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TELAUTOGRAPH.

No. 494,562. Patented Apr. 4, 1893.

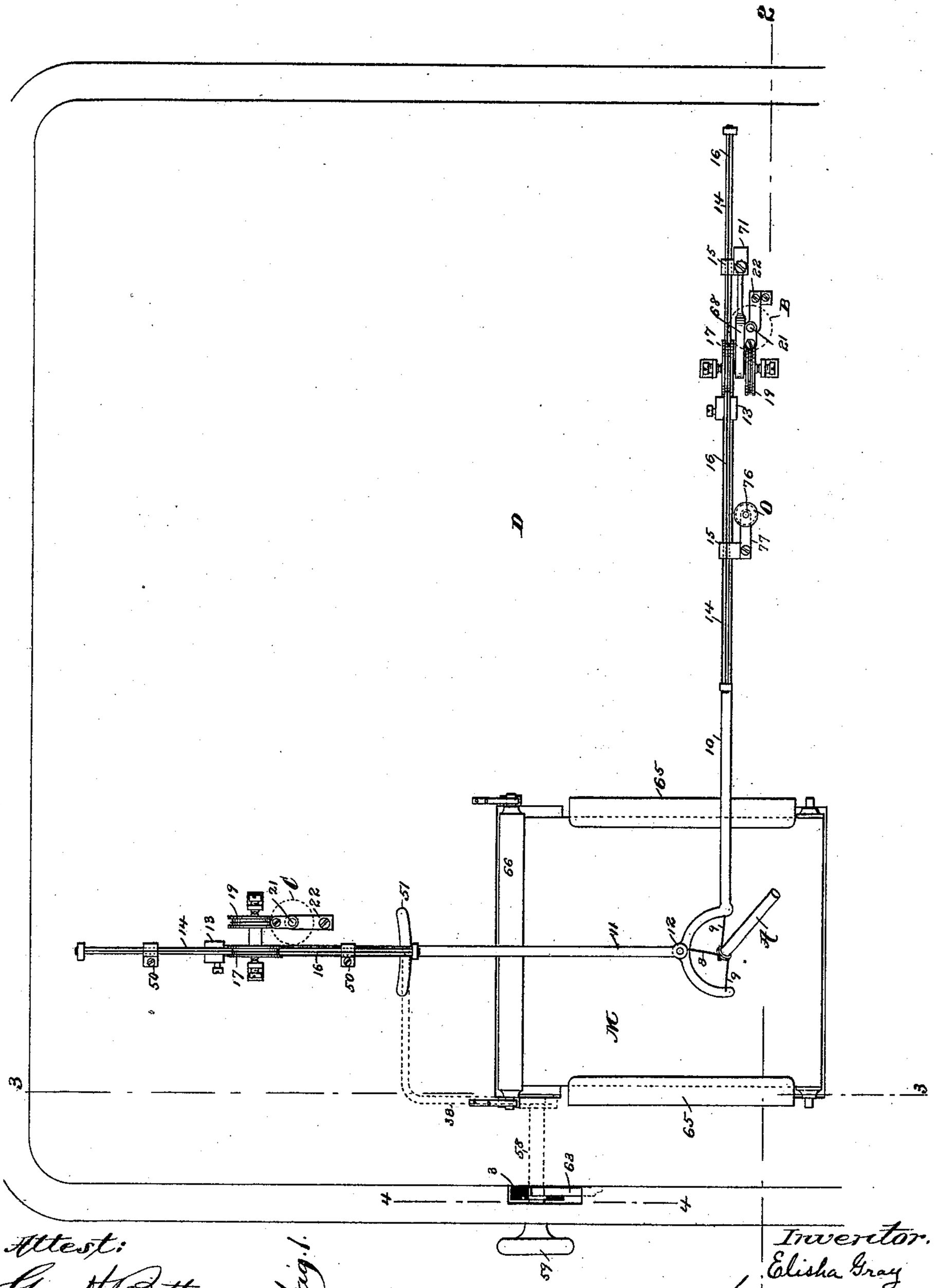

Fig. 1.

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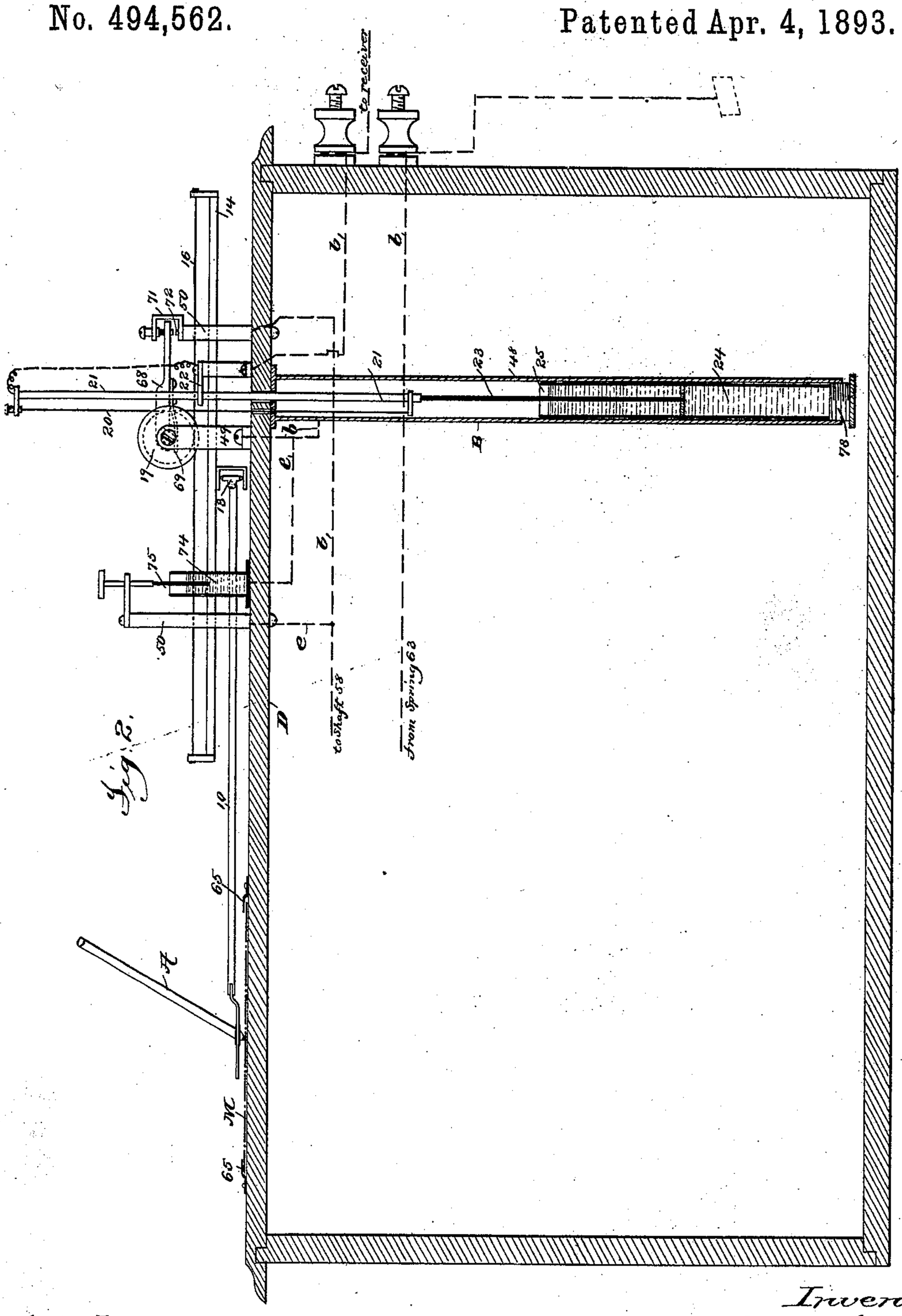

Fig. 2.

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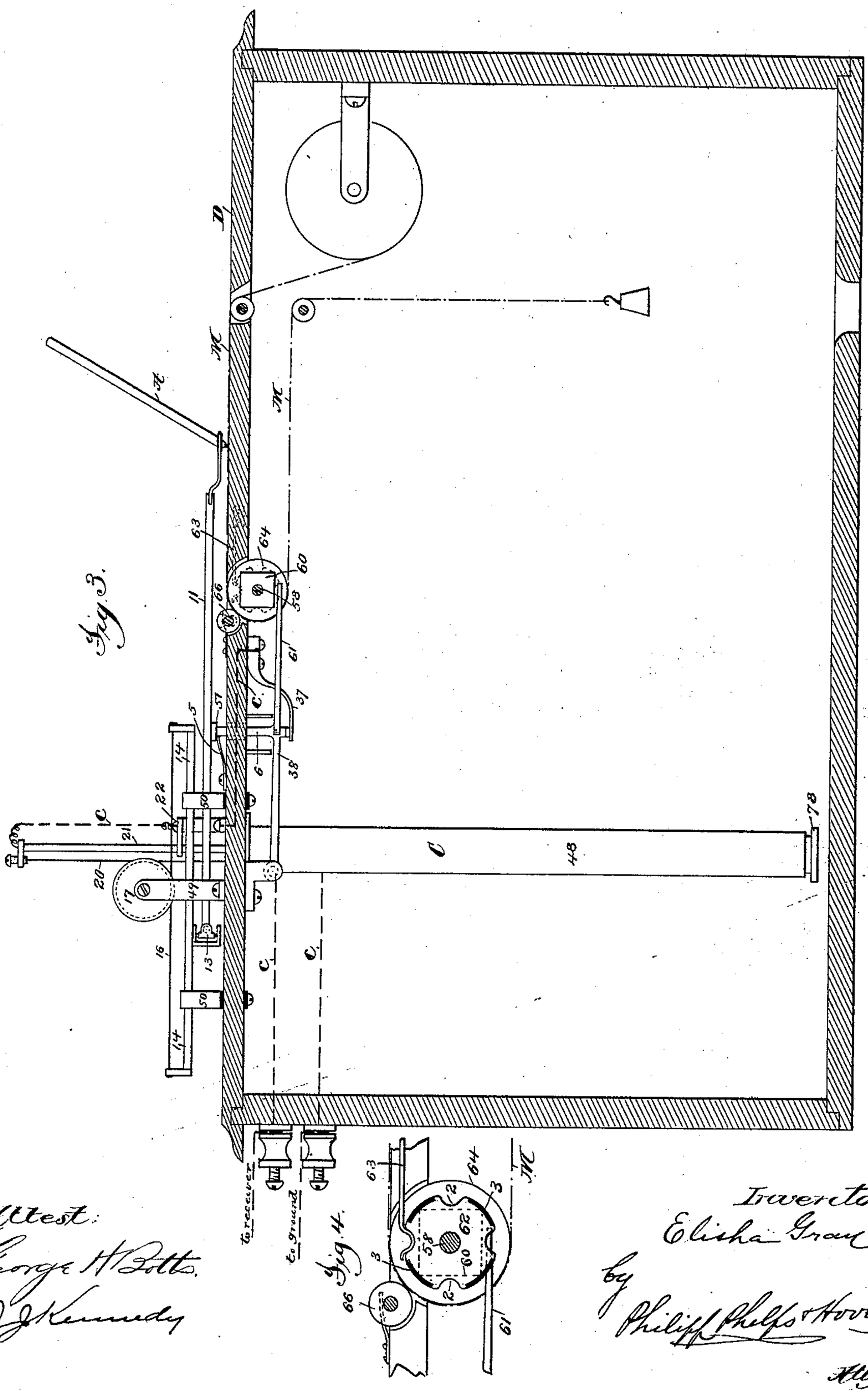

Fig. 3.

