

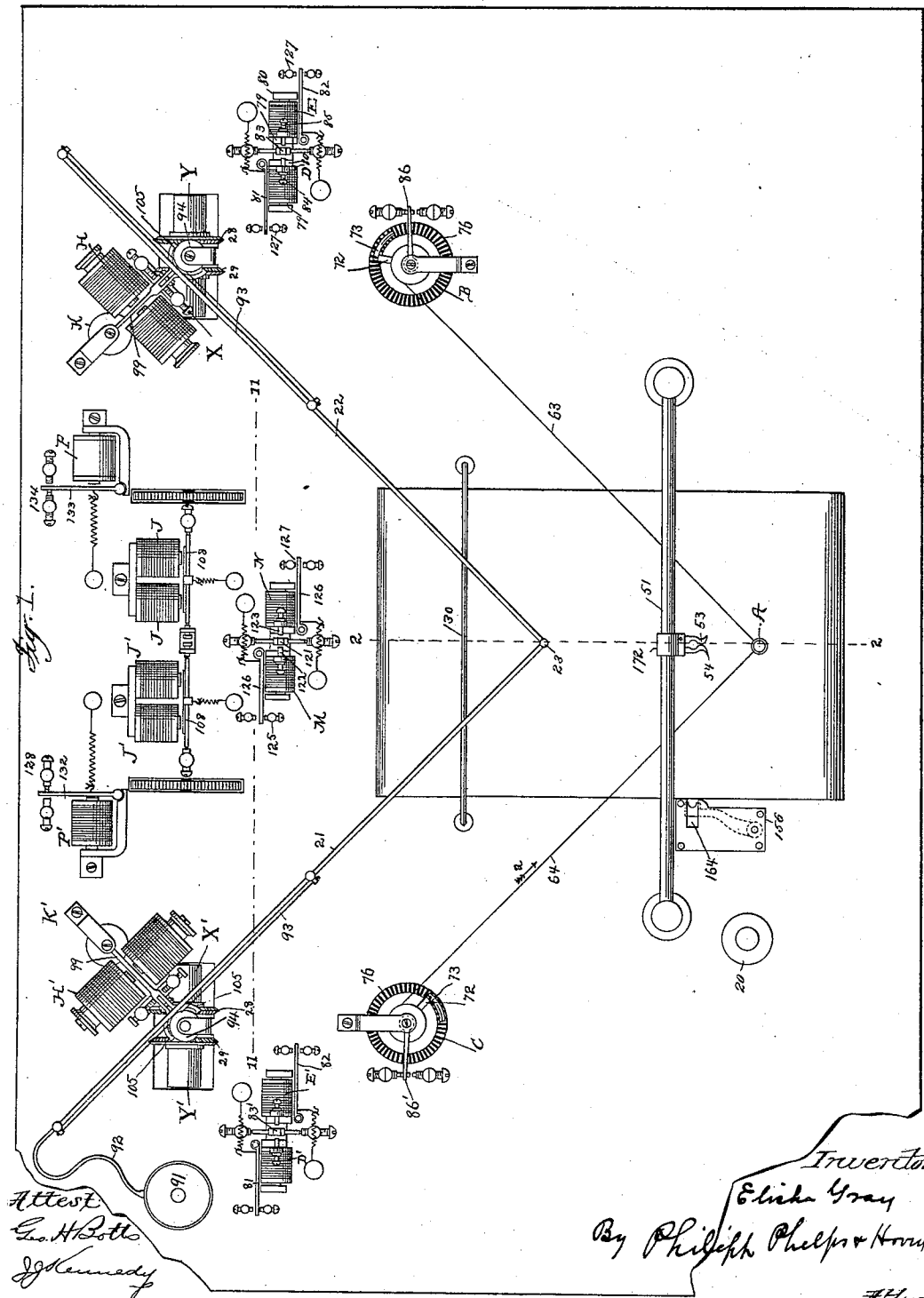
(No Model.)

6 Sheets—Sheet 1.

E. GRAY.  
TELAUTOGRAPH.

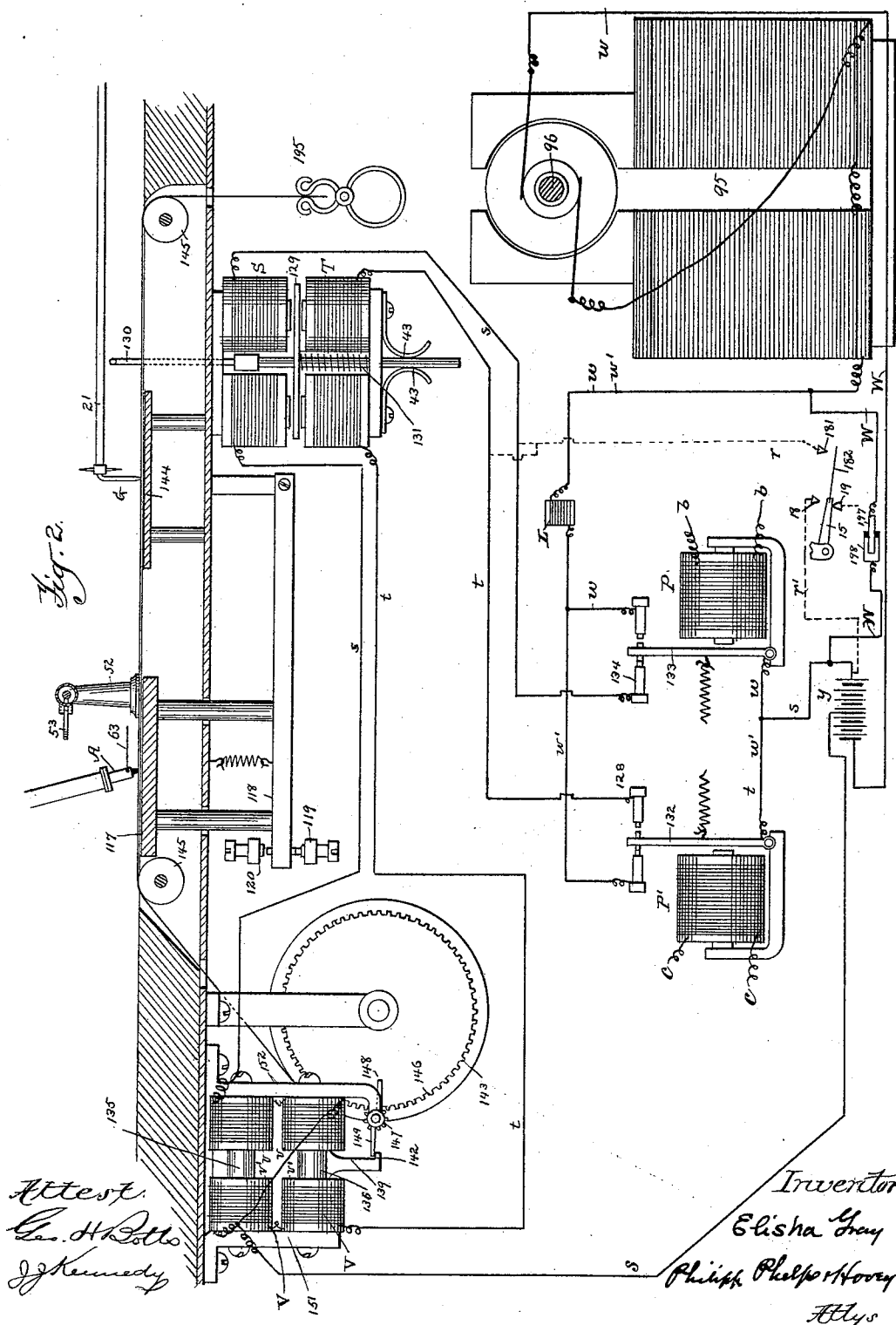
No. 461,470.

Patented Oct. 20, 1891.



6 Sheets—Sheet 2.

Patented Oct. 20, 1891.



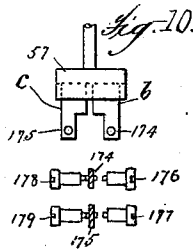
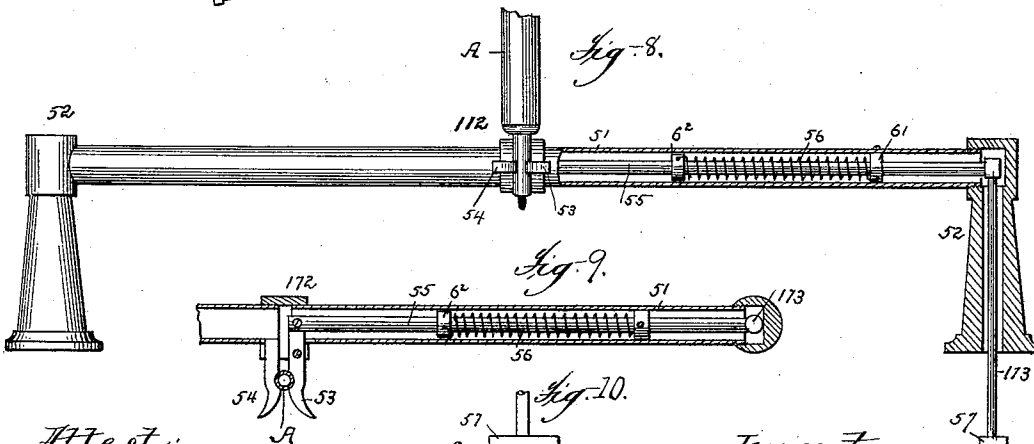
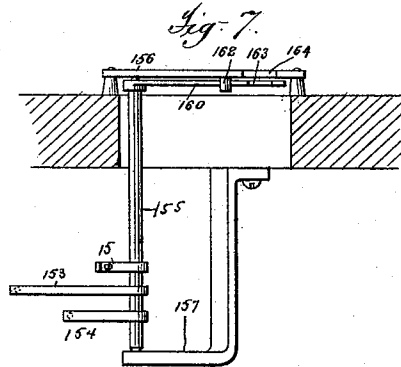
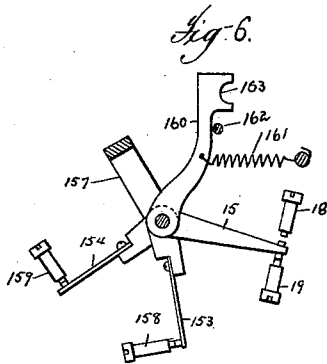
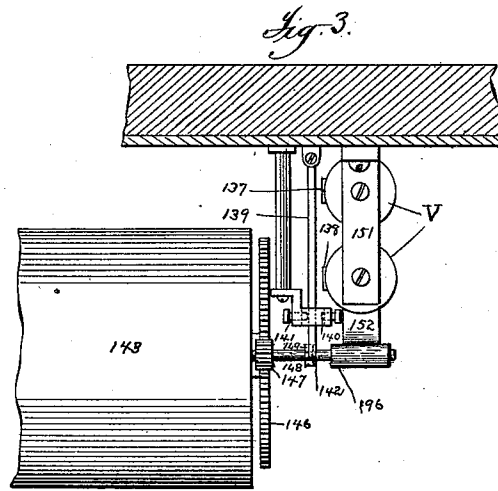
(No Model.)

6 Sheets—Sheet 3.

E. GRAY.  
TELAUTOGRAPH.

No. 461,470.

Patented Oct. 20, 1891.



