. Of these counters counter 1, which is supposed to be located at the county-seat, far distant from the other counters, is a two-wire counter, which contains not only the contacts and other mechanism shown in the two-wire counter in Fig. 64, but also the contacts 8 of Fig. 56 and mechanism for operating the same. It contains, in fact, all of the parts which have been hereinbefore described, as pertaining to the counter. Counters 2, 3, and 4, typical of a group of stations or subscribers in a country neighborhood, are single-wire counters similar to those in Fig. 56 in all respects. The wiring of the connecting-box is similar to that represented in Fig. 63. Each counter 2 3 4 is connected on the one hand to ground, and on the other hand by a branched wire to the connecting-box and isolator, one branch going direct to the appropriate rim-contact of the connecting-box and the other branch going to the appropriate rim-contact in the isolator. Counter 1 has its ground-connection on the one hand, and on the other it has, instead of a branch wire, two separate wires, one leading to the connecting-box and the other to the isolator. In Fig. 58 counter 2 is supposed to be in communication with counter 4. The circuit, as seen, is from counter 2 to isolator, through rim-contact 2 of the latter, to connecting-box, and out through rim-contact 4 of the latter to branch wire of counter 4, to ground 4, to ground 2, and thence back to counter 2. Such is the circuit for what may be termed "neighborhood communication," and this circuit includes only one battery—viz., the battery of the sender—as contemplated by the one-wire system; but for long-distance communication, as, for example, between any one of the distant counters with the county-seat counter, additional battery-power will be needed. Provision to meet this need is indicated in Fig. 59, in which counter 1 and counter 2 are supposed to be in communication, the circuit-connections being such that the circuit includes not only the battery of No. 2, but the more powerful battery of No. 1 also.

The circuit in Fig. 59 is as follows: from counter 2 to isolator by rim-contact 2, thence to connecting-box and out by rim-contact 1 to counter 1 by receiving-wire, through battery 1 of this counter, up again to counter and out to ground 1, to ground 2, and back to counter 2. In this way the two batteries of No. 1 and No. 2 are in series. When No. 1 is the sender, it will be sufficient for him simply to hang up his telephone, because thereby the contacts 8 will occasion the break and make needed to return the parts of all the instruments that were in the circuit to normal position; but when counter No. 1 is the recipient, then, in addition to hanging up his telephone, he must also depress the lever-handle of his special reversing mechanism in order to throw his own battery on the circuit also in reverse and in support of the more feeble battery of No. 2.

It is quite feasible to make both the connecting-boxes and the counters (whether under the single or double wire system) with two or three hundred subdivisions and rim-contacts without having the instruments unduly large or without multiplying unduly the connecting-wires, so that in case the subscribers to the system in any one place do not exceed that number each subscriber can have his individual counter and connecting-box, and his connecting-box can be connected directly to the individual connecting-boxes of the other subscribers, as contemplated in Figs. 62 and 64; or the individual subscribers may be divided into groups, each of which has a common connecting-box, as in Figs. 58 60, in which event each group-connecting box would be connected to all the other connecting-boxes of the other groups. Beyond this number, however, it becomes necessary to devise some other system of connection between the individual members of the system, still, of course, retaining the connecting-boxes and counters in accordance with my invention. Such a system of connection is diagrammatically represented in Fig. 61. In the system represented in this figure there are supposed to be four hundred individual subscribers, each having his individual counter and connecting-box. These subscribers are divided into two groups, (represented by case 1 and case 2,) each of which has the shape of a hollow square (one face only of which is shown) containing two hundred connecting-boxes. In connection with each group of individual connecting-boxes is a second box of precisely the same kind, which, however, I term a "communicating box," in order to distinguish it from the individual connecting-boxes, and with each communicating box may be used an isolator, as represented. One contact of each connecting-box of one group is connected to its appropriate rim-contact of the isolator of the other group, this connecting-wire being a sending-wire, (marked *s* in the drawings.) The remaining one hundred and ninety-nine contacts of this connecting-box are connected each to its appropriate branch of the nodus or terminal of the appropriate subscriber of the same group. (These latter connections have already been explained and are not here represented.) From the appropriate rim-contact of each communicating box leads a receiving-wire (letter *r*) to each connecting-box (if single-wire organization) or counter (if double-wire organization) of the group to which said communicating box pertains. Under this system the subscribers of each group can communicate with each other in the manner hereinbefore explained. Communication between subscribers of different groups is, however, made through the communicating boxes, and the manner in which such communication is established can best be explained by reference to the figure, in which it is supposed that subscriber 4 of case 1 is sending to subscriber 7 of case 2, and that simultaneously subscriber 5 of case 2 is sending to subscriber 3 of case 1. The normal position of inactivity or rest of the communicating boxes and their isolators is precisely that of individual isolators and connecting-boxes. Assuming, therefore, all parts of the system to be in this normal position, when subscriber 4 of case 1 desires to communicate with subscriber 7 of case 2, subscriber 4 first counts upon his own individual connecting-box a number (say two) sufficient to bring the circuiting-needle of his connecting-box over and down upon the rim-contact, which is connected to the isolator of communicating box 2. When this is done, the central ground of this connecting-box is broken, and its counting-magnet is cut out, and the circuit, which now is what I call the "communicating circuit," is completed through the counting-magnet of communicating box 2 and its central ground. Subscriber 4 of case 1 now counts a second time, in this instance counting seven, so as to bring the circuiting-needle of the communicating box over and down upon the rim-contact appropriate to subscriber 7 of case 2. When this is done, the circuit, which now becomes what I have termed the "distal circuit," is completed to subscriber 7 through his receiving-wire *r*. Thus in this system the subscriber, when wishing to communicate with any subscriber of the other group, makes two counts. The first count brings his own connecting-box into circuit with the desired communicating box, and the second count prolongs that circuit from the communicating box to the individual subscriber of the group served by that communicating box. Manifestly this system may be extended farther—that is to say, the communicating boxes in Fig. 61 may be considered as primary, and these communicating boxes in turn may be connected up in system with secondary communicating boxes, precisely as the individual connecting-boxes are represented as connected in system with the primary communicating boxes, and so on, it being feasible in this way to comprise in one system many thousand subscribers. With the primary communicating boxes only the subscriber is required to make two counts. With secondary communicating boxes added to the system he must make three counts, and so on.