Fig. 4.

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Fig. 6.

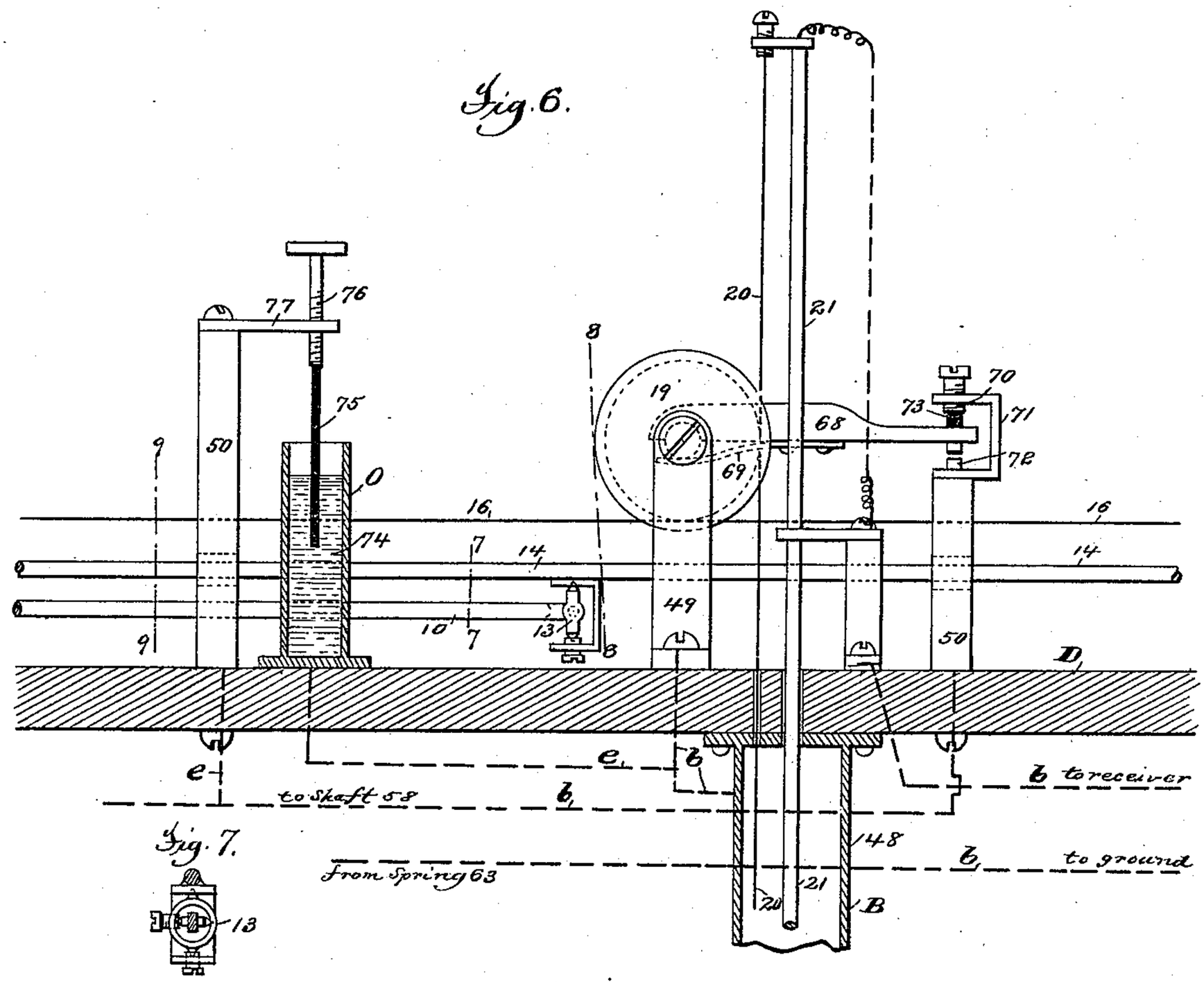

Fig. 7.

Fig. 5.

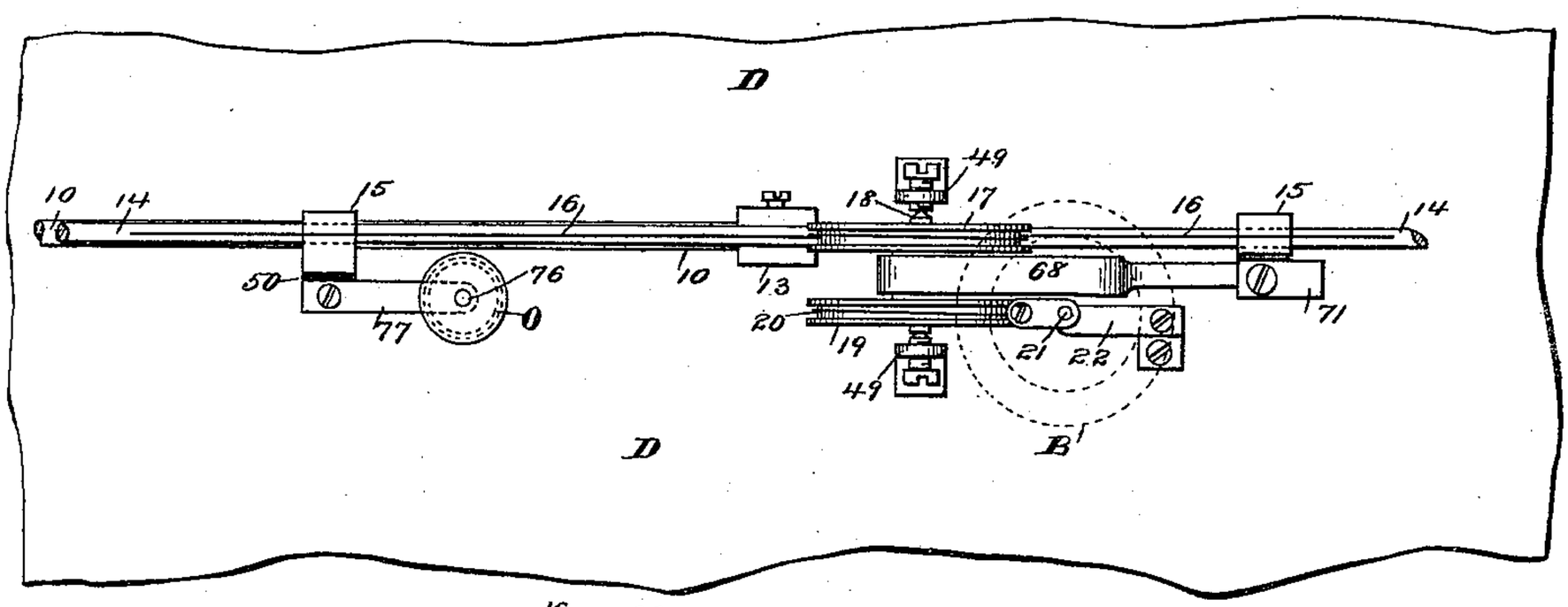

Fig. 8.

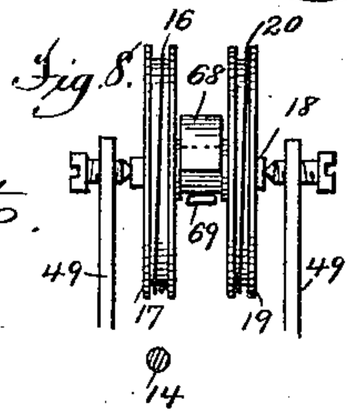

Fig. 9.

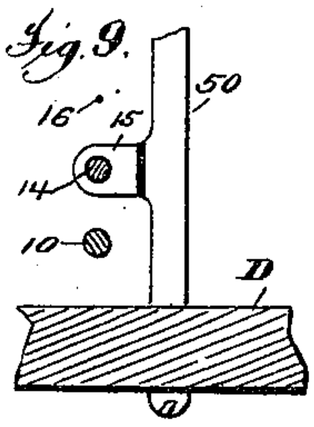

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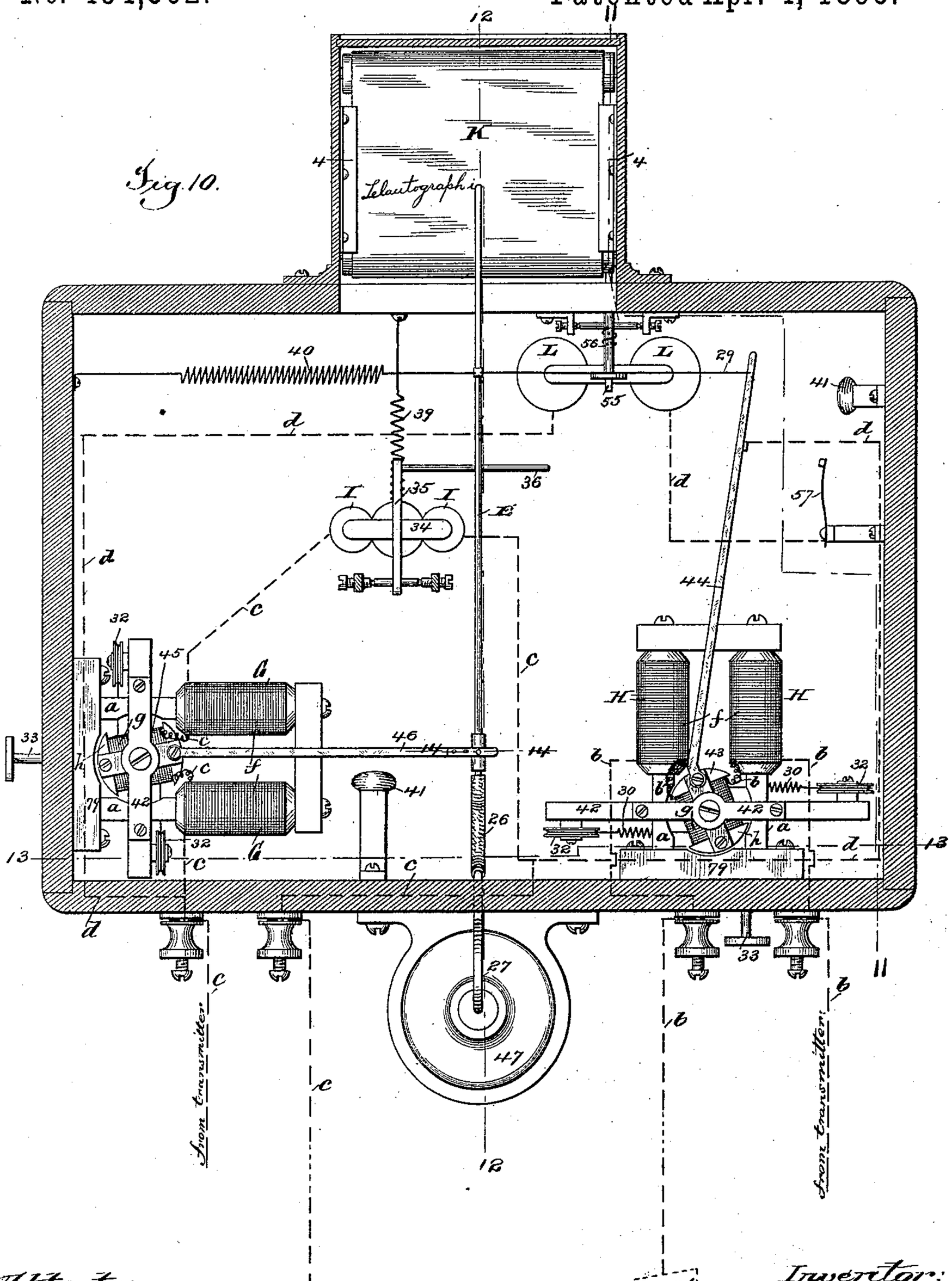
Fig. 10.