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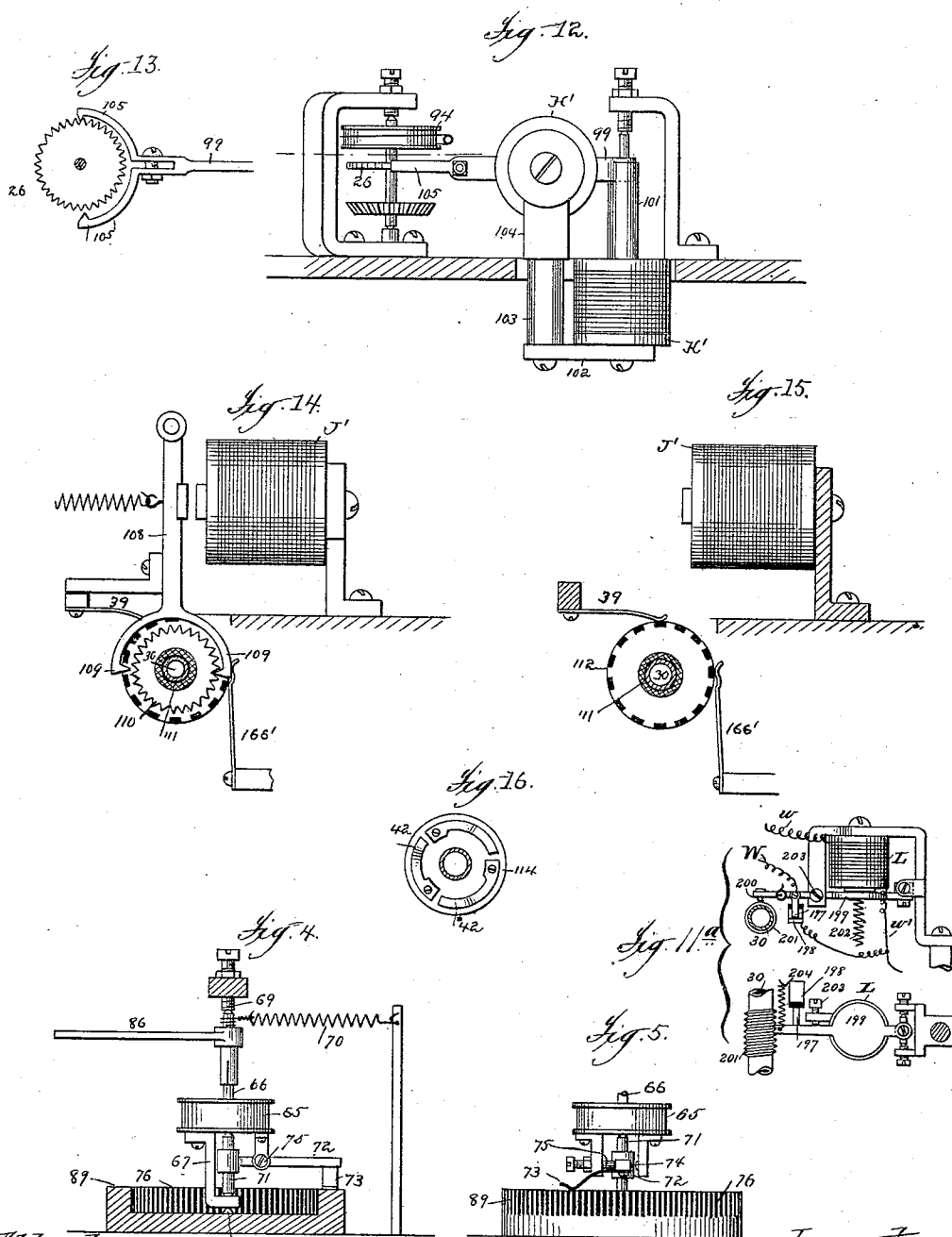
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6 Sheets—Sheet 4.

E. GRAY.  
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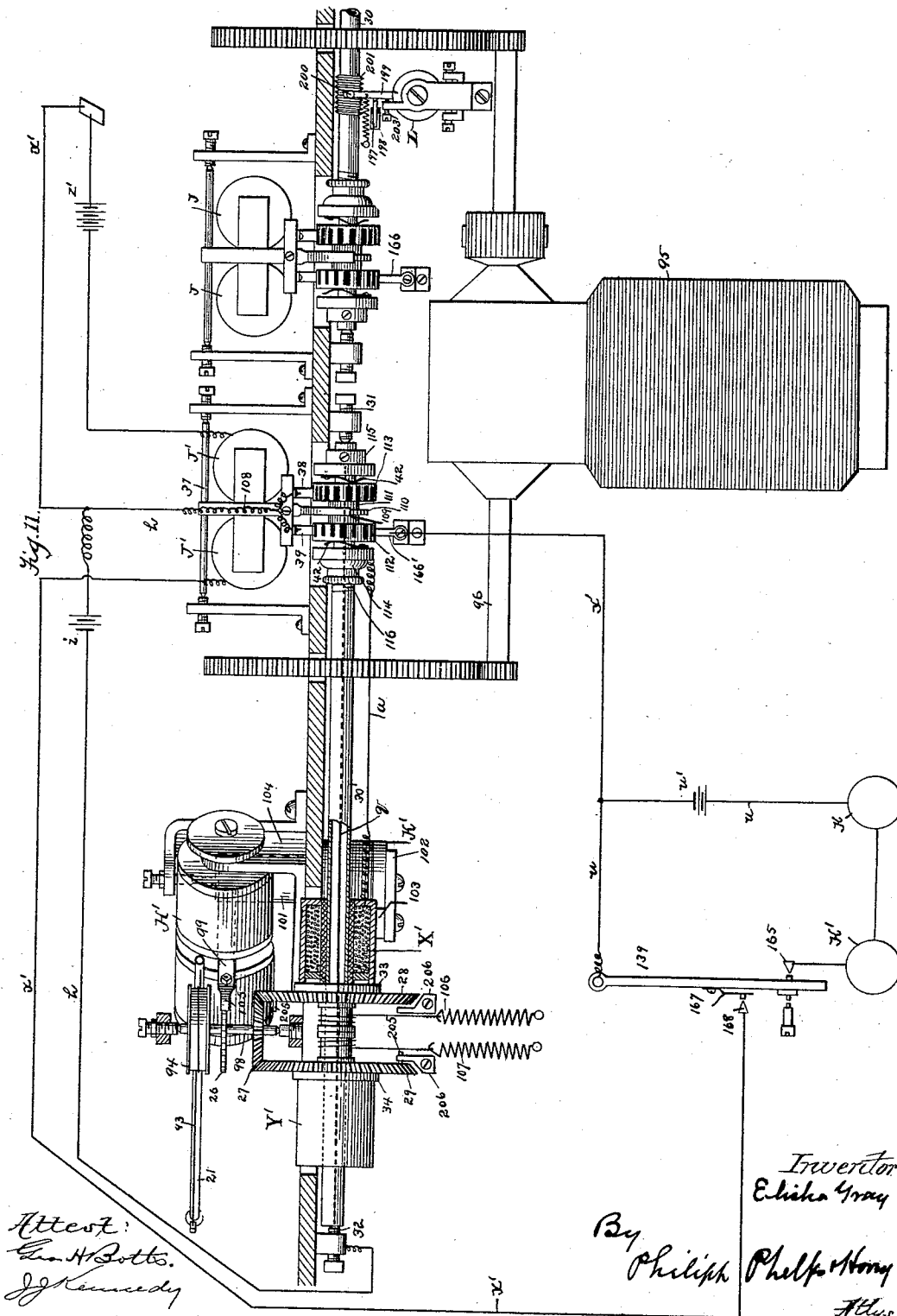
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6 Sheets—Sheet 5.

E. GRAY.  
TELAUTOGRAPH.

No. 461,470.

Patented Oct. 20, 1891.



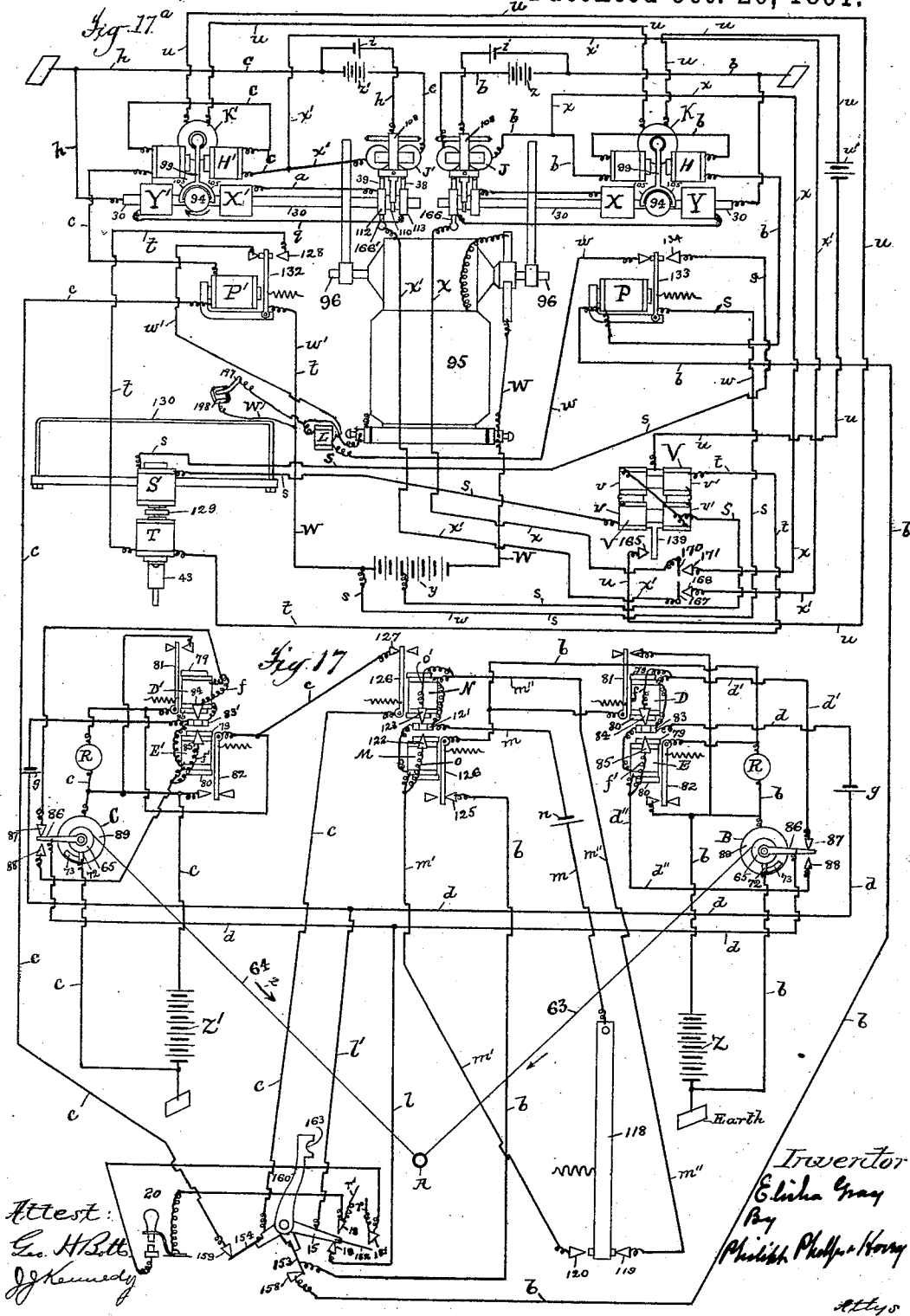
(No Model.)

6 Sheets—Sheet 6.

E. GRAY.  
TELAUTOGRAPH.

No. 461,470.

Patented Oct. 20, 1891.



# UNITED STATES PATENT OFFICE

ELISHA GRAY, OF HIGHLAND PARK, ILLINOIS.

## TELAUTOGRAPH.

SPECIFICATION forming part of Letters Patent No. 461,470, dated October 20, 1891.

Application filed June 13, 1889. Serial No. 314,151. (No model.)

*To all whom it may concern:*

Be it known that I, ELISHA GRAY, a citizen of the United States, residing at Highland Park, county of Lake and State of Illinois, have invented certain new and useful Improvements in Telautographs, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to a writing-telegraph of that class in which the act of writing the message at the sending-station operates to reproduce it at the receiving-station, and it is in the main an improvement upon the apparatus and organization described in my former patents, Nos. 386,814 and 386,815, dated July 31, 1888.

The object of my present improvements is to secure greater speed in transmission and greater accuracy in reproducing the characters transmitted than have heretofore been possible.

In order that the detailed description of the apparatus and its organization hereinafter given may be more readily apprehended a brief statement of the general features of my present improvements will first be given.