In a system involving three counts by the individual subscriber it is entirely practicable to include thirty thousand subscribers.

In considering the system represented in Fig. 61 it has been assumed that the connecting-boxes assembled in cases 1 and 2 are individual connecting-boxes; but each of these connecting-boxes can just as well be a box common to a group of subscribers, as hereinbefore described.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a system of electrical intercommunication, the combination of connecting-boxes, counters, a polarized device controlling the returning mechanism of the connecting-box, and circuit-connections, substantially as hereinbefore described, whereby when circuit has once been established between a sender and receiver a subsequent break in that circuit followed by a re-establishment of the same shall have the effect of throwing thereon a current the reverse of that which was upon said circuit before it was broken and re-established, substantially as and for the purposes hereinbefore set forth.

2. In a system of electrical intercommunication, the combination of connecting-boxes, counters, polarized devices controlling the returning mechanism of the connecting-boxes, circuit-breaking devices, automatic circuit restoring and reversing devices, and circuit-connections, substantially as described, whereby when circuit has once been established between a sender and receiver a subsequent break in that circuit shall cause the same to be automatically and momentarily re-established with the current passing thereon in a direction the reverse of that in which it passed before the circuit was broken, substantially as and for the purposes hereinbefore set forth.

3. The combination, in the connecting-box, with a series of rim or stationary contacts, a circuiting needle or bar, and mechanism for bringing said circuiting-bar by a step-by-step movement over any selected one of said rim-contacts, of a cam wheel or plate which is stationary or idle during the said movement by which the said bar is brought over its selected contact, but which, after the circuiting-needle has been brought to this position, is caused, for the purpose of depressing the bar upon its contact, to move always in one and the same direction and invariably to the same extent without reference to variations in the selected position of the said bar, and mechanism for imparting said movement to said cam-plate, substantially as and for the purposes hereinbefore set forth.

4. The combination of the circuiting-needle and the mechanism for actuating the same, the cam-plate, the mechanism for actuating the same, and the clutch for intermittently

connecting said cam-plate and its actuating mechanism, the starting and stopping plungers, and the cam-box, substantially as and for the purposes hereinbefore set forth.

5. The combination of the interrupting-wheel of the counter or other device for interrupting an electric circuit, the counting-magnet, its armature, the circuiting-needle and mechanism for actuating the same, the cam-plate, starting and stopping plungers, the polarized magnet and vibrating frame controlled by the same, circuit-connections, substantially as described, for the said counting-magnet and polarized magnets and contacts included therein, whereby, after the interrupting-wheel has ceased to act and circuit through the polarized magnet is established, the circuit through the counting-magnet is thereby broken, substantially as and for the purposes hereinbefore set forth.

6. The combination, with a number of counters and a connecting-box common to all of said counters, of an intermediate isolator electrically connected on the one hand with each individual counter and on the other hand with the branch circuit-wires leading, respectively, through the counting-magnet and polarized magnet of the connecting-box, substantially as and for the purposes hereinbefore set forth.

7. The combination, with the rim-contacts and spring-impelled circuiting-wheel, the counting-magnet and its armature, and the starting-plunger, of the spring-pressed escapement normally out of gear with the circuiting-wheel, and mechanism actuated from the armature of the counting-magnet to release said escapement and allow it to spring into gear with the circuiting-wheel at the times and in the manner substantially as hereinbefore set forth.

8. In an electrical system of intercommunication, the combination of a device for interrupting an electrical circuit, the rim-contacts and spring-impelled circuiting-wheel and contact-needle thereto attached and the mechanism for actuating the same, the clutch for intermittently connecting said cam-plate and its actuating mechanism, the counting-magnet and its armature, the stopping and starting plungers, the spring-pressed escapement normally out of gear with the circuiting-wheel, and mechanism operated from the armature of the counting-magnet to release said escapement and allow it to spring into gear with the circuiting-wheel at the time and in the manner substantially as hereinbefore set forth.

9. The combination, in a system of electrical intercommunication, of counters and connecting-boxes at different stations, each counter having a telephone-bar and appliances connected with it, and circuit-connections and contacts therein, substantially as described, whereby when circuit between any two distant stations has been established the subsequent lifting of the telephone-bar for the purpose of telephonic communication shall have the effect of cutting out the resistance of the connecting-boxes and counters through which communication was established (save the polarized magnet of one or both of the connecting-boxes) without disturbing the telephonic circuit, substantially as and for the purposes hereinbefore set forth.

In testimony whereof I have hereunto set my hand this 5th day of July, A. D. 1889.

WILLIAM HUTSON FORD.

Witnesses:
EWELL A. DICK,
WILLIAM H. SHIPLEY.