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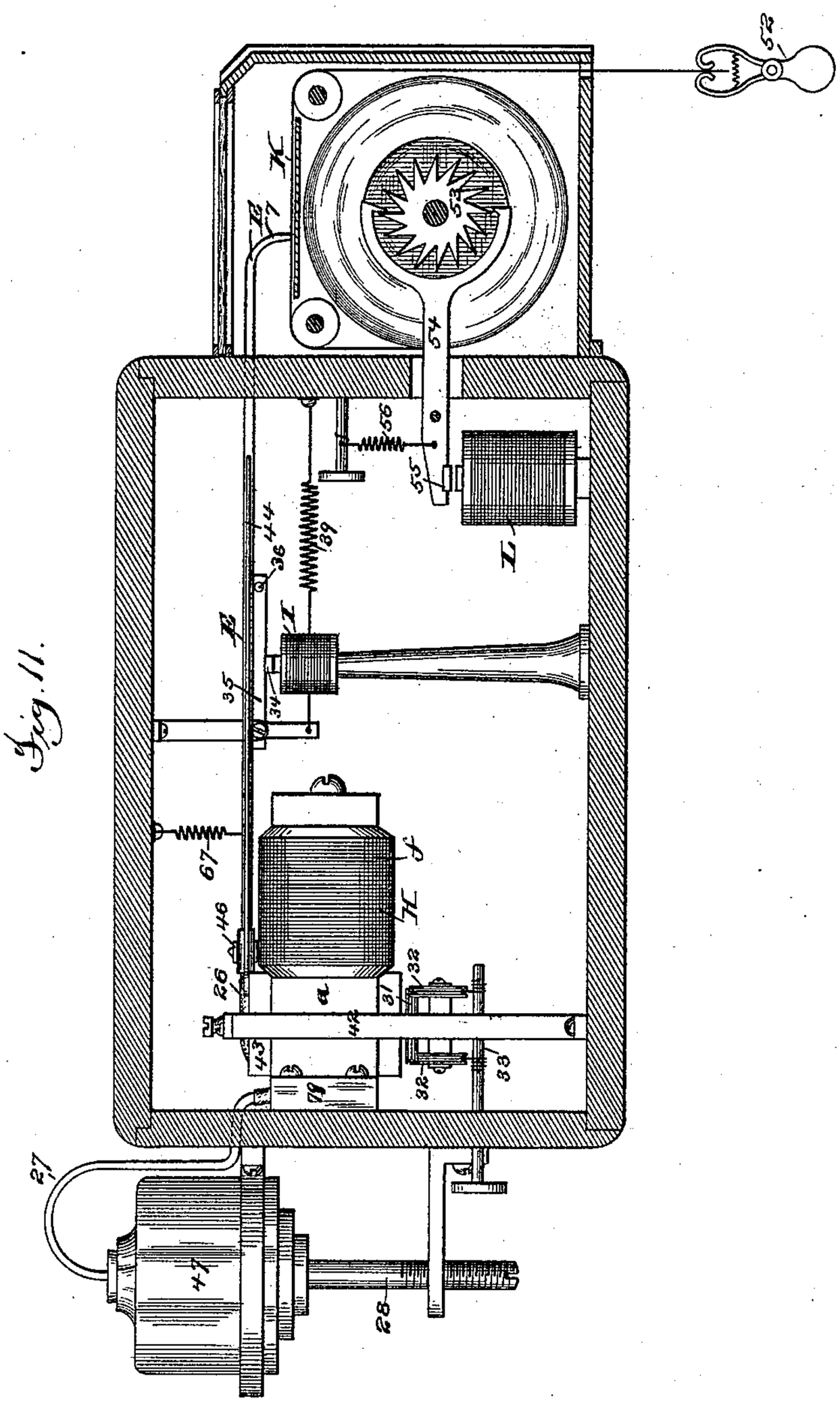

Fig. 11.

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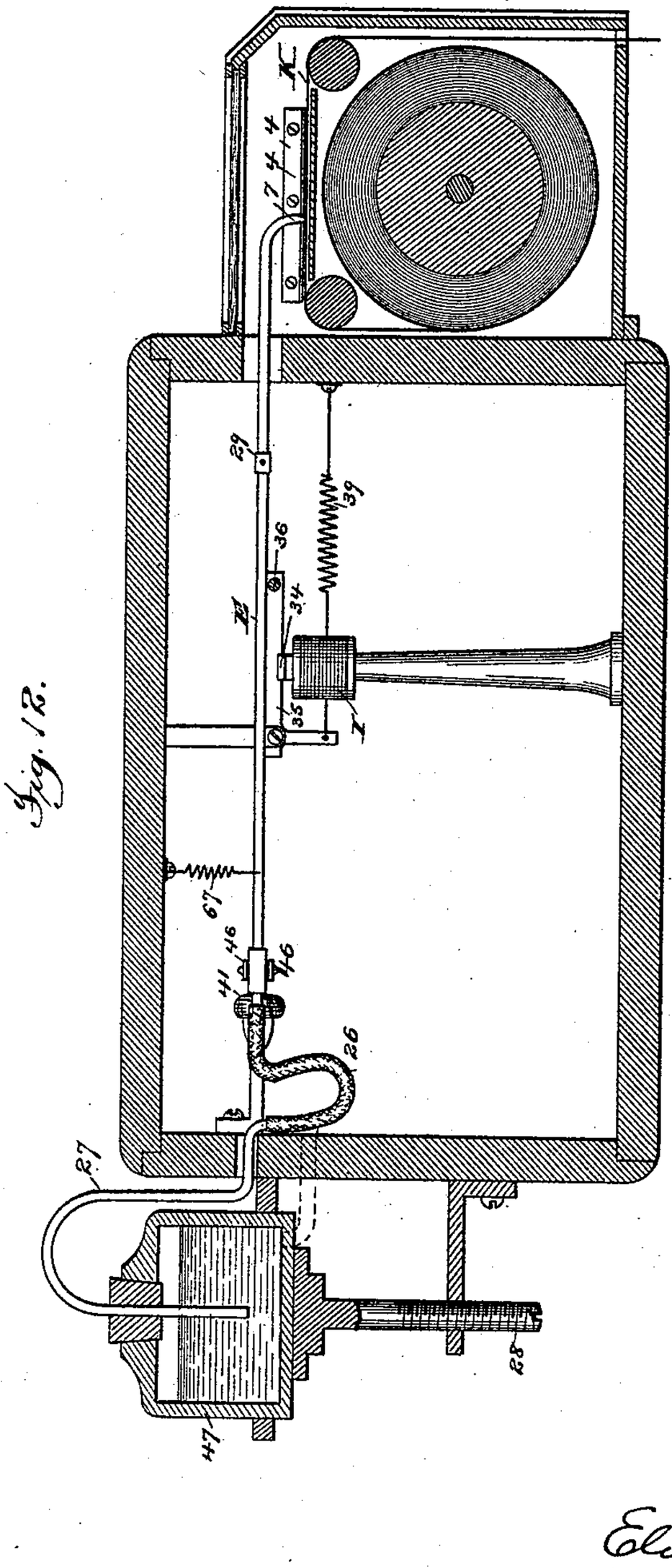

Fig. 12.

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TELAUTOGRAPH.

No. 494,562. Patented Apr. 4, 1893.

Fig. 13.