It is a well-known fact that pulsations of successively opposite polarity can be sent over a line-wire with greater rapidity and certainty of effect than pulsations of successively like polarity. In my system as heretofore patented by me the pulsations used to operate the receiving-pen were pulsations of the latter sort. It is a feature of importance in my present improvements that pulsations of successively opposite polarity are employed. The movement of the transmitting-pen in either of two directions, preferably at nearly right angles to each other, produces a succession of these pulsations in two electric circuits, the number of pulsations in the respective circuits being determined by the distance which the pen is moved in the respective directions and the speed of succession of the pulsations varying with the rapidity of movement of the transmitting-pen. In my present system these pulsations do not directly operate the motors which move the receiving-pen as do the pulsations sent to line in the system of my prior patents. I now propose to produce a constant strain upon the appara-

tus which drives the receiving-pen, this strain originating in a motor or revolving shaft operated independently as regards its source of power of the transmitting-instrument, and I propose to govern the application of this power to the driving of the receiving-pen by means of an escapement operated by the pulsations above referred to. Thus each pulsation sent over line will permit the receiving-pen to advance a space corresponding to one-half a tooth of the escapement-wheel, and as each pulsation represents a certain definite space traversed by the transmitting-pen and each tooth of the governing escapement-wheel of the receiver represents a certain definite space over which the receiving-pen is driven, the movements of the transmitting-pen will be reproduced with almost absolute accuracy by the receiving-pen.

The devices above referred to provide for reproducing motion of the transmitting-pen in two directions crosswise of each other. The additional devices for reversing the direction of movement of the receiving-pen upon the reversal of the direction of movement of the transmitting-pen consist of a reversing mechanism between the motor or revolving driving-shaft and each of the two devices which drive the receiving-pen in directions crosswise of each other and of an organization adapted to electrically control this mechanism from the transmitting-station. One form of this reversing-gear mechanism (shown in the drawings) consists of two reversely-beveled gear-wheels mounted upon the revolving motor-driven shaft, one or the other of which may be locked to the shaft, and so caused to transmit motion to the pen by means of an electro-magnetic clutch. Two of these clutches are provided for each of the two reversing-gear mechanisms, one for each beveled gear-wheel, and the current of a local battery is directed through the one or the other of them by means of a commutator controlled by escapement-pallets attached to the armature of an electro-magnet. This electro-magnet, like the other devices which have just been described, is duplicated for the two branches of the system, and one is placed in each of the two main circuits and is so organized as not to respond to the ordinary strength of current on line, but only to pulsations of

extraordinary strength. Provision is made for making temporary change or variation in the condition of the current, as by sending a stronger pulsation over each circuit at each reversal in the direction of movement of the transmitting-pen corresponding to that circuit for the purpose of operating the commutator-magnet and thereby changing the action of the reversing-gear mechanism; and my present invention consists in part of apparatus specially designed for this purpose.

A feature of special importance in this organization is the electro-magnetic clutch, so constructed as to permit slip between the motor or the revolving shaft and the apparatus driving the receiving-pen when the escapement-pallets are held by their magnet, but which has sufficient strength to drive the receiving-pen when unrestrained by the escapement.

My improvements also include devices and an organization of circuits for securing unison between the transmitting and receiving pens, and improved apparatus and organizations for raising and lowering the receiving-pen to correspond with like movements of the transmitting-pen and for shifting the paper.

Other novel features in organization and detail of construction will be hereinafter described in detail and specifically referred to in the claims.

The improvements thus briefly outlined will now be described at length, reference being had to the accompanying drawings, in which—

Figure 1 is a plan view of the transmitter and receiver. Fig. 2 is a vertical section through the table on line 2 2 of Fig. 1, (relay-magnets P P' and the motor, however, being shown out of their proper position.) Fig. 3 is an end view of the paper-shifting magnet, showing the drum-cylinder and connected parts. Figs. 4 and 5 are views on an enlarged scale of the interrupters and connected parts. Figs. 6 and 7 are plan and side views of the unison and paper-shifting switch. Figs. 8, 9, and 10 represent on an enlarged scale an improved pen-rack. Fig. 11 is a sectional elevation taken on about the line 11 11 of Fig. 1, the point of view being in the foreground of the latter figure. Fig. 11<sup>a</sup> is a side and rear view of the magnet controlling the motor-circuit and connected parts. Fig. 12 is a side view, on an enlarged scale, of the governing reversible escapement-magnet. Fig. 13 is a plan view of the escapement of said magnet. Figs. 14 and 15 are respectively side and sectional elevations, on an enlarged scale, of the reversing escapement commutator and magnet. Fig. 16 is a detail view of the commutator contact-brushes bearing on the commutator. Figs. 17 and 17<sup>a</sup> are diagrams showing the circuits and circuit connections between a transmitting and a receiving instrument at opposite ends of line-wires.

In my system as now organized I prefer to place the transmitting and receiving instru-

ments in close proximity, and so arranged with reference to each other that a single sheet of paper is used for making the copies of messages transmitted and for recording messages received. I have therefore shown the transmitting and the receiving instruments associated together in Fig. 1.

Referring now particularly to Figs. 1, 4, 5, 17, and 17<sup>a</sup>, the principal features of the transmitter will be described. This instrument consists, primarily, of the transmitting-pen A, which is moved by the operator to form the characters or other matter to be transmitted. This pen, as I have stated in my former patents, may be a simple handle of convenient form, or a pen or pencil, with which a copy of the message transmitted is made, and it is therefore termed a "pen;" but this term, wherever used in a general sense, is to be understood as including any writing-instrument or a simple handle of convenient form.

The pen A is connected at its tip to two cords or other flexible connections 63 64, which extend horizontally crosswise of each other and are connected to operate the two circuit-changing devices B C, termed herein "interrupters," located in the two electric circuits b c, termed "main circuits," and so arranged that as the pen A is moved in the direction of the cord 63 and interrupter B, or in the opposite direction, pulsations are produced in the circuit b in quick succession, varying in number with the linear extent of movement of the pen A and varying in speed of succession with the rapidity of such movement, while, as the pen is moved in the direction of the cord 64 and interrupter C, or in the opposite direction, in forming the characters, pulsations are produced in circuit c in the same manner. In my former telautograph patents the interrupters are so placed with reference to the transmitting-pen that the connecting-cords 63 64 extend in directions approximately parallel and perpendicular to the line of characters traced by the transmitting-pen. In my present organization, however, I place the interrupters in such positions that the cords will have a diagonal location about midway between lines perpendicular to and parallel with the line of writing. By this organization the steps causing the perpendicular and horizontal movements of the pen, which are the movements naturally made most rapidly in writing, are divided between the two halves of the machine, thus enabling a much greater speed to be attained without increasing the working capacity of either circuit. This organization also makes possible a greater degree of compactness in the apparatus, and thereby the use of one strip of paper for the transmitting and receiving instruments at the same end of line.

The function of the interrupters in my present transmitting-instrument is not only to cause pulsations in the main-line circuits, but to cause those pulsations to be of successively opposite polarity. That this may be effected,

each main circuit is provided with two batteries, one at the transmitting and one at the receiving end, so placed in line as to be opposed to each other in polarity, the one at the transmitting end being of about treble the strength of the other. The larger batteries in the two circuits are designated (see Figs. 17 and 17<sup>a</sup>) respectively  $Z$  and  $Z'$ , and the smaller batteries respectively  $z$  and  $z'$ . The interrupter is so arranged as to shunt the larger battery out of line at short intervals.

The two interrupters  $B$   $C$  and their auxiliaries and circuit connections are exact duplicates, and a description of one of them therefore applies to both.

Each of the cords 63 64 is connected to and wound upon a small drum 65, (see Figs. 1, 4, and 5,) fixed upon one of its sides to a shaft 66. To the other side of the drum is attached a bracket 67. The outer end of this bracket rests upon a pivot 68, and the upper end of the shaft 66 is in contact with a pivot 69. The drum is thus mounted so as to revolve between the pivots 68 69. To the shaft 66 is attached a spring 70, which is wound upon the shaft and tends to revolve the drum in the direction opposite to the pull of the pen upon the cords 63 64. Pivoted between the lower face of the drum and the bracket 67 and in line with the shaft 66 is another shaft 71, to which is attached an arm 72, which carries the revolving brush 73. The movement of the arm 72 upon its shaft 71 is limited between stops 74 75, fixed to the drum, (see Fig. 5,) one of which (75, as shown) is preferably adjustable. The face of the disk over which the brush 73 sweeps is provided with a series of channels or cuts located in proximity and containing pieces of insulating material 76, the width of each channel or cut being preferably about the same as that of the adjacent exposed metal surface between it and the next channel. Each main-line circuit divides before reaching the interrupter, (see Fig. 17,) one branch passing through the battery  $Z$  or  $Z'$  at the transmitting end of line and to earth, the other branch connecting with the metal disk of the interrupter. The brush 73 has a permanent connection to earth. When, therefore, the brush is in contact with the metal surface of the disk, the battery  $Z$  or  $Z'$  will be cut out and the battery  $z$  or  $z'$  at the receiving end of the line will alone be in circuit. When, however, the brush 73 rests upon a portion of the insulating material, the branch through the interrupter will be broken and both batteries  $Z$  or  $Z'$  and  $z$  or  $z'$  will be in circuit, their polarity being, as before stated, opposed to each other. In this condition the current of the smaller battery will be overcome and the polarity of the current on line determined by the large battery. The strength of the larger batteries is preferably made about treble that of the smaller batteries, so that the effective current on line is the same (except in polarity) when both batteries are in circuit, as when the smaller battery alone

is in circuit, and the effect on the receiving-instrument will be in both cases the same. The revolution of the brush over the face of the disk will thus cause upon line a succession of pulsations of opposite polarity and substantially equal effective strength, the number and rapidity of these pulsations being determined by the extent and rapidity of the movement of the brush. The mounting of the brush with reference to the drum gives the brush an independent motion, the amount of this motion being adjustable by means of the adjustable stop 75. It results that in practice whenever the motion of the pen reverses the rotation of the drum the brush will not begin to move in a reverse direction until the drum has so moved a distance corresponding to the amount of independent motion of the arm 72 between the stops 74 75. The object of this independent or lost motion of the brush will be stated hereinafter.

The transmitting-instrument is provided with two devices, one for each circuit, which I term "increase current-controllers," each of which acts automatically and momentarily to increase the amount of current passing over its main line whenever the movement of the transmitting-pen is reversed with reference to that line. Each increase-controller consists of two electro magnets or spools  $D$   $E$  and  $D' E'$ , (see Figs. 1 and 17,) provided with lugs 79 80 and armatures 81 82. These lugs are of soft iron and are in contact with the core passing through the helix of each magnet and extend out to the periphery of the same. Each armature is trunnioned in the usual manner and extends from one of the lugs 79 80 to the other in close proximity to but not in actual contact with them. The armatures are provided with the usual springs and front and back contact-points, which regulate their strokes to and from their respective magnets. The two magnets of each pair  $D E$  and  $D' E'$  are mounted in line with each other, with sufficient space between them for a third armature 83 83', respectively, common to them both, and provided with limiting contact-screws 84 85. This armature is without a spring and is attracted alternately by the two spools. Each of the increase-controllers is provided with a local circuit  $d$  and a local battery  $g$ . (See Fig. 17.) Both of these circuits are shown in detail in Fig. 17; but as they are precisely alike the description will be confined to the circuit  $d$  of increase-controller  $D E$ . In circuit  $d$  is circuit making and breaking arm 86, frictionally mounted upon the drum-shaft 66 of the interrupter  $B$ , (see Fig. 4,) and having a limited motion between contact-stops 87 88. From arm 86 the circuit passes by wires  $d$  and  $l$  to a contact-point 19 and circuit-breaking arm 15, (the purpose of which will be hereinafter stated,) thence by wires  $l'$  and  $d$  to battery  $g$  and armature 83. It will be noted that the wires  $l l'$  are common to the circuits of both increase-controllers. From armature 83 the circuit

has two branches, one designated by  $d'$ , including the coil of magnet D and connecting with the stop 87, and the other designated by  $d''$ , including the coil of magnet E and connecting with stop 88. The branch wire  $f$  connects the stop 84 on one side of the armature 83 with the wire  $d'$  at a point beyond the magnet D, forming a shunt around the same, and a wire  $f'$  in a similar manner forms a shunt around the magnet E to the wire  $d''$ . Each of the circuits  $b$   $c$  normally includes a resistance R; but a shunt around the resistance is provided for the circuit  $b$ , when either of the armatures 81 or 82 is on its front stop, and a like shunt is provided for the circuit  $c$  when either of the corresponding armatures of increase-controller D' E' is on its front stop, as shown by the connections in Fig. 17.