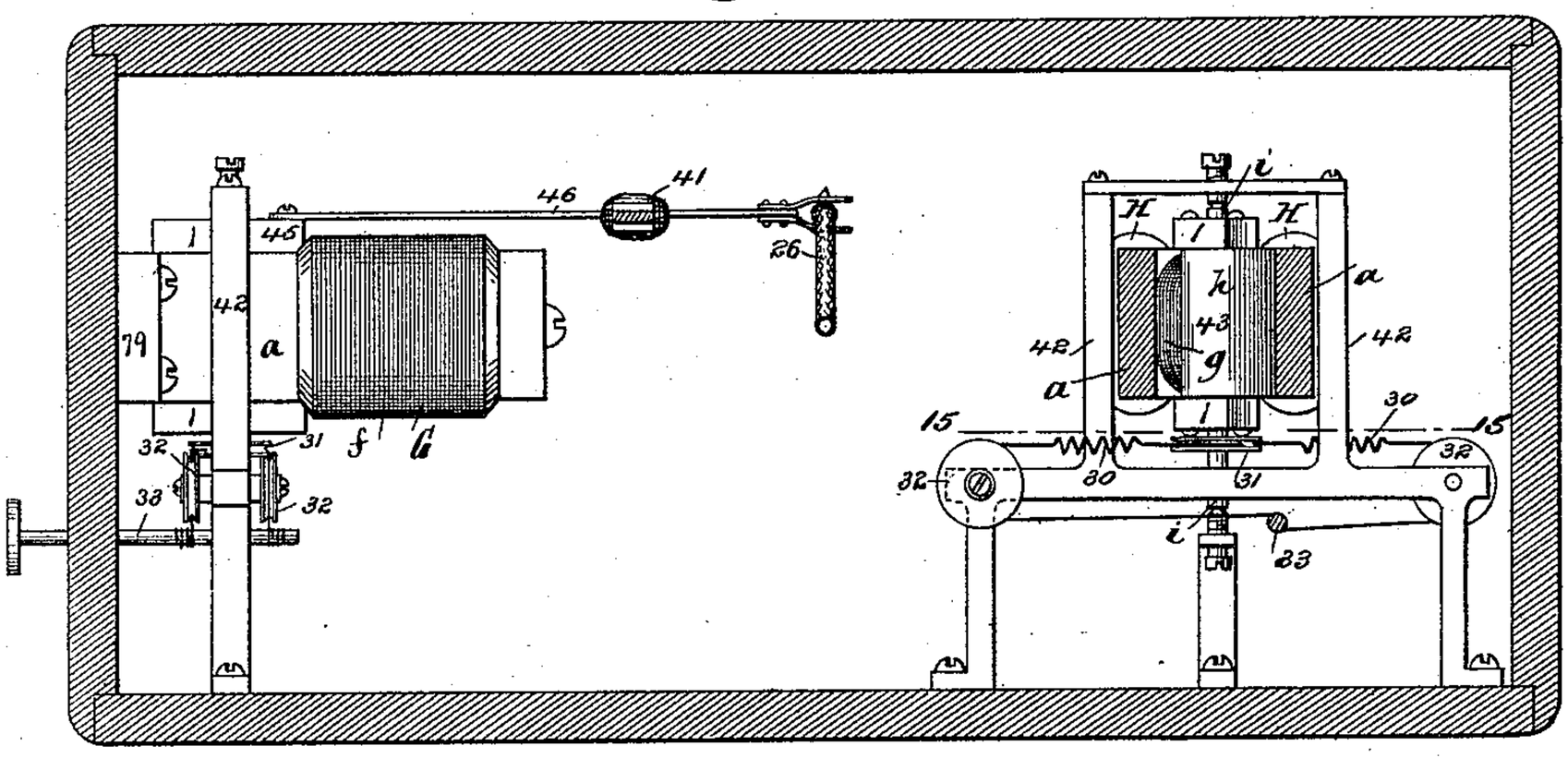
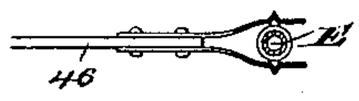


Fig. 15.

Fig. 14.



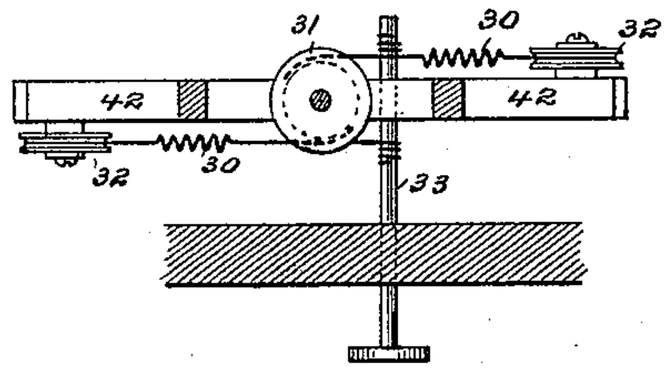


Fig. 16.

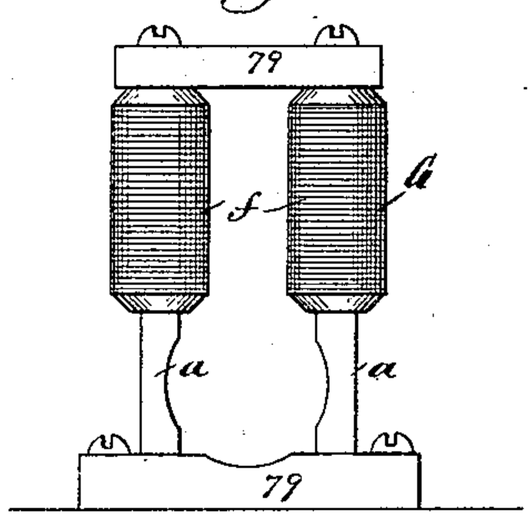
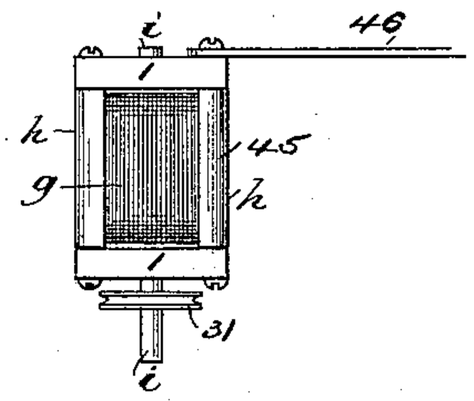


Fig. 17.



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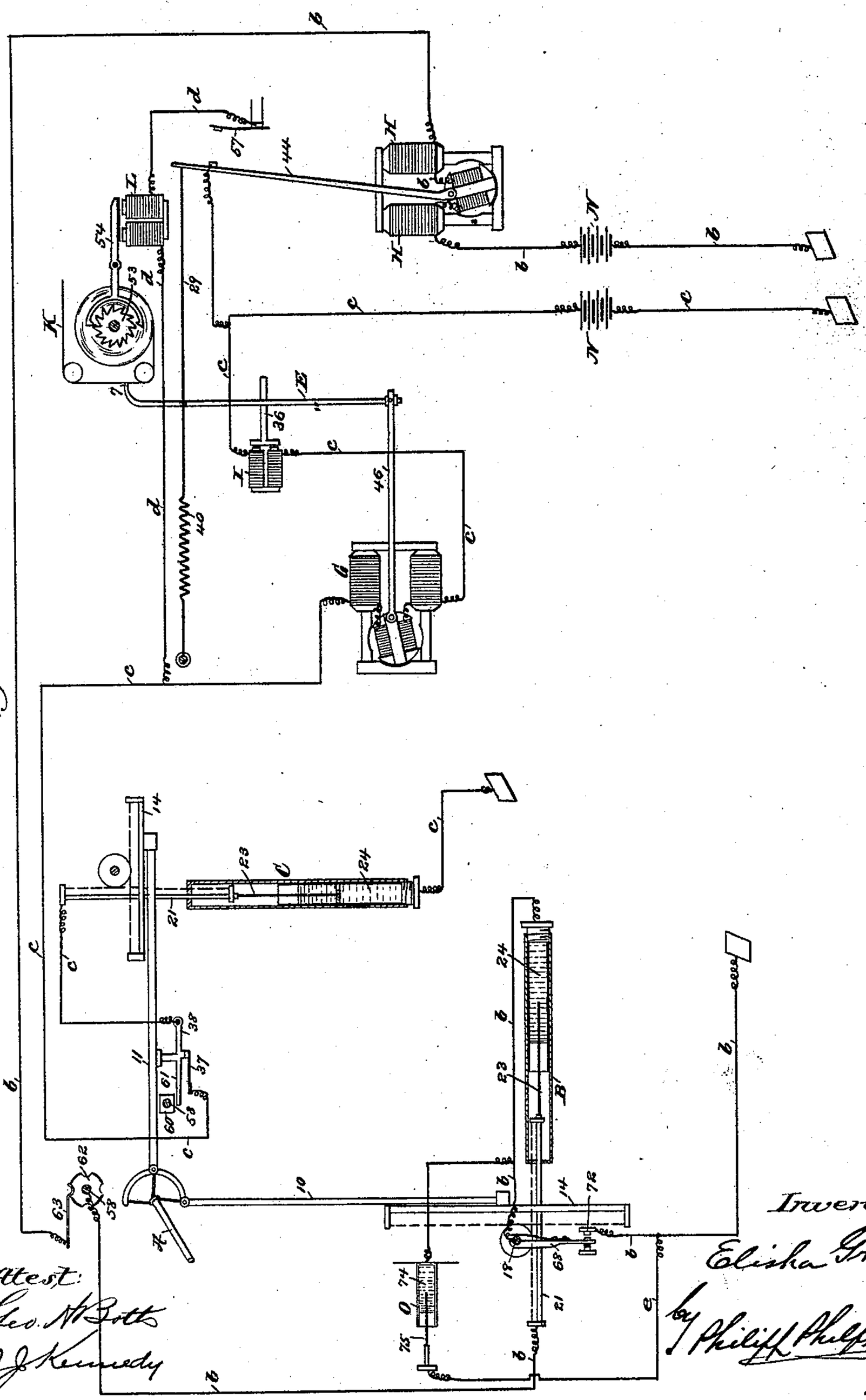

Fig. 18.

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UNITED STATES PATENT OFFICE.

ELISHA GRAY, OF HIGHLAND PARK, ILLINOIS.

TELAUTOGRAPH.

SPECIFICATION forming part of Letters Patent No. 494,562, dated April 4, 1893.

Application filed July 16, 1887. Serial No. 244,490. (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 telegraph of the class in which the act of writing the message at the sending station operates to reproduce it at the receiving station. In all the systems of telegraphy of this class which have heretofore been proposed the transmitting instrument proper, *i. e.* the instrument (hereinafter for convenience called a pen) which was moved by the hand of the operator to form the message, and also the receiving instrument proper, *i. e.* the instrument (also hereinafter for convenience called a pen) which moved in unison with the transmitting pen to reproduce the message, have been capable of only sufficient or slightly more than sufficient movement to produce a single character, the successive characters to make up the words and sentences being produced one after the other in the same field. In order to cause the characters thus produced to take their proper places one after the other to form the successive words, the paper upon which the message was written by the receiving pen and also the paper upon which the message was writen by the operator, if a copy of the message was to be preserved, was caused to move continuously beneath the pen by means of a feeding mechanism specially provided for that purpose and not under the control of the operator. From this it resulted that in order to produce characters of the proper form and to cause them to take their proper positions in succession to form the words and sentences, it was necessary for the operator to make allowance for the movement of the paper. To illustrate; if the operator formed his characters in too rapid succession the second character would be reproduced before the paper upon which the message was being written had moved sufficiently far to carry the first character away from the receiving pen, and the result would be that the two characters would overlap each other; or, if the operator formed his characters too slowly they would be separated too far from each other. In addition to this it was necessary for the operator to distort his characters in such a manner and to such an extent that the movement of the paper beneath the receiving pen would exactly or approximately compensate for this distortion and result in the production of characters of the proper form, and the amount and character of the distortion necessary on the part of the operator was dependent upon and varied with the speed at which he wrote and the speed at which the paper moved. All these things made it difficult to produce good results and made it practically impossible for the systems to be operated except by trained operators. This continued movement of the paper by means not under the control of the operator, together with the limited range of movement of the transmitting and receiving pens, made it practically impossible to make alterations or corrections in a sentence or even in a word after it had been written, and thus made it necessary, if a mistake was made, to re-write the whole matter, and this again resulted in trouble because there was no means of erasing the erroneous matter.