When the motion of the pen is reversed and it is caused to move in the direction of the arrow on Fig. 17—that is, from the interrupter B—the arm 86 will, at the moment of reversal, come into contact with the stop 87, which will close the circuit  $d$  through the magnet D, the armature 81 will be attracted to its front stop, and at the same time the common armature 83 will be attracted against the stop 84. As soon as armature 83 strikes stop 84 the magnet D will be demagnetized because of the shunt, closed through wire  $f$ , and the armature 81 will fall back to its back point, while the armature 83, having no spring and being held by residual magnetism, will remain in its position until the next reversal of the pen motion causes the arm 86 to rock against the point 88, when the magnet E will be charged, drawing back the armature 83, and, in a manner similar to that just described, momentarily attracting its armature 82. It will thus be seen that the armatures 81 82 rest normally on their back points, and only momentarily touch the front points—first one and then the other—at the moment the writing is reversed. The effect of the momentary advance of the armature 81 or 82 is to close the shunt before referred to, around the resistance R in the main line, thus causing a strong impulse to momentarily pass through the line, this strong impulse effecting a reversal in the writing at the receiving end in a manner hereinafter described.

The operation of the transmitter as thus far described is as follows: The operator takes the pen A in his hand and forms the characters in proper sequence in the usual manner, moving the pen up and down and from left to right, the same as in ordinary writing. As the pen makes the downstrokes in forming the characters the cords 63 64 will be unwound from the drums of the interrupters B C, thereby rotating the drum and its shaft and moving the brush 73 over the disk 89, and causing a succession of pulsations of opposite polarity over the circuits  $b$   $c$  in quick succession, the number and rapidity of the pulsations being determined by the extent of movement and speed of the pen. As the pen

makes the upstrokes the springs 70 will rewind cords 63 64 and move the brushes 73 in the reverse direction, causing pulsations upon the two main circuits in the same manner. So long as the movement of the pen recedes from either of the interrupters, as B, the shaft 66 will continue to revolve in one direction and the arm 86 will be held against the stop 87, and the pulsations on the line will pass through the resistance R. As soon, however, as the movement of the pen is reversed—i. e., changed from a motion from the interrupter B to a motion of approach to the interrupter—the movement of the shaft 66 will be reversed and the arm 86 will be caused to rest against the contact 88, thereby momentarily energizing magnet E, drawing up armature 82, and sending a strong pulsation over the line  $b$ , and this strong pulsation will besent over line  $b$  as often as reversal in the direction of movement of the pen with reference to the interrupter B occurs. The same succession of operations occurs in connection with the circuit  $c$ , interrupter C, increase-controller D' E', and connected parts upon each reversal of the direction of movement of the transmitting-pen with reference to the interrupter C.

The purpose of the independent or lost motion in the arm 72 and brush 73, heretofore described, is to allow the reversal of the receiving mechanism to be made while the brush is standing still, whether on a metal or insulating segment of the disk. To accomplish this the stroke of the arms 86 is made as short as possible, (say the two-hundredth of an inch,) while the play of the brush 73 between its stops is made a trifle longer. This provision for lost motion in the brush 73 is not absolutely essential for perfect writing; but prevents possible loss of steps at the receiving end when the writing is done at a high rate of speed, and is therefore a preferred construction.

Referring now particularly to Figs. 1, 2, 11, 12, 13, 14, 15, 16, 17, and 17<sup>a</sup>, the principal features of the receiver will be described.

The receiving-pen G is a writing-instrument of any suitable form for recording the message. The term "pen" therefore, as applied to this instrument, is to be understood as including any form of writing-instrument. In the cases shown a fountain-pen is employed, which is composed of a tube of glass of very fine or capillary bore, having its end formed into a writing-point. This pen is supplied by a piece of flexible rubber tubing which runs through the tubular pen-arm 21 and connects by means of a preferably flexible capillary tube 92 with the ink-well 91, as described in my former patents. The pen-arms 21 and 22 are made of light metal tubing, hinged at the point 23 immediately over the point of the pen. Each of the arms 21 22 is provided with a cord 93, attached to the arm at each end and having a turn about a drum 94. Motion is given to the receiving-pen by the revolution of these drums 94, and this revolution is

effected in correspondence with the movements of the transmitting-pen by means of a mechanism which will be presently described. The receiving-pen arms are so adjusted with reference to the pen and the cords upon the drum that the distance from the receiving-pen to the hinging point or drum 94 of either of its pen-arms will be equal, when the transmitting and receiving instruments are in unison, to the length of the unwound cord connecting the transmitting-pen with the drum of the interrupter upon the same side of the instrument. This organization causes the transmitting and receiving pens to swing in arcs having the same radii, and consequently to that extent insures an exact reproduction by the receiving-pen of the movement of the transmitting-pen. It will be observed that this advantage is in part secured by the transfer of the circuit-changing arm 86 to the shaft of the interrupter from a position between the interrupter and the transmitting-pen.

The revolution of the drums to move the receiving-pen is effected in my present organization by a power derived from a motor 95, (see Fig. 11,) and the application of the power of the motor to the pen-drums is controlled by a reversible escapement governed by the pulsations sent over the line, as above described. The motor may be of any suitable construction, the form which I prefer and which is shown in this application being an electric motor. The shaft 96 of this motor is geared to two distinct shafts, (although there may be but one, if preferred,) one on each side of the receiving-instrument and one for each of the pen-drums 94. As the two shafts with their connected parts are identical in construction, but one set thereof is described and shown in full—to wit, that upon the left-hand side of the machine as it appears in Fig. 1. The following description may therefore be understood as applicable to both of these sets of devices.

The shaft 30 (see Fig. 11) is trunnioned between screws 31 32 and passes loosely through the hubs of the two bevel gear-wheels 28 29. Fastened to each of the gear-wheels 28 and 29, one for each wheel, are the soft-iron disks 33 34. Fast on the shaft 30 and on either side of the wheels 28 29 are two clutch-magnets X' Y', (the corresponding clutch-magnets on the right-hand side of the receiver being designated in Fig. 17<sup>a</sup> by the letters X Y, respectively,) which are fastened to and revolve with the shaft 30. The shaft 30 is preferably of brass, the cores of the clutch-magnets being made of soft iron and bored out of such size as to allow the shafts to slip into the hole and fit tightly therein. The head of each magnet-spool at the end nearest the bevel gear-wheel is made of hard rubber and also the outer shell or covering is of soft iron, as is the head of the spool farthest from said gear-wheel. The end of this shell next to the gear-wheel, and also the end of the core, project forward a short distance beyond the head

and come into contact with the iron disk fastened to the wheel. There is thus formed a frictional clutch between the shaft and the gear-wheel, which may be electro-magnetically controlled from the transmitting-station, as hereinafter described. While this clutch may be constructed and used having the magnetizable metallic surfaces in actual contact, I find it preferable, in order to prevent sticking or demagnetization, to face the magnetizable surface with a layer of non-magnetic substance, as parchment. For convenience, I term such a clutch as this—i. e., one in which operativeness depends upon friction controlled by magnetic attraction—an “electro-magnetic frictional clutch.” Both of these magnets X' Y', with their connected parts, are exactly alike. Meshing with the two bevel gear-wheels 28 29 is a third bevel gear-wheel 27, mounted upon a trunnioned shaft 98, which carries the receiving-drum 94 and an escapement-wheel 26. The pallets 105 of this escapement-wheel (see Fig. 13) are preferably made adjustable to and from each other, and are attached to the armature 99 of a magnet H', (the corresponding magnet on the other side of the instrument being designated H.) This magnet is a polarized relay constructed on the principle of the well-known Siemens relay, with the exception that the polarizing-coil K' (the corresponding coil on the other side of the instrument being designated K) is an electro-magnet and not a permanent magnet, for a purpose hereinafter stated. The soft-iron core 101 of the magnet K' is extended upward, and upon it is trunnioned the arm 99. The other end of the core is connected by soft-iron connecting-pieces 102 103 and bracket 104 with the soft-iron cores of the spools of magnet H'. The angles of the faces of the escapement-pallets 105, and also those on the faces of the escape-wheel teeth, are preferably made the same, so that the escape-wheel will be reversible and operate in either direction with equal facility upon the reversal of the strain which tends to move it.

The two wheels 28 and 29 are each provided with a lost-motion spring 106 107, (see Fig. 11,) which serves to give the wheels a normal tendency to revolve in the same direction in which they are propelled by the motor, and keep them, consequently, always in driving-contact with the cogs of the wheel 27. The use of these springs is made possible because of the fact that the wheels 28 29 are preferably made of such a size that they need never be moved continuously in one direction for more than one revolution, a complete rotation of either of these wheels corresponding to the extreme range of movement of the receiving-pen in its field, and because of the further fact that the gear-wheel 27 so connects the wheels 28 29 that that one of these two wheels which is not clutched to the motor-shaft is driven backward by the one which is operating the receiving-pen through the agency of wheel 27. It results that each of

the two wheels 28 29 revolves to and fro upon the shaft 30, first in one direction and then in the other, and always within the limit of a single revolution, and that consequently the lost-motion springs will remain permanently in their proper relation to the hubs upon which they are wound. It is not essential to the operation of my system that the range of the movement of the wheels 28 29 should be restricted to a single rotation; but it is a preferred construction, for the reason that pins 205 may be placed upon these wheels, adapted to come in contact with fixed stops 206 at the extreme limits of motion of the receiving-pen, whereby maintaining unison between the transmitting and receiving instruments is aided, as hereinafter stated.

The direction of rotation given to the drum 94, and consequently the direction of movement given to the receiving-pen thereby, will be determined by the existence of magnetism in the coils of one or the other of the two clutch-magnets X' Y'. The mechanism for determining which one of these coils receives a current will next be described.

Situated in the main lines, one for each line *b c*, are two magnets J J', (see Figs. 1, 11, 14, and 15,) of ordinary construction. Magnet J', which alone need be described in detail, has an armature 108, trunnioned in the ordinary way and carrying upon its end pallets 109, similar to the pallets 105 already described, which engage with an escape-wheel 110, the teeth of which are like those of wheel 26 above described, mounted upon a hub 111, which may be of insulating material loosely mounted upon the shaft 20. To the hub 111 are fixed two commutator-disks 112 113, (see Figs. 11, 14, and 15,) which disks are insulated from each other by the insulating material of hub 111, or otherwise, and from the shaft 30, as shown in Figs. 14 and 15, each of these commutator-disks consisting of a metal disk having a rim set with sections of insulating material alternating with metallic sections in metallic connection with the disk. Attached to the armature-lever 108 are two springs 38 39, which ride lightly upon the commutator-disks. Outside of each commutator-disk and upon shaft 30 are two contact-collars 114 115, made of insulating material. One of these collars 115 is rigidly attached to the shaft and the other 114 is feathered upon it, so as to rotate with it, but to be adjustable lengthwise of the shaft. These collars carry springs 42 (see Figs. 11 and 16) upon their faces, which bear continuously against the metal portion of the two commutator-disks and serve two purposes: first, to furnish a means of electrical communication with the commutator-disks, and, second, to cause the proper amount of friction between the rotating commutators and escapement-wheel and their bearings upon the shaft to cause the commutators to move with the shaft when permitted by the escapement. A lock-nut 116 is provided behind the collar 114, by the use of which the

collar may be set backward or forward upon the shaft to secure the proper degree of friction between the shaft and the commutators. The commutator-springs 38 39 are so adjusted that one of them rests upon a metallic section of one commutator-disk, while the other rests upon an insulating section of the other commutator-disk. Both of these springs are insulated from the armature 108. A circuit *h*, passing through a local battery *i*, connects with the shaft 20, with which there is in electrical contact one end of the coil of clutch-magnet X', the other end of the coil of this magnet being connected through insulated wire *a* with the contact-spring on collar 114. One end of the coil of clutch-magnet Y' is also in electrical contact with the shaft 30 and the other end of this coil connects by means of wire *g* passing through the center of shaft 30 and insulated therefrom with the contact-springs on collar 115. (See Fig. 11.) It will be understood that the circuits of the clutch-magnets may be made in the manner indicated or in any other convenient way. It results that when the spring 38 is in contact with a metallic segment of its commutator-disk, clutch-magnet Y' is in circuit with the local battery *i*, the clutch-magnet X' being cut out of circuit, and that when spring 39 rests upon a metallic segment of its commutator-disk clutch-magnet X' is in circuit with the local battery *i*, clutch-magnet Y' being then cut out.

The operation of the mechanism thus far described will now be stated. The motor-shaft 96, being continually in rotation while a message is being received, gives constant rotation to the shafts 30. When one or the other of the clutch-magnets X' Y' is energized, the end of its core and shell lying in contact with the disk 33 or 34 becomes magnetic and causes the disk to adhere to it with greater or less force, according to the strength of the local battery. Under such circumstances the attached bevel gear-wheel 28 or 29 is given a tendency to revolve in the same direction as the shaft and will communicate that tendency to the escape-wheel 26 and drum 94. This tendency to revolve will, however, be checked when the line-current is on by the escapement-pallets 105 engaging with the teeth of the escape-wheel 26, except when the armature 99, carrying the pallets, oscillates. The pulsations of successively opposite polarity sent to line from the transmitter cause changes of magnetic polarity in the poles within the two coils of magnet H', causing the armature 99 to be drawn first to one side and then to the other, giving an oscillating motion to the pallets, and permitting the escape-wheel 26 to revolve step by step—one step for each pulsation—in the direction in which the constant strain of the motor impels it. The strength of the battery used to charge the clutch-magnets X' Y' is so regulated that when the pallets 105 are at rest with a line-current on the clutch-magnet will

rotate against the disk 33 or 34 with a friction not great enough to overcome the resistance offered by the pallets, but yet sufficient to carry the pen-drum with its attachment, when released by the pallets 105, in whichever direction the particular clutch-magnet which is energized may determine. When a reversal occurs in the direction of motion of the transmitting-pen a strong pulsation is sent to line through the agency of the increase-controller in the manner above described, and this pulsation affects the magnet J', which is so organized that it does not respond to the ordinary pulsations. The armature 108 of this magnet is attracted and the commutator-disks 112 113 are permitted to advance by the space of one tooth of the escapement-wheel 110. That one of the springs 38 39 which prior to this strong pulsation was in contact with a metallic segment, is now in contact with an insulating-segment and vice versa; and it follows that the circuit of the local battery *i* has been broken through that one of the magnets X' Y' which was previously in circuit and closed through that one which was previously out of circuit. A tendency to rotate in a reverse direction will therefore be imparted to the shaft 98 and drum 94 and its pen-carrying arm 21, and this direction of motion will continue until another strong impulse is sent over the line.

On referring to Figs. 17 and 17<sup>a</sup> it will be seen that when the transmitting-pen is moving in the direction indicated by arrow numbered 2, and the motor 95 at the receiving end is causing the shaft 30 to revolve in a direction which when observed from the right-hand end is opposite to the movement of the hands of a watch, the two instruments being in unison, the spring 39 will be in contact with a metallic segment of its commutator-disk, closing the circuit of battery *i* through clutch-magnet X' and revolving the drum 94 on the left-hand side of the instrument in the direction of the arrow, Fig. 17<sup>a</sup>. Upon reversal the operation of the increase-controller D' E' upon the magnet J' throws spring 39 onto an insulating-segment and spring 38 onto a metallic segment, cutting in magnet Y' and cutting out magnet X' and causing the drum 94 on the left-hand side of the receiving-instrument to rotate in the direction opposite to that indicated by the arrow in Fig. 17<sup>a</sup>. The main circuit *b* being also provided with a polarized relay H K similar to the relay H' K' and connections such as above described, the effect of the ordinary pulsations and the occasionally strong pulsations over that line upon the pen-carrying arm 22 operated from the other pen-driving drum 94 is the same as that which has been just above described with reference to pen-carrying arm 21.

The purpose of attaching the springs 38 39 to the armature 108 will now be stated. It is desirable that the change of the clutch-circuit from one clutch to the other should be

made in the quickest possible time after the pulsation of increased strength has been sent to line from the transmitter. The length of the stroke of the armature 108 is so adjusted and the springs 38 39 are so mounted upon it with reference to the metallic and insulating segments of the commutator-disk upon which they bear that, when the armature begins to move, the spring which was on an insulating-segment is thrown onto a metallic segment, and the spring that was on a metallic segment is thrown onto an insulating-segment without waiting for the reversing-escapement to act. It results from this arrangement that the clutches X' Y' are in fact reversed before the reversing-escapement acts, the action of the escapement simply causing the changed condition to continue until the next reversal occurs, and increased speed of writing is thus secured.

It has now been explained how the movement of the transmitting-pen in a direction to or from either of the interrupters B C will cause the receiving-pen to move in the same direction, the movement of the latter pen being made up of a series of short steps. It is apparent that, as with the system described in my former patents, any movement of the transmitting-pen in a direction intermediate between these two directions will cause the receiving-pen to move in a corresponding direction; but with a movement made up of a number of steps taken at right angles to or crosswise of each other, the relative number of steps in each direction depending upon the obliquity of the movement of the transmitting-pen, the receiving-pen is thus caused to substantially follow any movement of the transmitting-pen, and thus reproduce a substantial fac-simile of whatever is written or traced by the latter. The use of the escapement accurately defines the length of each step of the receiving-instrument, and, in connection with the equality in radial distance between the pens and the pivotal points of the cords and arms at the transmitting and receiving stations, respectively, which I now secure, insures the substantially accurate reproduction at the receiving-station of the writing of the sender.

The mechanism for causing the receiving-pen to be raised and lowered in accordance with the position of the transmitting-pen will now be described.

A temporary circuit-breaker consisting of two magnet-spools M N, constructed in a manner and having connections in all respects similar to those above described, constituting the increase-controllers D E and D' E', is provided as a part of the transmitting-instrument. The transmitting-pen in writing rests upon a platen 117, (see Fig. 2,) which in turn rests upon a spring-supported plate 118, which in its normal position rests against a contact-point 120, but when depressed by the pressure of the transmitting-pen in writing swings on a pivot and meets contact-point 119. (See

Figs. 2 and 17.) A circuit  $m$  connects the support 118 with local battery  $n$  and armature 121, placed between the two coils  $M$   $N$  of the temporary circuit-breaker. Thence the circuit divides and returns on the one side through wires  $m'$  and the coil of magnet  $M$  to stop 120, and on the other side through wires  $m''$  and the coil of magnet  $N$  to stop 119. The armature 121 vibrates between contact-stops 122 and 123, and a shunt-wire  $o$  connects stop 122 with the wire  $m'$  around the coil of magnet  $M$ , and a shunt  $o'$  connects stop 123 with wire  $m''$  around the coil  $N$ . Main line  $b$ , after leaving the increase-controller  $D$   $E$ , passes through the armature 126 of coil  $M$  and its contact-stop 125. Main line  $c$ , after leaving the increase-controller  $D'$   $E'$ , passes through contact-stop 127 and armature 126 of magnet  $N$ . The weight of the transmitting-pen in writing a message depresses the support 118 against contact 119, closes the circuit  $m$   $m''$  through the magnet  $N$ , and attracts the armature 126, causing a break in main-line circuit  $c$ . This break is only momentary, since the armature 121 is simultaneously attracted to the magnet  $N$  and the shunt around the coils of this magnet through wire  $o'$  is closed. The armature 126 returns to its back stop 127 and the main-line circuit  $c$  is again closed. When the transmitting-pen is raised from the paper, support 118 rises, the circuit  $m$   $m'$  is closed through coil  $M$ , and the main-line circuit  $b$  is momentarily broken in like manner. The effect of these breaks at the receiving end of the line will presently be stated. First, however, the devices for raising and lowering the receiving-pen will be described.

The receiving-pen is raised and lowered by means of two magnets  $S$   $T$ , placed preferably one above the other, and a local battery  $y$ . (See Figs. 2 and 17<sup>a</sup>.) The armature 129, which carries the pen-rest 130, is located between the two magnets  $S$   $T$  and is operated upon by both of them. This armature is held in such position as it is left by the attraction of one or the other of the magnets by means of friction-springs 43, the spring 131 serving merely to balance the weight of the pen-rest and armature. The circuit of magnet  $S$  passes through wires  $s$ , coils  $v$  of paper-shifting magnet  $V$ , a section of local battery  $y$ , armature 133 of a relay  $P$  in the main-line circuit  $b$ , and its back-stop 134. The circuit of magnet  $T$  passes through wires  $t$ , (some of these wires, being common to circuits  $t$  and  $s$ , are marked with both letters, and other local circuits having wires in common are lettered in the drawings in the same manner,) coils  $v'$  of paper-shifting magnet  $V$ , thence by wire  $s$  to local battery  $y$ , thence by wires  $t$  to armature 132 of a relay  $P'$  in main-line circuit  $c$ , its back-stop 128, and wire  $t$  to magnet  $T$ . The momentary break in the main circuit  $c$  caused by the pressure of the transmitting-pen upon the writing-platen 117 and the consequent operation of the temporary circuit-breaker  $M$   $N$  by reason of the energization of

coil  $N$  causes the relay  $P'$  at the receiving end to release its armature, which falls upon its back point and closes the circuit through wires and pen-lowering magnet  $T$ , causing the armature 129 and the pen-rest 130, carried by it, to be depressed and the pen  $G$  to descend to its writing position upon the paper. The armature will be held in this position by the friction-springs 43, and the pen will continue upon the paper until the sender raises the transmitting-pen and removes the pressure from the platen 117. The support 118 will then rise, closing the circuit of coil  $M$  of temporary circuit-breaker  $M$   $N$  through wires  $m$   $m'$  and making a temporary break in the main-line circuit  $b$ . This temporary break results in releasing the armature of the relay  $P$  at the receiving end, which falls upon its back-stop 134 and closes the circuit of magnet  $S$  through wires  $s$  and a section of battery  $y$ . The armature 129 and pen-rest 130 are now raised, lifting the pen  $G$  from the paper, and these parts remain in this position through the pressure of springs 43 until the transmitting-pen is again placed upon the paper.