Another objection to the telegraphs of this class which have heretofore been proposed was due to the fact that no means was provided for breaking the line made by the receiving pen from the commencement to the close of the message. From this it resulted that not only the letters of each word but all the words of the message were connected, thus not only making unsightly writing but making it impossible to distinguish between the different words unless care was taken by the operator to separate the words a considerable distance. This continuous marking of the receiving pen also made it impossible (even if the continual movement of the paper had not precluded it) to dot an i or cross a t or underscore or erase a word or make any other character or sign above or below a letter or word without joining such additional mark or character to the word or letter, which, of course, injured the appearance of the writing.

Owing to the difficulties which have been enumerated the telegraphs of this class heretofore proposed could not be used successfully

for transmitting any matter such as pictures, drawings, maps or diagrams, or such characters as Hebrew or Chinese, or those employed in shorthand writing, which in order to be of value or to be distinguished and read must be made with at least comparative accuracy.

It is the object of the present invention to overcome the above mentioned difficulties and to provide a writing telegraph, or more properly a telautograph, in which the receiving pen shall operate simultaneously and in unison with and produce an exact fac simile of whatever matter is written or traced by the transmitting pen, in which the continuance of the mark or line made by the receiving pen shall be under the control of the operator so that the connection between the letters or words can be broken whenever desired and in which it shall be possible to make erasures, insertions, corrections, changes or additions in or to the matter which has been transmitted, at the will of the operator.

In order that the detailed description of the construction, organization and operation of the instruments and the system embodying the invention which will be hereinafter given may be more readily understood a brief outline of the system will be first given. The system consists primarily of two instruments; a transmitting instrument and a receiving instrument. The transmitting instrument consists primarily of the transmitting pen which can be moved by the operator over a field of considerable extent. If the instrument is designed for transmitting messages in writing the field will be equal in one direction to the length of a line of the writing and in the other direction to the distance above and below the line occupied by any character. The transmitting pen is arranged to control resistances located in two electric circuits and arranged to increase and diminish the strengths of the currents passing over their respective circuits, as the pen is moved along the length of the line and above and below the line. These two circuits pass through the receiving instrument and are connected to two electromagnets the armatures of which control two levers in such manner that the levers are caused to vibrate a greater or less distance according to the strengths of the currents passing through the magnets. By this means the movements of the transmitting pen along the line and above and below the line will, through the variations caused in the currents passing over the circuits, impart corresponding movements to the two levers in the receiving instrument. The movements thus imparted to the two levers in the receiving instrument are, through suitable connections, transmitted to other parts of the instrument, preferably directly to the receiving pen, in such a way as to exactly reproduce the movements of the transmitting pen and thus reproduce an exact fac simile of the line of writing or other matter written or traced by the operator.

Co-operating with the receiving instrument, or forming a part thereof, is a means for supporting a sheet of paper or other recording surface, either in the form of a continuous band or strip or in the form of a pad or a detached sheet, in proper position beneath the pen to receive the message and a means for shifting this paper after the completion of each line of writing, so as to bring it in proper position beneath the pen to receive the succeeding line.

In the preferred construction the paper is stationary during the writing and is shifted after the completion of each line. It is to be remarked, however, that the instrument may be so organized that the pen will be stationary, the movements of both of the levers before referred to being transmitted to the paper, or the movement of one lever may be transmitted to the pen and the other to the paper. In any case, however, the paper is not advanced continuously and independently of the control of the operator during the writing but is only moved in perfect harmony with the movements of the transmitting pen and is under the perfect and continual control of the operator. From this it results that the operator can pause at any point or for any length of time and, the paper in the receiving instrument being stationary, upon recommencing the writing the receiving pen will continue the record from the point where it was interrupted. From this feature it also results that the operator can go back in the line and make a correction, erasure or interlineation at any point. This also permits the operator to write at irregular speeds and relieves him from the necessity of distorting his writing to compensate for the movement of the paper. At the end of the line the operator simply moves the transmitting pen back to the point where the line commenced and the receiving instrument responds to that movement so as to bring the receiving pen and the paper into the same relative positions to commence a new line.

The two instruments are provided with suitable devices and electrical connections, which will be hereinafter described, by which the operator after writing one line and before commencing the next shifts the paper the proper distance to receive the next line.

The circuit in which one of the resistances and one of the magnets are located is provided with connections by which whenever the transmitting pen is raised slightly, the same as in raising a pen or pencil from the paper, the receiving pen is correspondingly raised and vice versa. From this it results that whenever the end of a line is reached and the transmitting pen moved back to commence a new line or whenever it becomes necessary to go back on the line to make changes or corrections, it is only necessary to raise the transmitting pen in the ordinary way in order to prevent the receiving pen from making a continuous line on the paper and thus

mutilating the record. By this means also the operator is enabled to break the connection between letters or words if he desires to do so. The system thus briefly outlined will now be described more in detail, reference being had to the accompanying drawings, in which:—

Figure 1 is a plan view of the transmitting instrument. Fig. 2 is an irregular sectional elevation taken on the line 2—2 of Fig. 1. Fig. 3 is a similar view taken substantially on the line 3—3 of the same figure. Fig. 4 is a section upon an enlarged scale taken on the line 4—4 of the same figure. Fig. 5 is an enlarged view of a part of Fig. 1. Fig. 6 is a similar view of a part of Fig. 2. Fig. 7 is a section taken on the line 7—7 of Fig. 6. Fig. 8 is a section taken on the line 8—8 of the same figure. Fig. 9 is a section taken on the line 9—9 of the same figure. Fig. 10 is a plan view of the receiving instrument; the case of the instrument being shown in section. Fig. 11 is an irregular sectional elevation taken substantially on the line 11—11 of Fig. 10. Fig. 12 is a similar view taken on the line 12—12 of the same figure. Fig. 13 is a similar view taken substantially on the line 13—13 of the same figure. Fig. 14 is a sectional detail taken on the line 14—14 of the same figure. Fig. 15 is a horizontal section taken on the line 15—15 of Fig. 13. Fig. 16 is a view of one of the receiving magnets with its armature removed. Fig. 17 is a view of the armature removed from the magnet; and Fig. 18 is a diagram illustrating the electrical connections.

Referring now particularly to Figs. 1 to 9 and 18 the principal features of the transmitting instrument will be described: This instrument consists, primarily, of the transmitting instrument proper which is moved by the operator to form the characters or other matter to be transmitted. This instrument may be a simple handle or holder of convenient form to be grasped by the operator and moved to describe the outlines of the characters, but as it will usually be desirable to preserve a copy of the message, this instrument will commonly be a pencil or a fountain pen and it will therefore be herein termed the transmitting pen and this term, wherever used in a general sense, is to be understood as including any writing instrument or a simple handle suitable to be moved to form the outlines of the characters. The transmitting pen A is, in the organization herein illustrated, connected to two rods 10 11 which extend horizontally at substantially right angles to each other and are hinged together, as indicated at 12. In case the transmitting pen consists of a simple handle and not a writing instrument it may be rigidly connected to the rod 10, but where the transmitting pen is a writing instrument, as illustrated in the present case, it will preferably be connected to the rod so as to be free to vibrate in all directions to give the operator facility in writing. The preferred form of connection is that shown, in which the end of the rod is shaped to form a bow, across which are stretched two cords or flexible wires 8 9 which at their point of intersection are connected to the point of the pen. By this means the pen is permitted to vibrate freely in all directions, while at the same time any movement of the pen in the direction of the length of the line or above or below the line imparts a corresponding movement to the rods 10 11 respectively. The rods 10 11 are connected to and control the two resistances B C located in the two electric circuits *b c* before referred to, in such manner that as the transmitting pen is moved from left to right across the sheet in forming the line of writing the resistance B will be gradually changed so as to vary the strength of the current passing over the circuit *b*, while as the pen is moved above and below the line in forming the characters the resistance C in the circuit *c* will be changed to vary the current passing over that circuit. The connections between the pen and the resistances will preferably be so arranged, as herein shown, that the resistance in the circuit *b* will be gradually increased and the current correspondingly diminished as the pen moves from left to right and that the resistance in the circuit *c* will be gradually increased and the current diminished as the pen is moved to make the down strokes in forming the characters, and vice versa. The connections with one or both of the resistances may, however, be reversed, if preferred, and such an arrangement will not be a departure from the invention. The form of the connections between the transmitting pen and the resistances, and also the character of the resistances, may be varied very widely without departing from the essential features of the invention. The form of the connections and the character of the resistances herein shown are, however, regarded as the best and are deemed sufficient for the purpose of illustrating the invention. The two resistances and their connections are exact duplicates and a description of one will therefore apply to both. The rods 10 11 at their ends opposite to the pen are connected by universal joints 13 (see Fig. 7) to a pair of sliding rods 14 which move in bearings 15 (see Fig. 9) formed on standards 50 rising from a table D of insulating material which forms the top of the transmitting instrument. In the construction shown the bearings 15 are insulated from the standards as indicated in Figs. 5 and 9. Each of the rods 14 is provided with a cord or very flexible wire 16 which is attached to the opposite ends of the rod and passes one or more times around a pulley 17 mounted upon a shaft 18 supported in bearings on standards 49 rising from the table D. From this arrangement it results that whenever the rods 14 are moved longitudinally in their bearings the cords 16 impart a rotary movement to the pulleys 17 and their shafts. Each of the shafts 18 is also provided with a

second pulley 19 around which passes a cord or very flexible wire 20 which is attached at its opposite ends to a vertical rod 21 which passes through an opening in the table D and enters a metal tube 48 suspended beneath the table. These rods are guided in their vertical movement by guides 22 and each is connected at its lower end to a small rod 23 of carbon, graphite or other substance of low conductivity which enters and moves freely in a body of mercury or other fluid 24 of high conductivity contained in a glass tube 25 inserted within the metal tube 48. These devices constitute the two resistances B C before referred to. One wire of the circuit *b* is connected to the mercury 24 of the resistance B, while the other wire of the circuit is connected to the metal rod 21 carrying the graphite rod 23. The two wires of the circuit *c* are similarly connected to the mercury and the graphite rod of the resistance C, all as indicated in Fig. 18. The wires of the circuits *b c* may be connected to the rods 23 and the mercury 24 in any suitable manner but as herein shown the glass tubes 25 which contain the mercury 24 are open at their lower ends and rest upon and are connected to metal plugs 78 which screw into the tubes 48, thus forming metallic contact between the mercury and the tubes 48 so that one wire of each circuit can be attached to the tubes 48, as shown in Figs. 2, 3 and 6, or to the plugs 78, as shown in Fig. 18. The other wires of the circuits are shown (see Figs. 2 and 3) as connected to the standards which support the guides 22 and thence by sections of slack wire to the upper ends of the rods 21. The connections between the transmitting pen and the resistance B are so adjusted that when the transmitting pen is moved to the extreme left of the sheet of paper, which will be its position at the commencement of the line of writing, the rod 23 of that resistance will be largely immersed in the mercury, thereby leaving the minimum amount of resistance in the circuit *b;* but as the pen is moved from left to right as the successive characters are formed across the sheet, the rod 23 will be more and more withdrawn from the mercury thereby gradually increasing the resistance in the circuit and correspondingly decreasing the strength of the current. The connections between the pen and the resistance C are so adjusted that when the pen is moved to its extreme position above the line, the rod 23 of that resistance will be in position to offer the minimum resistance in the circuit *c*, but as the pen is moved downward from that position, the rod 23 will be more and more withdrawn from the mercury so as to gradually increase the resistance and correspondingly diminish the current over the circuit.