While these operations are in progress the paper-shifting magnet  $V$  is inactive, although both the circuits  $s$   $t$  pass through certain of its coils. This inactivity results from the fact that the magnet  $V$  is of the peculiar construction known as a "consequent pole-magnet." It is made up of two soft-iron rods of any convenient length 135 136, (see Figs. 2 and 3,) and upon the ends of these rods are wound helices of the usual construction, spaces being left at the centers of the two rods between the helices of sufficient width to receive an ordinary armature. At these points it is convenient to place pole-pieces 137 138, which extend outward beyond the contour of the coils in such position as to conveniently act upon an armature 139, trunnioned in the ordinary manner. The soft-iron rods 135 136 are united at their ends by soft-iron heel-pieces 151 152, so that there is a continuous ring of iron. When only one of the two sets of coils  $v$   $v'$  are in circuit, the magnetic circuit of the magnet  $V$  is closed through the heel-iron opposite to the excited coils, and no magnetism of consequence is developed in the points 137 138. It results that when either of the circuits  $s$   $t$  are separately closed sufficient magnetism is not developed in magnet  $V$  to cause it to attract its armature. When, however, both of these sets of coils  $v$   $v'$  are simultaneously energized by a current flowing in opposite directions, polarity will be developed in the points 137 138 and the armature 139 will be attracted. The connections of circuits  $s$   $t$  are such that the current of battery  $y$  flows through the two sets of coils  $v$   $v'$  in opposite directions when these circuits are closed, so that it is only necessary, in order to cause the magnet  $V$  to become active, to simultaneously close these two local circuits. The armature 139 has a play limited by stops

140 141, depending from the frame-work of the table, and carries a toe 142, which serves as the trigger of an escapement controlling the revolution of the paper-drum 143. The paper passes from the drum 143 over the transmitting-platen 117 and the receiving-platen 144 and then down, friction-rollers 145 being preferably provided to facilitate its movement and is given a forward tendency by the weighted clip 195 or an equivalent tension device. The escapement controlling the paper-drum consists of a cog-gearing 146, attached to the drum or drum-shaft meshing with a small pinion 147, the shaft 196 of which is provided with two arms 148 149, the ends of these arms revolving in the plane of the toe 142. When the toe 142 is in its normal position, it will arrest the revolution of one of the arms 148 149, and thus prevent the unwinding of the paper; but the temporary action of the magnet V upon its armature 139 withdraws the toe 142 and permits the paper-drum to revolve until the pinion 147 has made a half-revolution. The arm carried upon the opposite side of the pinion then comes in contact with the toe 142, which has meanwhile returned to its normal position. This escapement is so adjusted that this amount of rotation of drum 143 is sufficient to move the paper a distance equal to the space properly left between two lines of writing. The means provided at the transmitter for causing the simultaneous closing of the two local circuits *s t* at the receiving end consists of two circuit makers and breakers located near the upper left-hand corner of the field of the transmitting-pen. (See Figs. 1, 6, 7, and 17.) These circuit makers and breakers consist of springs 153 154, attached to a vertical shaft 155, journaled between a plate 156 set over an opening in the table and a bracket 157 depending from the table, these springs playing upon contact-points 158 159. To the upper end of the shaft 155 is attached an arm 160, which is drawn forward by a spring 161 until it rests against a stop 162, in which position the notch 163 formed in its outer end is just below an opening 164 in the plate 156, so that it can be readily reached by the part of the transmitting-pen just above the nib. The main circuit *b*, after leaving the temporary circuit-breaker M N, passes to spring 153, contact 158, and thence to the receiving-instrument. Main circuit *c*, after leaving the temporary circuit-breaker M N, passes to spring 154, contact 159, and thence to the receiving-instrument. It results that when the transmitting operator, having completed a line, desires to shift the paper he has only to carry his pen to the upper left-hand corner of its field and cause its nib to enter the slot 164 and press against the arm 160, operating the circuit-breaking springs 153 154 and making a simultaneous break in both the main-line circuits *b c*. The two main-line relays P P' at the receiving-station simultaneously drop back, their armatures and circuits *s t* are closed, both sets of coils *v v'* are energized, and mag-

net V attracts its armature, releasing the paper-drum escapement and permitting the paper to feed. This operation does not disturb the position of the receiving-pen, which is now resting upon the pen-rest 130, for the reason that both the magnets S and T, being simultaneously energized, will balance each other in their effect upon the armature 129, and the pen-rest will not be moved.

It is obvious that to enable the receiving-instrument to reproduce characters traced by the transmitting-pen the direction of motion of the receiving-pen must accord with that of the transmitting-pen, and to secure an exact reproduction it is necessary that the length of the cords connecting the transmitting-pen with the hinging-points on the interrupter-drums should be exactly equal to the lengths of the corresponding pen-arms of the receiving-instrument; or, in other words, in order to secure perfect results it is necessary to start the two instruments in unison and keep them in that relative condition. I have devised a mechanism for bringing the transmitting and receiving instruments into unison when they are not so, and will now describe it and its operation.

Armature 139 of the paper-shifting magnet controls three local circuits which have not yet been noticed. One of these circuits *u* (see Figs. 11 and 17<sup>a</sup>) includes the two polarizing-coils K K' of the governing escapement-magnets, local battery *u'*, back-stop 165, and armature 139. Another circuit *x'* includes the coils of magnet J', local battery *z'*, a brush 166', which I term a "unison-brush," and which bears upon commutator-disk 112, contact-spring 39, armature 139, contact-spring 167, and stop 168. A like circuit (see Fig. 17<sup>a</sup>) *x* includes unison-brush 166 and other parts exactly similar to those above described connected with magnet J, armature 139, spring 170, carried by armature 139, and stop 171. When the transmitting-pen is carried against the switch-arm 160, the springs 153 154 leave their contacts and break both the main lines *b c*, which causes the paper-shifter armature to move to its forward stop, as heretofore stated. As the armature 139 leaves its back-stop the circuit *u* is broken, which depolarizes the escapement polarizing-magnets H H'. No action now takes place except to shift the paper unless the receiving-instrument is out of unison with the transmitting-instrument. The unison-brush 166' is so placed that in case there is a want of unison in the reversing-clutch organization of the left-hand side of the receiver it will be in contact with one of the metallic segments of the commutator upon which it bears, causing a current to flow from battery *z'* through the circuit *x'* and coils of magnet J'. This operates the reversing-escapement one step and brings the unison-brush again upon an insulating-segment of the commutator, which should be its position at the shifting of the paper. In case there is a want of unison in the reversing-

clutch organization of the right-hand side of the receiver it will be corrected in a similar manner through circuit  $x$ , brush 166, magnet J, and the connected parts. The circuits of both the polarizing-magnets K K' being now broken and the main-line circuits being also both broken, and the clutch-magnets of both halves of the system being so set as to carry the receiving-pen toward the upper left-hand corner of the field, it will be seen that the two governing-escapements, having nothing to retard them, the receiving-pen, if behind the transmitting pen, will be permitted to run without hinderance to the left-hand upper corner of its field, where it will be stopped by pins properly placed upon gear-wheels 28 29, said pins being arranged to come in contact with fixed stops. If prior to the shifting of the paper the receiving-pen was in advance of the transmitting-pen, it will have been checked by these stops and the transmitting-pen will have overtaken it at the paper-shifting switch. Complete provision is therefore made for securing unison between the two pens.

After the paper has been shifted and the transmitting and receiving instruments have been brought to unison, the transmitting-pen is withdrawn from the switch-lever 160 and the writing of the next line proceeds. The effect of the withdrawal of the pen is, of course, to reverse the positions of the circuit making and breaking arms 86, closing the circuits  $d$  of the increase-controllers D E and D' E'. If, however, these circuits are closed while the main-line circuits are still open, no increased pulsation will be sent to line and the receiving-instrument will not be reversed. To provide against such an occurrence a circuit making and breaking arm 15 is provided, rigidly fixed to the shaft 155 and playing between contact-points 18 19, (see Figs. 1, 6, 7, and 17,) and the circuit  $d$  of both the increase-controllers D E and D' E' is caused to pass through the arm 15, contact-point 19, and wires  $l l'$ , connected therewith, as heretofore stated. Consequently neither of these circuits can be completed while the lever 15 is out of contact with the stop 19. Arm 15 is so placed on shaft 155 that as the transmitting-pen is drawn away from the lever 160 and that lever returns to its position springs 153 154 strike their respective contact-points and close the main circuits  $b c$  before the arm 15 reaches its contact 19. The circuits  $d$  therefore cannot be closed until after the closing of main-line circuits  $b c$ , even if arms 86 are actuated while the main-line circuits are still open. As soon as the arm 15 reaches its stop 19, which will be immediately after the closing of the main circuits  $b c$ , both increase-controllers will simultaneously operate to send a strong impulse through both main lines, causing a reversal to take place in both the reversing-escapements at the receiving end and setting the clutches in proper manner to cause the receiving-pen to follow the motion of the transmitting-pen.

The provision for shifting the paper at the transmitting-instrument consists (see Fig. 17) of proper circuit connections, by means of wires  $r r'$ , from contact-points 18 and 181 and spring-extension 182, attached to arm 15, to the two paper-shifting and pen-raising circuits  $s t$  at the transmitting-station, whereby these circuits are closed by the rocking of the switch-lever 160 and arm 15 at the completion of a line of writing. Connections for this purpose are shown in broken lines, Fig. 2. The paper is thus simultaneously shifted at the transmitting and receiving stations.

Provision for shifting the paper at the transmitting-station independently of the receiving-station is also made, and consists of a push-button 20, so placed that when depressed it electrically connects contact-stops 18 and 181. When the operator has completed the sending of his message and placed his pen in the rack, he presses button 20 a sufficient number of times to move his paper forward, so that clean paper is brought under his receiving-pen; and by the connections just described he accomplishes this without disturbing the connections which control the paper at the distant station.

I will now describe an improved pen-rack for holding the transmitting-pen when not in use, which forms a part of my present invention and is illustrated in Figs. 8, 9, and 10. This rack consists of a tube 51, supported between two posts 52 52'. At the center of the tube is fixed a collar 172, to which is rigidly fixed a curved projecting jaw 54, and to which is pivoted another projecting jaw 53. The jaw 53 projects into as well as out of the tube, and to its inner end is pivoted a rod 55, extending centrally through the tube 51 to one of the posts, (52,) and carrying on its end an upright rod 173, which extends down through and below the post 52 and carries at its lower end a block of insulating material 57. Wrapped loosely around the rod 55 is a spiral spring 56, of considerable strength, fastened at each end to washers 61 62, washer 61 being fastened to the tube 51 and washer 62 being attached to the rod 55. The insulating-block 57 has set in it two contact-springs 174 175, which are respectively connected to line-wires  $b$  and  $c$ . Four contact-stops 176 177 178 179 are provided, with one pair of which (176 and 177) are connected the wires in circuits  $b c$ , respectively, passing to the transmitting-instrument at the home station, and with the remaining pair of which (178 179) are attached the wires  $b c$ , passing to the receiving-instrument at the home station. The jaws 53 54 are so shaped as to form between them a recess adapted to hold the nib of the pen and retain it in a fixed, preferably an upright, position. These jaws also preferably flare outward to permit the pen to be forced between them into the recess. The effect of introducing the pen into the recess is to swing the jaw 53 on its pivot and draw the rod 55 against the tension of the spring 56 to the left, causing the springs 174 175,

(see Fig. 10,) which when the pen is being used for transmitting rest against the contact-points 176 177, to leave those contact-points and be pressed against the contact-points 178 179, the result being to break the connection of the line-wires with the transmitting-instrument and place them in connection with the receiving-instrument. The operator, when he has finished using the transmitting-pen, will place it in the rack, and will thereby swing the system from the condition in which it is fitted to send messages to that in which it is fitted to receive messages, and the upright position of the pen in the rack will indicate at a glance that the system is set for receiving a message, and afford a check against carelessness on the part of the operator. The function of this pen-rack is therefore the same, substantially, as that of the rack described in my former patents. It is, however, superior to that rack in point of simplicity, and in that it gives the pen a position immediately over the field and holds it in a more conspicuous manner and a more convenient position. When the pen is taken from the rack for the purpose of transmitting a message, the action of the spring 56 automatically returns the contact-springs 174 175 to their position in contact with the contacts 176 177 and completes the circuit for transmitting.

It will be observed that with this organization when the transmitting-pens at both ends of the line-wire are hung up both of the stronger line-batteries  $Z Z'$  will be cut out and only the two small batteries  $z z'$  will be on line, and these batteries being opposed in polarity will neutralize each other and the condition of the line will be equivalent to that of having no battery in circuit. The main-line relays, therefore, at both ends of the line will rest on their back points. I take advantage of this fact to control the operation of the motor in the following manner: The motor is normally in circuit through the wire  $W$  with the whole of battery  $y$ , only a section of this battery being required to operate the magnets  $S, T$ , and  $V$ . Circuit  $W$  is provided with a circuit maker and breaker consisting of a spring 197 riding upon a block 198, partly of metallic and partly of insulating material. The motor-circuit has two branch circuits  $w w'$ , one of which ( $w$ ) includes the armature and front stop of relay  $P$ , and the other of which ( $w'$ ) includes the armature and front stop of relay  $P'$ .

Both of the circuits  $w w'$  pass through an ordinary single spool-magnet  $L$ , having an armature-lever 199 trunnioned upon double pivots so as to move to and from the magnet and also sidewise in either direction, as shown in Fig. 11<sup>a</sup>. The magnet  $L$  and its armature 199 are so placed with reference to one of the shafts 30 that a pin 200, fixed to the outer end of the armature, will engage when the armature is released by its magnet with a screw 201, carried by the shaft. The arma-

ture 199 is drawn back from its magnet by a spring 202 in the ordinary manner, and is also provided with a side stop 203, against which it is normally held by a spring 204, this spring 204 putting a strain upon the armature-lever 199 in a direction opposite to the direction in which it is carried by the engagement of the screw 201 with the pin 200. The contact-spring 197 is attached to the armature 199 and rides upon the metallic portion of the block 198 when the armature 199 is against the side stop 203, and the width of this metallic portion of the block 198 is such that the spring 197 will continue to rest upon it as it is moved away from the stop 203 during the time occupied by a number of revolutions of the shaft 30.

The resistance of the magnet  $L$  is made such with reference to that of the motor that it will take sufficient current when the motor is in circuit to energize it and cause it to attract its armature. When therefore either of the relays  $P$  or  $P'$  is energized and its armature rests upon its front contact, the magnet  $L$  will be energized, the pin 200 on its armature will be held out of engagement with the screw 201, and the spring 204 will hold it in contact with the stop 203, the spring 197 will rest upon the metallic portion of the block 198, and the circuit of the motor will be closed. If, however, both of the relays  $P P'$  are de-energized and both of the circuits  $w w'$  in consequence thereof are broken, the magnet  $L$  will release its armature, pin 200 will engage with screw 201 and be carried away from the stop 203 against the tension of the spring 204 as the shaft 30 rotates, so that if the break in the two main-line circuits continues long enough the spring 197 will be carried out of contact with the metallic portion of the block 198, and the motor-circuit will be broken, causing the motor to stop. It results that when there is an effective current on either of the main lines  $b c$  the circuit of the battery  $y$  will be closed through the motor; but when there is an effective current in neither main-line circuit the motor-circuit will be broken and the motor will stop after a few revolutions of the shaft 30. The spring 197 is so adjusted with reference to the metallic portion of the block 198 that the circuit of the motor will not be broken in bringing the transmitting and receiving pens to unison under ordinary circumstances, or, in other words, unison will be reached before the spring 199 is carried off from the metallic portion of the block 198.

It follows from this construction that when the transmitting-pen is placed in the rack the relays of the distant receiver will both be de-energized and the motor at this distant station will be brought to rest after a few revolutions of its shaft 30, and that when both transmitting-pens are placed in their racks, there being no effective current on line, both motors will come to rest. If now one of the transmitting-pens is taken from its rack, it

will cut out the relays at the transmitting end through the agency of the pen-rack switch, and at the same time by throwing the current upon the main line it will close the relays at the distant end and start up the motor, which will remain in operation until the message is completed and the pen again hung up. This organization gives the transmitting operator the full control of the motor, as well as of all of the rest of the machinery at the receiving end.

Modifications may be made in most of the details of the system and still it will contain my invention. A few of the more general modifications which may be made will be referred to.

While I prefer to operate the governing reversible escapement-magnet by pulsations of successively opposite polarity, I do not confine myself to a system in which such pulsations are used. I have secured good results by merely making and breaking the line-circuit, as in the system described in my former patents, these impulses of like polarity operating a governing-escapement magnet.

It is not essential that two line-batteries of unequal strength be employed, as the alternately positive and negative pulsations may be sent from the transmitting station by means of a pole-changer operated and controlled by the interrupters or in any other suitable manner.

While I prefer an electric motor as a source of power for driving the receiving-pen, in that it is more readily controlled from the transmitting-station than other forms of prime motors, I do not limit myself to the use of such a motor, but may employ in its stead any convenient type of mechanical motor or a shaft rotated from any appropriate source of power. Under the term "motor" I intend to include any and every device from which power may be derived.

It is to be understood that in this application, as in my former patents, the terms "character," "writing," and "message," as herein used, include any matter, such as pictures, maps, drawings, diagrams, and arbitrary characters of all kinds, as well as ordinary and short-hand writing; also, that the term "paper" includes any surface suitable for writing or from which any writing or printing is to be traced. If in addition to transmitting messages in writing it should be desired to capacitate the mechanism to transmit and reproduce diagrams, maps, and pictures, all that is necessary is to allow the transmitting and receiving pens to have the necessary range of movement in each direction.

In some cases it may be preferred to write the message in the form of a single line extending along the length of a narrow ribbon of paper, as suggested in my former patents, and in such cases it will only be necessary to arrange the mechanism for shifting the paper

in the direction of a line of writing instead of in a direction perpendicular thereto.

The receiving-pen may in some cases consist of a simple pencil or tracer and the ink-supplying apparatus be dispensed with.

The closing and breaking of the local circuits for lowering and raising the receiving-pen may be effected by a special key instead of by the transmitting-pen or by a circuit-closer arranged and operated in any suitable manner.

The paper, instead of being shifted by a weight controlled by an escapement, may be shifted in any other desired manner, as by separate circuits for this purpose, or the means for shifting the paper or raising the pen, or both, may be omitted.

Separate line-wires may be employed for operating the reversing-clutches instead of using an increased current for that purpose; or other changes in the current besides an increase thereof may be resorted to for this purpose.

Also, as stated in my prior Letters Patent, the movements necessary to reproduce the message, instead of being imparted to the receiving-pen, may be wholly or in part imparted to the paper. It is therefore to be understood that whenever the movement of the receiving-pen is referred to as forming the characters that also includes the equivalent movement of the paper, and that for the purposes of this specification a recording-surface movable for the purpose of forming characters is the equivalent of a movable pen.

If preferred, two motors may be used for operating the receiving-pen, governed by pulsations transmitted over the two circuits, respectively.

No particular form of interrupter is essential in my invention. I intend to include under that term every device by means of which electric pulsations, whether successively of the same or opposite polarity, may be rapidly produced in the circuit.

I do not confine myself to the particular form of reversing mechanism shown herein, meaning to include under that term all forms of mechanism adapted for the purpose. So, too, I mean to include under the term "gear" or "train of gearing" all forms of suitable mechanism adapted to continuously transmit power.

I contemplate the use of each of the several foregoing improvements separately, as well as in conjunction with each other. Thus, for instance, I intend to protect herein the feature of my invention which consists in employing pulsations of successively opposite polarity, whether those pulsations energize the motor-magnets of the receiving-pen directly, as in the organization shown in my said former patents, or whether they operate the receiving-pen by restraining or regulating the force which moves it, as in the organization shown herein meaning to include both

varieties of receiving-instruments when I speak of a motor governed in the application of its power to the receiving-pen by said pulsations; and so of my other several improvements.

I do not herein claim the methods and processes hereinbefore described, as they are claimed in my other applications, Serial Nos. 318,091 and 324,232.

I do not limit myself in any of my claims to the same construction of apparatus as that herein shown and described; but under the terms "means," "mechanism," and similar expressions I intend to include all other devices whatsoever capable of being substituted for the structures or elements thereof claimed.

Having thus described my invention, what I claim is—

1. The combination, with a transmitting-pen, of an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor giving movement to the receiving-pen and caused to operate thereon through said pulsations, a reversing mechanism between the motor and the receiving-pen, whereby the direction of movement of the latter may be reversed, magnetically-controlled clutches controlling the reversing mechanism, a current-controller at the transmitting-station for causing a temporary change in the line-current upon each reversal of the direction of motion of the transmitting-pen, and circuit connections whereby such temporary change in the line-current operates upon the magnetically-controlled clutches to cause the direction of movement of the receiving-pen to be reversed, substantially as set forth.

2. The combination, with a transmitting-pen, of an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor giving movement to the receiving-pen and controlled in the application of its power to the receiving-pen by said pulsations, a reversing mechanism between the motor and the receiving-pen, whereby the direction of movement of the latter may be reversed, magnetically-controlled clutches controlling the reversing mechanism, a magnet in line-current controlling the clutches, and a current-controller at the transmitting-station for sending to line currents of increased strength upon each reversal of the direction of motion of the transmitting-pen, and thereby operating the last-named magnet to control the action of the clutches and cause the direction of movement of the receiving-pen to be reversed, substantially as set forth.

3. The combination, with a transmitting-pen, of an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor giving movement to the receiving-pen and controlled in the application of its power to the receiving-pen by said pulsations, a reversing mechanism between the motor and

the receiving-pen, whereby the direction of the movement of the latter may be reversed, clutch-magnets connected with the reversing mechanism and provided with electric connections, a commutator or other suitable circuit-controller for controlling the energization of the clutch-magnets, a magnet controlling the position of the commutator or other circuit-controller, and means for electrically controlling the last-named magnet from the transmitting-station, and thereby operating the reversing mechanism at the receiving-station upon a change of the direction of motion of the transmitting-pen, substantially as set forth.

4. The combination of a transmitting-pen, an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor for moving the receiving-pen and caused to operate thereon through said pulsations, a train of gearing connecting the motor with the receiving-pen, a part of said train consisting of a magnetically-controlled clutch, and electrical connections with the transmitting-station controlling said clutch, substantially as set forth.

5. The combination of a transmitting-pen, an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor for moving the receiving-pen and caused to operate thereon through said pulsations, a train of gearing connecting the motor with the receiving-pen, a reversing mechanism constituting a part of said train of gearing, and electrical connections with the transmitting-station controlling the reversing mechanism, substantially as set forth.

6. The combination of a transmitting-pen, an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor for moving the receiving-pen and caused to operate thereon through said pulsations, a train of gearing connecting the motor with the receiving-pen, two electrically-controlled clutches constituting parts of said train of gearing, and electrical connections with the transmitting-station, whereby one or the other of said clutches is brought into operation according to the direction of motion required to be given to the receiving-pen, substantially as set forth.

7. The combination, in a telautograph system, of a receiving-pen, a motor for giving movement to the same, a reversible escapement controlled from the transmitting-station, whereby the application of the power of the motor to the receiving-pen is governed, reversing mechanism between the motor and the escapement, consisting of two reversely-acting gear-wheels provided with portions capable of magnetic attraction, and two magnets rotated by the motor, the magnetic portions of the gear-wheels acting as armatures for the two magnets, respectively, and elec-

trical connections controlled from the transmitting-station, whereby one or the other of these magnets may be energized at the will of the transmitting operator to grip its gear-wheel, substantially as set forth.

8. The combination of a motor, a telautographic receiving-pen, an escapement for governing the application of the power of the motor to the telautographic receiving-pen, an electro-magnetic frictional clutch constituting a part of the train of gear between the motor and the escapement, and electrical connections for operating the clutch, as required, to cause the motor to operate the telautographic receiving-pen, substantially as set forth.

9. The combination of a motor, a driven mechanism, an escapement for governing the application of the power of the motor to the driven mechanism, a power-transmitting device intermediate between the motor and the escapement, consisting in part of a magnetically-controlled frictional clutch, one part of said clutch being moved by the motor and the other intermediate between the motor and the escapement, and electrical connections whereby the magnetizable portions of said clutch may be excited in a determinate degree, whereby power is transmitted by the friction of its surfaces sufficient to drive the driven mechanism, but insufficient to overcome the restraining action of the escapement, substantially as set forth.

10. The combination, with a transmitting-pen, of an electric circuit, an interrupter operated through said pen for producing pulsations in the circuit, a receiving-pen, a motor giving movement to the receiving-pen and governed in the application of its power to the receiving-pen through said pulsations, an electrically-controlled frictional clutch constituting a part of the train of gear between the motor and the receiving-pen, one of the parts of said clutch being moved by the motor, and electrical connections operated from the transmitting-station, whereby the magnetization of the excitable portions of the clutch, and consequently the transmission of power therethrough, is controlled by the transmitting operator, substantially as set forth.