Referring now to Figs. 10 to 18 the principal features of the receiving instrument will be described: This instrument consists, primarily, of the recording instrument which may be a pen or other writing instrument, but which will for convenience be herein termed the receiving pen, and this term is to be understood, wherever used in a general sense, as including any form of writing instrument. In the case shown the receiving pen E is a fountain pen and is composed of a glass tube of very fine bore, arranged in a substantially horizontal position with its end bent downward to form a writing point 7. The opposite end of the pen is connected by a piece of flexible rubber tubing 26 with a siphon 27 the short arm of which enters an ink well 47 located at the back of the instrument. The ink well and the pen are arranged at such relative heights, for which purpose the ink well is provided with an adjusting screw 28, that the siphon 27 will act to keep the pen constantly supplied with ink. It is to be remarked in passing, however, that the pen may communicate directly with the bottom of the ink well, as indicated by dotted lines in Fig. 12, so that the ink will flow directly to the pen by gravity. The rear end of the pen is pivoted (see Fig. 14) to the end of a lever 46 which extends from the oscillating armature 45 of an electro-magnet G located in the circuit *c*. The rear end of the pen may be supported by a light spring, as 67, which will serve to partly relieve the lever 46 of the weight of the pen. The armature 45, is so arranged that as the energy of the magnet is increased and diminished by the variations in the strength of the current passing over the circuit *c* (caused by the variations in the resistance C), it will oscillate in accordance with the energy of the magnet, and through the lever 46 impart a corresponding movement to the pen E, which movement will correspond to and be in unison with the movements of the transmitting pen above and below or at right angles to the line of writing. At a point some distance in advance of that at which it is pivoted to the lever 46 the pen E is connected by a cord or light rod 29 with a lever 44 which extends from the armature 43 of a second magnet H located in the circuit *b*. This magnet and its armature are of the same construction as the magnet G and armature 45 and are arranged so that as the energy of the magnet is varied by the change in the resistance in the circuit *b* (due to the movement of the transmitting pen in the direction of the length of the line) it will rock the lever 44 so as to impart a movement to the pen E crosswise to the movement imparted to the lever 46 and corresponding to the movement of the transmitting pen in the direction of the length of the line or across the page.

The construction of the receiving magnets G H and their armatures 45 43 is as follows: The cores *a* of the magnets are attached to brass pieces 79 and extend at one end considerably beyond the coils *f*. The armatures 45 43 consist of spools which are wound with coils *g* which are connected by short slack

wires *b c* with the coils *f* of the magnets, as shown in Fig. 10, and are supported so as to oscillate freely between the projecting ends of the cores *a* of the magnets. For this purpose the two heads *h* of the spool of each armature are connected by brass plates *l* (see Fig. 17) which are supported on pivots *i* in brackets 42 rising from the base of the instrument so as to oscillate freely in either direction, the armatures being oscillated in one direction by the energy of the magnets and in the reverse direction by springs 30 connected to the opposite sides of pulleys 31 located upon the axes of the armatures. The wires of which the springs 30 are composed, or cords attached to the springs, are extended around pulleys 32 located upon opposite sides of the armatures and are wound around small adjusting rods 33. By employing the two springs 30 attached to the opposite sides of the pulleys 31 the tension of the springs is almost entirely removed from the pivots of the armatures, thus reducing the friction, and by employing the single tightening rod 33 for the two springs they are simultaneously adjusted to the necessary degree of tension.

The receiving instrument is provided with cushions or back stops 41 against which the levers 44 46 are drawn and held by the springs 30 whenever the magnets are de-energized or their energy reduced to the minimum. The pen E may also be provided with a spring 40 which will act in conjunction with the magnet H in overcoming the tension of the springs 30 and keep the cord 29 taut, but if a light rod is used in place of the cord 29 the spring 40 may be omitted.

It has been already stated that it is important that the receiving pen should be so under the control of the operator that when he desires to pause in the sending of the message or to go back on the line for the purpose of making a correction or interlineation, or when he has completed one line and wishes to move the transmitting pen back to the point to commence a new line, the receiving pen will make the corresponding movements without making any mark on the paper. To accomplish this when the receiving pen is of the character herein shown, it is only necessary to provide means by which the operator can, when he desires to make these movements, cause the receiving pen to be raised from the paper. To effect this the receiving instrument is provided with an electro-magnet I which is located in the circuit *c* and the armature 34 of which is provided with a lever 35 having a rod 36 which extends horizontally beneath the pen E in such position that when the magnet is energized and its armature drawn downward the lever 35 and rod 36 will move downward so as to permit the point 7 of the pen to rest upon the paper. The lever 35 is also provided with an arm which is acted upon by a spring 39 in such manner that whenever the magnet is not energized its armature and the lever will be rocked upward so as to raise the rod 36 and lift the point of the pen out of contact with the paper. The bore of the tube forming the pen is so fine that the ink will not flow from the point of the pen except at such times as the pen is in contact with the paper. From this it results that whenever the point of the pen is raised from the paper, the line made by the pen will be broken.

The transmitting instrument is provided with a circuit making and breaking apparatus located in the circuit *c* and under the control of the pen A and which operates, whenever the pen is raised slightly from its writing position, to break the circuit. This apparatus consists of a spring contact plate 37 which is connected to one of the wires of the circuit *c* and a pivoted lever 38 which is connected to the other wire, and is arranged to form contact with the plate 37 and thus close the circuit. The lever is provided with an arm 6 which extends upward through an opening in the table D and terminates in a plate or bar 51 which extends transversely beneath the rod 11. The lever is provided with a spring 5 the tendency of which is to hold it out of contact with the plate 37 and thus keep the circuit broken. The plate 51 is, however, arranged at such a height that when the pen is depressed to the writing position the rod 11 will press upon the plate and depress the lever 38 into contact with the plate 37 so as to close the circuit, and this will continue as long as the pen is kept in the writing position. So long, therefore, as the transmitting pen is maintained with its point on the paper or in the depressed position, the magnet I of the receiving instrument will remain energized and the point 7 of the receiving pen will remain on the paper. If at any time, however, the operator should wish to go back on the line to make any correction or addition, or if he desires to break the connection between successive words, all that is necessary is to raise the transmitting pen sufficiently to allow the spring 5 to carry the lever 38 out of contact with the plate 37. This will cause the circuit *c* to be broken which will instantly de-energize the magnet I and allow the lever 35 to be rocked by the spring 39 so as to raise the point of the receiving pen away from the paper. The receiving pen will then follow the movements of the transmitting pen without making any mark upon the paper until the transmitting pen is again lowered onto the paper. Since the magnet I is in the same circuit with the magnet G it is obvious that the latter magnet will also be de-energized whenever the circuit is broken by the raising of the transmitting pen from the paper.

From the foregoing it will be seen that all the movements required to bring the characters into proper position, one after another, to form the words of a line, are made by the receiving pen, the paper remaining stationary during the writing of the line. When, however, the line has been completed it is neces-

sary that the paper should be shifted so as to bring a new portion into position to be written upon. If the message is to be written in the form of a single line extending along the length of a narrow ribbon paper, the ribbon must be shifted longitudinally the length of the line which has been written, so that when the writing is again commenced it will continue from the point on the paper where it was interrupted. If, on the other hand the message is in lines extending across a sheet or wide ribbon of paper, the sheet or ribbon must be shifted forward a distance equal to the space between two lines so as to bring the second line the proper distance beneath the first. In either case it is important that the mechanism for accomplishing the shifting of the paper in the receiving instrument should be under the perfect control of the operator at the transmitting instrument. One important feature of the invention relates to the means by which this is accomplished.

As herein illustrated the message is written in the receiving instrument upon a wide ribbon of paper K which is led from a roll and after passing over a support beneath the point of the receiving pen passes downward out of the instrument where it is attached to a clip 52 of sufficient weight to maintain it at the proper tension. Suitable side guides as 4 will preferably be provided to overlap the edges of the paper so as to hold it evenly and smoothly beneath the pen.

The roll upon which the paper is wound is provided at one end with an escapement wheel 53 which is controlled by an escapement lever 54 to which is attached the armature 55 of an electro-magnet L located in a branch *d* of the circuit *c* and arranged so that when energized it will rock the escapement lever and permit one tooth of the escapement wheel to pass and the weight 52 to unwind and shift the paper a distance equal to the distance between two of the teeth of the escapement. The escapement lever is also provided with a spring 56 which as soon as the magnet is de-energized will rock the lever in the opposite direction and thus permit another tooth in the escapement to pass and the paper to be again drawn forward a short distance. The movement thus given to the paper will be equal to the space between two lines.

One end of the branch circuit *d* in which the magnet L is located is connected to the main circuit *c* at a point between the magnet G and the transmitting instrument, while the other end of the branch circuit is connected to the circuit *c* at a point between the magnet G and the ground. Located in the branch circuit *d* is a circuit making and breaking apparatus which is controlled by the magnet H. For this purpose one wire of the branch circuit *d* is connected by a slack piece of wire to a contact point carried by the lever 44 while the other wire is connected to a spring contact point 57 which is so located that as long as the current is passing through the circuit so as to impart at least the minimum energy to the magnet H the latter will rock its armature and the lever 44 sufficiently to keep it from contact with the point 57, but whenever the circuit *b* is broken so as to entirely de-energize the magnet H, the springs 30 will rock the lever 44 so as to bring it into contact with the point 57 and thus close the branch circuit *d*.

For the purpose of breaking the circuit *b* to operate the lever 44 to close the branch circuit *d* and also for the purpose of closing the circuit *c* to energize the magnet L to operate the escapement, the transmitting instrument is provided with a shaft 58 having a knob 59 by which it can be conveniently rotated and carrying an insulated polygonal head 60 which, as the shaft revolves, is arranged to engage with an extension 61 of the lever 38 in such manner as to depress it and close the circuit *c*. The shaft 58 also carries a metal disk 62 which is provided around its periphery with a number of notches or recesses 2 and between the recesses 2 with pieces 3 of insulating material. Located adjacent to the disk is a spring 63 having a curved end which is arranged to engage with the notches 2 of the disk. This spring is connected to one of the wires of the circuit *b;* the other wire being connected to the shaft 58 so that whenever the spring rests in one of the notches 2 the circuit is closed, and whenever the spring rests upon one of the pieces 3 of the insulating material the circuit is broken. The purpose of this part of the organization will more fully appear when the operation of the system is described.