11. The combination, with a transmitting-pen, of an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor for giving movement thereto, an escapement controlling the application of the power of the motor to the receiving-pen and in turn controlled by said pulsations, a train of gearing connecting the motor with the receiving-pen and having as a part thereof two electro-magnetic frictional clutches, together constituting a reversing mechanism, and electric connections with the transmitting-station, whereby one or the other of said clutches is energized as one or the other direction of motion of the receiving-pen is desired, the degree of energization of the clutches being

such that power is transmitted through the frictional contact of their surfaces sufficient to drive the receiving-pen, but insufficient to overcome the restraining action of the escapement, substantially as set forth.

12. The combination, with a transmitting-pen, of an electric circuit, an interrupter operated through said pen for producing pulsations in the circuit, a receiving-pen, a motor for giving movement to the receiving-pen and governed in the application of its power to the receiving-pen through said pulsations, a reversing mechanism situated between the motor and the receiving-pen, consisting in part of two electro-magnetic frictional clutches, electrical connections, and a commutator or other suitable circuit-controller whereby one or the other of the said clutches may be operated, a magnet controlling the position of the commutator or other circuit-controller, and electrical connections with the transmitting-station, whereby the transmitting operator may operate the last-named magnet, and thereby control the direction of motion transmitted from the motor to the receiving-pen, substantially as set forth.

13. The combination of a commutator-disk, an escapement by which the position of the disk is controlled, a magnet controlling the escapement through its armature and contact, a spring through which an electric current passes to the commutator, said spring being attached to the armature of the escapement-magnet, whereby the change of current controlled by the commutator is effected immediately upon the movement of the armature, substantially as and for the purposes set forth.

14. The combination, in a telautograph system, of a transmitting-pen, a line-circuit, a receiving-pen, a motor for giving motion to the receiving-pen, an interrupter operated through the transmitting-pen for sending pulsations over the circuit, whereby the application of the power of the motor to the receiving-pen is governed, a reversing mechanism between the motor and the receiving-pen, two magnets and electrical connections for controlling said reversing mechanism, a commutator whereby one or the other of said magnets is caused to be energized according to the direction of rotation desired, a magnet governing said commutator, a unison-brush bearing upon the commutator and forming a part of a local circuit which includes the commutator-magnet, and electrical connections having a circuit maker and breaker at the transmitting-station, whereby the transmitting operator can close the unison-circuit, and thereby operate the commutator-magnet if the two pens are out of unison as to direction of motion, substantially as set forth.

15. In a telautograph system, the combination, with a receiving-pen, of a recording-surface, a feeding mechanism for shifting the recording-surface, an electro-magnet controlling said feeding mechanism, a motor for

giving motion to the receiving-pen, an electrically-controlled reversing mechanism between the motor and the receiving-pen, and a unison-circuit for shifting the position of said reversing mechanism when the receiving-pen is out of unison with the transmitting-pen as regards direction of motion, said unison-circuit being controlled by the armature of the magnet for shifting the recording-surface, whereby the shifting of the paper and the bringing of the receiver into unison with the transmitter are simultaneously effected, substantially as set forth.

16. The combination, with a transmitting-pen, of a receiving-pen, an electric circuit, an interrupter operated through the transmitting-pen for producing pulsations in the circuit, a motor for giving movement to the receiving-pen, an escapement governing the application of the power of the motor to the receiving-pen and controlled by said pulsations, a polarized electro-magnet governing the escapement and operated by said pulsations, a magnetically-controlled reversing mechanism between the motor and the receiving-pen, a unison-circuit and connections for causing the position of the reversing mechanism to be shifted, and means operated from the transmitting-station for actuating the unison-circuit connections and depolarizing said escapement-magnet, thereby bringing the transmitting and receiving pens into unison as regards direction of motion and permitting the receiving-pen to run without restraint and overtake the transmitting-pen if behind it, substantially as set forth.

17. The combination of a receiving-pen, mechanism for reversing its direction of movement, a magnet, as  $J'$ , for controlling the reversing mechanism, a local circuit, as  $x'$ , for operating the magnet  $J'$  when the receiving-pen is out of unison, and connections with the transmitting-station for controlling the circuit  $x'$ , substantially as set forth.

18. The combination of a receiving-pen, power mechanism for moving the same, controlled by a magnet, as  $H'$ , mechanism for reversing the direction of movement of the receiving-pen, controlled by a magnet, as  $J'$ , local circuits, as  $u$   $x'$ , for acting upon the magnets  $H'$   $J'$ , respectively, when the receiving-pen is out of unison, and connections with the transmitting-station for controlling said local circuits, substantially as set forth.

19. In a telautograph system, the combination of a main-line wire, two magnets, each provided with an armature, each of said armatures when on its front or back stop forming a part of a path for the main-line circuit, a third armature so placed as to be acted upon alternately by the said two magnets, circuit connections between the coils of each magnet and a local battery, and shunt or short circuits from the said third armature passing once around the coils of each magnet and closed by the attraction of the third armature to that magnet, whereby the alternate

energization of the magnets causes momentary changes in the line-circuit, substantially as set forth.

20. An apparatus for effecting a momentary change in one or more circuits, consisting of two magnets, each provided with an armature which, with a contact-stop, constitutes a circuit-changer, a third armature operated upon by each of the two magnets alternately, a circuit connecting the coils of each of the magnets with a battery, and two shunt or short circuits, one around the coils of each of the magnets, the shunt around each magnet being closed upon the attraction of said third armature to that magnet, substantially as set forth.

21. As a means for controlling the reversal of motion of a receiving-pen to correspond with reversals in direction of movement of the transmitting-pen, a commutator controlling the circuits of the reversing-magnets and having a tendency to move, and mechanism controlled from the transmitting-station holding the commutator in restraint as against said tendency and permitting it to move in correspondence with reversals in direction of movement of the transmitting-pen, substantially as set forth.

22. As a means for controlling the reversal of motion of a receiving-pen to correspond with reversals in direction of movement of the transmitting-pen, a commutator controlling the circuits of the reversing-magnet and having a tendency to move, an escapement holding the commutator in restraint as against said tendency, and a magnet controlling the escapement and itself electrically controlled from the transmitting-station to permit the commutator to move step by step and thus select between the circuits of the reversing mechanism, substantially as set forth.

23. The combination, with a transmitting-pen, of an electric circuit, means operated through said pen for producing pulsations in the circuit, a receiving-pen, a motor giving movement to the receiving-pen governed through said pulsations, a circuit for the motor independent of the line-circuit, a circuit maker and breaker in said circuit, connections between the circuit maker and breaker and a normally-moving part of the apparatus, and an electro-magnet controlling said connections, whereby cessation of the pulsations on the line-circuit causes operative connection to be effected between the circuit maker and breaker in the motor-circuit and said moving part of the apparatus, thereby presently breaking the motor-circuit and bringing the motor to rest, substantially as set forth.

24. The combination, with a transmitting-pen, of an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor for driving the same, and a polarized escapement-magnet for governing the application of the power of the motor to the receiv-

ing-pen in accordance with said pulsations, and means controlled from the transmitting-station for depolarizing the escapement-magnet for the purpose of permitting the pen-driving mechanism at the receiving-station to run to unison with the transmitting mechanism, substantially as set forth.

25. The combination of a transmitting-pen, an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor for giving movement to the receiving-pen and caused to operate thereon through said pulsations, a reversing mechanism between the motor and the receiving-pen, and electrical connections for shifting the position of the reversing mechanism when the receiving-pen is out of unison with the transmitting-pen as regards direction of motion, substantially as set forth.

26. The combination of a transmitting-pen, an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor for giving movement to the receiving-pen, an escapement for controlling the motor, said escapement being controlled through said pulsations, a reversing mechanism between the motor and the receiving-pen, electrical connections for shifting the position of the reversing mechanism when the receiving-pen is out of unison with the transmitting-pen as regards direction of motion, and means for suspending the operative engagement of the escapement to permit the receiving-pen to run to unison with the transmitting-pen, substantially as set forth.

27. The combination of a transmitting-pen, an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor for giving movement to the receiving-pen and caused to operate thereon through said pulsations, a reversing mechanism between the motor and the receiving-pen, and means for producing a temporary change in the condition of the current upon the said circuit upon each reversal of the direction of movement of the transmitting-pen, whereby the reversing mechanism is operated to reverse the direction of movement of the receiving-pen, substantially as set forth.

28. The combination of a transmitting-pen, an electric circuit, an interrupter operated through said pen and producing pulsations of successively-opposite polarity in said circuit, a receiving-pen, a motor for giving movement to the receiving-pen and caused to operate thereon through said pulsations, a reversing mechanism between the motor and the receiving-pen, and means for producing a temporary change in the condition of the current upon the said circuit upon each reversal of the direction of movement of the transmitting-pen, whereby the reversing mechanism is operated to reverse the direc-

tion of movement of the receiving-pen, substantially as set forth.

29. The combination of a transmitting-pen, an electric circuit, an interrupter operated through said pen and producing pulsations in said circuit, a receiving-pen, a motor giving movement to the receiving-pen and caused to operate thereon through said pulsations, a magnetically-controlled clutch controlling the connection of the motor with the receiving-pen, and means for producing temporary changes in the current traversing said circuit, whereby the action of the clutch is controlled from the transmitting-station, substantially as set forth.

30. In a telautographic system, the combination of a transmitting-instrument and a receiving-instrument located at the same station, a single recording-surface serving for the pens of both instruments, a feeding mechanism for shifting the recording-surface, connections whereby the transmitting operator may operate the feeding mechanism to shift the recording-surface at the distant station and at the home station simultaneously, and independent connections whereby he may shift the recording-surface at the home station alone, substantially as set forth.

31. The combination of the two main circuits *b c*, connections whereby temporary changes are produced in said circuits upon reversals in direction of movement of the transmitting-pen, a circuit-controller for simultaneously breaking the circuits *b c*, and a circuit-controller, as 15, for preventing the occurrence of said temporary change while said circuits are open, substantially as set forth.

32. The combination, with a transmitting-pen, of an electric circuit, means operated through said pen for producing electric pulsations of successively-opposite polarity in the circuit, whereby the receiving-pen is caused to move, and a circuit-controller operated through the movements of the transmitting-pen for effecting a temporary change of current-strength in the circuit upon each reversal in direction of movement of the transmitting-pen, substantially as described.

33. The combination, with a transmitting-pen, of an electric circuit, means operated through said pen for producing electric pulsations of successively-opposite polarity in the circuit, whereby the receiving-pen is caused to move, a circuit-controller operated through the movements of the transmitting-pen for effecting a temporary change of current-strength in the circuit upon each reversal in direction of movement of the transmitting-pen, whereby the receiving-pen is reversed, a pen-rest for the receiving-pen, and circuit connections for breaking the circuit to operate the pen-rest, substantially as set forth.

34. The combination, with a transmitting-pen, of two electric circuits, means operated through said pen for producing a series of

electric pulsations of successively-opposite polarity in each of said circuits, whereby the receiving-pen is caused to move, a circuit-controller operated through the movements of the receiving-pen for effecting a temporary change of current-strength in each of said circuits upon each reversal in direction of movement of the transmitting-pen, whereby the receiving-pen is reversed, a pen-rest for the receiving-pen, and circuit connections for breaking one of said circuits to lower the pen-rest and the other of said circuits for raising the pen-rest, substantially as set forth.

35. The combination of a telautographic pen driven from an appropriate source of power, reversing-magnets X' Y', and their respective local circuits, a commutator controlling said circuits, magnet J', governing the commutator, and electrical connections with the transmitting-station controlling the magnet, substantially as set forth.

36. The combination, with a transmitting-pen, of an electric circuit, means operated

through said pen for producing pulsations in said circuit, a receiving-pen, mechanism independent as regards its source of power for moving the receiving-pen and caused to operate thereon through said pulsations, electrical connections whereby when the transmitting-pen is placed at one extreme point of its movement the receiving-pen is brought into unison with the transmitting-pen as regards direction of motion, and electrical connections whereby the pen-moving mechanism at the receiving-station is at the same time caused to operate and drive the receiving-pen to its corresponding extreme point of movement, substantially as set forth.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

ELISHA GRAY.

Witnesses:

G. F. BENETT,  
MARY A. JENNINGS.