In the practical operation of the system it will usually be desirable to make a copy or duplicate of the message at the sending station and means for doing this is illustrated in the present case. For this purpose the transmitting instrument is provided with a wide ribbon of paper M similar to that used in the receiving instrument which is led from a roll and passes forward over the table D beneath the transmitting pen and after passing around a roll 64 mounted upon the shaft 58 is led from the instrument. Suitable side guides 65 similar to those of the receiving instrument will also in this case be provided to overlap the edges of the paper to hold it smooth and prevent it from moving laterally. To effect the proper shifting of the paper the roll 64 is provided with a small co-operating spring-pressed roll 66 between which rolls the paper passes so as to be drawn forward whenever the roll 64 is turned by the knob 59.

The instrument having been supplied with paper K M as described and the circuits being supplied with battery power as indicated at N the operation of the system as thus far described will be as follows:—The operator will take the transmitting pen in his hand and move it to the left hand edge of the paper or to the point where he desires to commence the message. In doing this he will,

through the connections with the transmitting pen, plunge the rod 23 of the resistance B into the mercury and strengthen the current passing over the circuit *b* so as to increase the energy of the magnet H and cause it to rock the lever 44 so as to carry the point 7 of the receiving pen to the left until it takes a position over the paper K corresponding to that occupied by the transmitting pen. The transmitting pen being during this operation raised from the paper the rod 11 will be raised so as to allow the lever 38 to break the circuit *c*, thus de-energizing the magnet I and allowing the rod 36 to raise the point of the receiving pen from the paper so as to prevent that pen from making a mark on the paper. The transmitting pen being then lowered to the writing position, the rod 11 will press downward the plate 51 so as to cause the lever 38 to close the circuit *c*. As soon as this is done the magnet I will be energized, thereby rocking the rod 36 downward and lowering the point 7 of the pen E onto the paper and at the same time the magnet G will be energized to an extent depending upon the position of the rod 23 of the resistance C, which position will be determined by the position of the transmitting pen with relation to the line upon which the operator is about to write. The energy thus imparted to the magnet G will rock the lever 46 so as to carry the point of the receiving pen to a corresponding position with relation to the line upon which the message is to be written by that pen. The operator will then proceed to write across the paper in the ordinary manner, and as this is done the movements of the transmitting pen from its extreme position above the line upon which it is writing to its extreme position below the line will withdraw the rod 23 of the resistance C farther and farther out of the mercury, thereby increasing the resistance in the circuit and decreasing the strength of the current in regular gradations between these two points, and this will cause the energy of the magnet G to be gradually decreased to the same extent so that it will permit the springs 30 to rock the lever 46 and cause the pen E to take corresponding positions. As the operator moves the pen A from its extreme position below the line to its extreme position above the line the operation will be reversed; the rod will be plunged farther and farther into the mercury, thereby increasing the energy of the magnet and causing it to overcome the springs 30 and carry the receiving pen to corresponding positions.

In the operation of writing a line across the paper the general movement of the pen will be from left to right along the line, but in the formation of certain characters the pen will recede slightly. These movements of the pen will be communicated to the rod 23 of the resistance B thereby causing it to be gradually withdrawn more and more from the mercury, but at the same time to be temporarily plunged slightly farther into the mercury. These movements of the rod 23 will cause a gradual decrease in the strength of the current over the circuit *b* and in the energy of the magnet H accompanied by slight temporary increases in the strength and energy, and the magnet H will thus, through the lever 44 and connections, cause the pen E to follow the movements of the pen A in the direction of the length of the line. By means of the combined movements thus given to the receiving pen by the receiving magnets G H, which movements are made in unison with the movements of the transmitting pen and are under the control of the operator, a fac simile of the matter written or traced by the transmitting pen can be reproduced upon the paper K. If at any point in the line the operator wishes to go back for the purpose of dotting an i or crossing a t or making any correction, he will raise the transmitting pen from the paper, thereby breaking the circuit *c* so as to cause the pen E to be raised from the paper, and will then move the pen A back to the point where the correction or addition is to be made. By then lowering the pen A onto the paper the circuit *c* will be closed and the receiving pen lowered onto the paper and caused to take a corresponding position with relation to the line, after which the correction or addition will be made by the operator and reproduced by the receiving pen. To break the connection between words or to leave a space in a line the operation is the same except that the operator moves the transmitting pen forward instead of backward. When the end of a line is reached the operator will turn the knob 59 a quarter turn, which, through the co-operating rolls 64 66, will shift the paper M a proper distance for the next line. As this movement is commenced one of the pieces 3 of the insulating material on the disk 62 will be brought beneath the spring 63 so as to break the circuit *b*, and at the same time the polygonal head 60 will be brought into position to depress the lever 38 into position to keep the circuit *c* closed. As soon as the circuit *b* is broken the magnet H will be entirely de-energized, thus permitting the springs 30 to carry the lever 44 against the back stop 41 so as to close the branch circuit *d*. The main circuit *c*, including the magnets G I, will then offer greater resistance than the branch circuit *d* including the magnet L, so that the main part of the current will pass through the branch circuit and energize the magnet L to operate the escapement lever 54 and permit the paper K to be shifted one step. As the movement of the shaft 58 is continued and the quarter revolution completed, the piece 3 of insulating material will be carried out from beneath the spring 63 so that the spring will drop into the next one of the notches 2 and thus close the circuit *b* and energize the magnet H so as to rock the lever 44 slightly away from the back stop 41 and break the branch circuit *d*. The magnet L will then be de-energized so

that the spring 56 will restore the escapement lever to its normal position and permit the paper K to shift another step, which will bring it into proper position to receive the next line of writing, and at the same time the polygonal head 60 will be restored to its normal position so as to permit the circuit *c* to be broken upon the raising of the transmitting pen. The operator will then raise the transmitting pen from the paper and carry it back to the left of the sheet into position to commence a new line, and so the operation will be repeated.

From the foregoing it will be seen that the system embodying the present invention differs from those of a similar nature heretofore proposed in the following essential particular. In the systems heretofore proposed the writing at the transmitting instrument has been effected in part by the movements of the transmitting pen, and in part by the continuous feed of the paper by independent mechanism, while in the receiving instrument the writing has been effected in part by the movements of the receiving pen through the variations in the electric currents and in part by the continuous and independent feed of the paper. In the present system the paper has no continuous feed and the writing is effected wholly by the movements of the pens. In accomplishing this result the oscillating armatures 43 45 are important elements. The energy of the magnets G H will be in proportion to the strengths of the currents, and the strengths of the currents will be in inverse ratio to the resistances in the circuits. The energy of the magnets will, therefore, be varied in proportion to the movement of the transmitting pen. It is, however, a well known fact that the attraction of a magnet for its armature varies inversely as the square of the distance through which it acts. If, therefore, the armatures 43 45 were of the ordinary form and arranged to move directly to and from the magnets, the attraction of the magnets for the armatures, instead of being governed entirely by the strengths of the currents, and therefore varying in proportion to the movement of the transmitting pen, would also be effected by the positions of the armatures, and it would result that a given movement of the transmitting pen, starting from one position, would produce a much greater change in the attractive force of the magnets for their armatures and as a consequence a much greater movement of the armatures, than the same movement of the pen would produce, starting from another position, and this unless counteracted, which would be very difficult, would produce irregularities in the movements of the receiving pen. By employing the oscillating armatures this difficulty is practically overcome, since these armatures do not move directly to and from the magnets, but move in arcs through the magnetic fields so as to remain at substantially the same distances from the magnets at all times. From this it results that the great variations in the attractive force of the magnets, which would be caused if the armatures moved directly to and from the magnets, is entirely or practically avoided, the only variations in the attractive force being those caused by the variations in the strengths of the currents produced by the movements of the transmitting pen. It will further be observed that in the present system the mechanism for shifting the recording surface is independent of the pen moving mechanism, by which I mean that the operator can write as long as he chooses without shifting the recording surface, and can shift the recording surface to any desired extent without writing; from which it results that the operator can use a field of such size as he chooses, within the capacity of the instrument, and can place in that field characters many or few, and of such size and shape as he desires, the instrument thus attaining approximately the freedom and range of movement of the ordinary pen upon an ordinary sheet of paper.

The organizations of the instruments as thus far described are such that the amount of resistance interposed in each of the circuits *b c* bears a certain relation to the position of the transmitting pen and is increased and diminished in accordance with the movements of the pen in either direction from any point.

It has been found in practice that when the pen is in motion and so long as it continues to move in the same direction the gradual increase or decrease in the strengths of the currents will cause the receiving pen to exactly reproduce the movements of the transmitting pen. It has been found, however, that when the direction of the movement of the transmitting pen is reversed, so as to reverse the movements of the resistances and change the currents from gradually increasing to gradually decreasing currents or vice versa, there is a certain amount of what may be termed magnetic inertia, which will prevent the magnets G H from responding fully to this change and thus the receiving pen will fail to respond fully to the movements of the transmitting pen. In many cases this does not materially interfere with the correctness of the matter reproduced by the receiving pen, and this is particularly the case with the movements of the pen at right angles to the line of writing. There are cases, however, in which this magnetic inertia would, unless counteracted, seriously interfere with the correctness of the writing produced by the receiving pen. An instance of this is found when the transmitting pen, after having been moved from left to right, as for example in forming the up stroke of the letter l is moved backward, to form the loop of the letter, in making the down stroke. In such a case as this the magnetic inertia of the magnet H would prevent it from responding fully to the reverse movement of the transmitting pen, and the result would be that the letter would be formed without the loop and thus an l would be con-

verted into an uncrossed t. Numerous other examples might be cited but this will sufficiently illustrate the action of the magnet which it is necessary to overcome. I have found, however, that this difficulty can be entirely overcome by so organizing the circuit *b* that whenever the movement of the transmitting pen is changed from right to left or left to right, there will at that time, in addition to the resistance taken from or added to the circuit by the corresponding movement of the rod 23, be an additional amount of resistance taken from or added to the circuit, thereby causing a sudden increase or decrease in the strength of the current at that time, which, acting upon the magnet H, will so change its energy as to cause it to reverse the movement of the lever 44 quickly and thus cause the receiving pen to respond instantly to the movement of the transmitting pen. For this purpose the circuit *b* is provided with a loop *e* in which is located a resistance O consisting of a cup or tube of mercury 74 to which one wire of the loop is connected and a carbon or graphite rod 75 to which the other wire of the loop is connected. The rod 75 is attached to a screw rod 76 which works in an arm 77 extending from one of the standards 50 in such manner that the rod 75 can be adjusted to vary the resistance. The rod 75 is connected to the loop *e* through the rod 76, arm 77 and standard 50.

Located in the circuit *b* between the ends of the loop *e* is a circuit making and breaking device which consists of an arm 68 which is held frictionally upon the shaft 18 by a spring 69 in such manner that any change in the direction of the rotation of the shaft caused by a change in the direction of the movement of the transmitting pen will at once impart a rocking movement to the arm. The end of the arm 68 is arranged to play between a stop 70 and a contact point 72 carried by a bracket 71 rising from the top of the other of the standards 50. The arm 68 is provided upon one side with a piece of insulating material 73 which when it is rocked in that direction prevents it from forming an electrical connection with the bracket 71. When the arm is rocked in the opposite direction, however, it comes into contact with the contact point 72 and forms an electrical connection with the bracket 71 and thence with the standard 50. One wire of the circuit *b* is connected to the contact point 72 through the standard 50, while the other is connected to the arm 68 through the standard 49 and shaft 18.

The operation of this part of the system is as follows:—Assuming the transmitting pen to be moving from left to right, the shaft 18 will rock the arm 68 away from the contact point 72 so as to break the circuit *b* at that point. The current will then pass through the resistance B and also through the loop *e* and its resistance O. This will continue as long as the pen continues to move from left to right. Immediately upon the movement of the pen in the opposite direction, even though the movement is very slight, the arm 68 will be rocked in the reverse direction, thereby closing the main circuit *b* and cutting out the resistance O. This will give a sudden increase to the current and to the energy of the magnet H to overcome the magnetic inertia referred to and cause the receiving pen to respond promptly to the reverse movement of the transmitting pen. Upon the movement of the pen being again reversed to proceed from left to right the arm 68 will be rocked back to its other position so as to break the circuit *b* and throw the resistance O into the circuit, thereby suddenly reducing the strength of the current and the energy of the magnet H so that the springs 30 will cause the receiving pen to quickly respond to the reverse movement of the transmitting pen. This will take place whenever the movement of the pen is changed from one direction to the other. The circuit *c* may be provided with a similar apparatus to overcome the inertia of the magnet G, but in ordinary writing this will not be found necessary.

If the wires of the circuits *b c* and the loop *e* are connected to the several parts as herein shown, the several parts must be suitably insulated unless, as in the present case, the table D is of insulating material.

In conclusion it is to be remarked that modifications may be made in many of the details of the organization without departing from the essential features of the invention. While the construction herein shown and described is believed to be the best for carrying the invention into practical operation, it is still to be understood that the invention relates more particularly to the general organization of the system than to the details of the apparatus. A few more of the general modifications which may be made will, however, be referred to.

The receiving pen may in some cases be a simple pencil or stylus, and in such cases the apparatus for supplying the ink will be dispensed with, or where ink is used other means may be employed to stop the flow of the ink to break the line.

If, instead of producing a simple written message, it should be desired to capacitate the system to transmit and reproduce diagrams or pictures, all that will be necessary is to so proportion the parts as to give the transmitting and receiving pens the proper range of motion in both directions.

The breaking of the circuit *c* to raise the receiving pen may be effected by a special key provided for that purpose instead of by the transmitting pen.

The paper in the receiving instrument instead of being shifted by a weight controlled by the escapement, may be shifted by a positive feed operated by the magnet L; so also a weight or weights may be employed in place of the springs 30.

The means herein illustrated for support-

ing or holding the paper or other recording surface or surfaces at rest during the sending and reproducing of the message, may also be modified, but in all cases there must be some suitable means for this purpose; so also the means for shifting the paper may be modified, or in some cases wholly omitted without departing entirely from the invention.

It has been stated that the movements necessary to reproduce the characters, instead of being imparted to the receiving pen may be wholly or in part imparted to the paper. This will be a simple reversal of the parts and is to be considered as, in a broad sense, the equivalent of correspondingly moving the pen. It is to be understood, therefore, that wherever the paper is referred to as "stationary" or "at rest," that term simply means that the paper has no independent feeding movement while the writing is in progress, and it is also to be understood that where the movement of the receiving pen is referred to, that also includes the equivalent movement of the paper.

In a practical embodiment of the system it will usually be necessary to have one of the transmitting instruments and one of the receiving instruments located at each station so that messages can be both sent and received at any station. In such case it will be desirable to utilize the same circuits for operating both instruments. This can readily be done by providing a switch apparatus by which the transmitter or receiver can be switched into or cut out of the circuits.

It is to be understood that the terms "writing," "message" and "character," as herein used, include any matter, such as pictures, maps, drawings, diagrams and arbitrary characters of all kinds, as well as ordinary and shorthand writing; also that the terms "paper" and "recording surface" include any surface suitable for receiving writing or from which writing or printing already made is to be traced.

Under the term "electrical effects" as used in the claims, I intend to include variations of current strength, the production of pulsations, reversals of polarity of the current, and other manipulations of the current through which operations may be performed from a distance.

What I claim is—

1. The combination, substantially as before set forth, of a transmitting pen, a recording surface over which said pen is operated, means for supporting said surface at rest during the formation of characters by said transmitting pen, a receiving pen, and means for causing the receiving pen to reproduce the movements of the transmitting pen, substantially as set forth.

2. The combination, substantially as before set forth, of a transmitting pen, a recording surface over which said pen is operated, means for supporting said surface at rest during the formation of characters by said transmitting pen, means for shifting the position of said recording surface while the operation of the transmitting pen is suspended, a receiving pen, and means for causing the receiving pen to reproduce the movements of the transmitting pen, substantially as set forth.

3. The combination, substantially as before set forth, of a transmitting pen, a recording surface over which said pen is operated, means for supporting said surface at rest during the formation of characters by said transmitting pen, electrical connections with a receiving station, means for producing electrical effects upon said electrical connections through the movement of the transmitting pen, a receiving pen and means for transmitting said electrical effects into movements of the receiving pen reproducing the movements made by the transmitting pen.

4. The combination, substantially as before set forth, of a transmitting pen, a recording surface over which the pen is operated, means for supporting the recording surface at rest during the formation of characters by the transmitting pen, two electric circuits and currents for the same, two mechanisms for producing a series of electrical effects in each of said circuits respectively, said mechanisms responding respectively to movements of the transmitting pen in two directions crosswise of each other, a receiving pen, and two mechanisms for driving the same in two directions crosswise of each other, said pen driving mechanisms being caused to operate upon the receiving pen by the said two series of electrical effects respectively.

5. The combination, substantially as before set forth, of a transmitting pen, a recording surface over which the pen is operated, means for supporting the recording surface at rest during the formation of characters by the transmitting pen, two electric circuits and currents for the same, two mechanisms for producing a series of electrical effects in each of said circuits respectively, said mechanisms responding respectively to movements of the transmitting pen in two directions crosswise of each other, a receiving pen, two mechanisms for driving the same in two directions crosswise of each other, said pen driving mechanisms being caused to operate upon the receiving pen by the said two series of electrical effects respectively, a recording surface over which said receiving pen operates, and means for supporting the last mentioned surface at rest while the characters are being reproduced thereby.

6. The combination substantially as before set forth, of a transmitting pen, a recording surface over which said pen is operated, means for supporting said surface at rest during the formation of characters by said transmitting pen, two electric circuits and means for varying the strengths of the currents over said circuits by the movement of said pen in two directions crosswise of each other, two re-

ceiving electro-magnets the positions of whose armatures are varied by the variations of said currents, a receiving pen operated in two directions crosswise of each other by said armatures, and a recording surface over which such receiving pen operates.

7. The combination substantially as before set forth, of a transmitting pen, a recording surface over which said pen is operated, means for supporting said surface at rest during the formation of characters by said transmitting pen, means for shifting the position of the recording surface when the writing is suspended, two electric circuits and means for varying the strengths of the currents over said circuits by the movement of said pen in two directions crosswise of each other, two receiving electro-magnets the positions of whose armatures are varied by the variations of said currents, a receiving pen operated in two directions crosswise of each other by said armatures, and a recording surface over which such receiving pen operates.

8. The combination substantially as before set forth, of a transmitting pen, a recording surface upon which said pen is operated, means for supporting said surface at rest during the formation of characters by said transmitting pen, two electric circuits and means for varying the strengths of the currents over said circuits by the movement of said pen in two directions crosswise of each other, two receiving electro-magnets the positions of whose armatures are varied by the variations of said currents, a receiving pen operated in two directions crosswise of each other by said armatures, a receiving recording surface, and means for supporting said receiving recording surface at rest while the characters are being reproduced.

9. The combination substantially as before set forth, of a transmitting pen, a recording surface upon which said pen is operated, means for supporting said surface at rest during the formation of characters by said transmitting pen, two electric circuits and means for varying the strengths of the currents over said circuits by the movement of said pen in two directions crosswise of each other, two receiving electro-magnets the positions of whose armatures are varied by the variations of said currents, a receiving pen operated in two directions crosswise of each other by said armatures, a receiving recording surface, means for supporting said receiving recording surface at rest while the characters are being reproduced and means for shifting the position of one of the recording surfaces when the writing and reproduction of the characters are suspended.

10. The combination with a transmitting pen, of an electric circuit, means connected with said pen for varying the strength of the current over said circuit in accordance with the movements of said pen, and means also connected with said pen for imparting an additional abrupt variation to the strength of the current when the movement of the pen is reversed, substantially as set forth.

11. The combination with the transmitting pen and two electric circuits, of means connected with said pen for varying the strengths of the currents over said circuits in accordance with the movements of said pen and means also connected with said pen for imparting an additional abrupt variation to the strength of the current over one of the circuits when the movement of said pen is reversed, substantially as described.

12. The combination with the transmitting pen and two electric circuits, of means connected with said pen for varying the strengths of the currents over said circuits in accordance with the movements of said pen, an auxiliary resistance located in a loop of one of said circuits, and a circuit making and breaking device also connected with said pen, whereby said auxiliary resistance is thrown into or cut out of the circuit whenever the direction of the movement of the pen is reversed, substantially as described.

13. The combination with an electro-magnet and means for varying the strength of the current passing through the same, of an armature arranged to oscillate in the field of said magnet, and two springs or their equivalent arranged upon opposite sides of the oscillating axis, to antagonize the action of the magnet upon said armature, the said springs tending to rotate the armature in one direction and each balancing the pull of the other upon the axis of the armature, whereby the friction of the armature in its bearings is minimized, substantially as described.

14. The combination with an electro-magnet and means for varying the strength of the current passing through the same, of an armature mounted on a pivot placed between the armature poles and arranged to oscillate in the field of the magnet, and a receiving pen operated by said armature substantially as described.

15. The combination with two electro-magnets and means for varying the strengths of the currents passing through them, of two armatures mounted on pivots placed respectively between the armature poles of each magnet and arranged to oscillate in the fields of said magnets, and a receiving pen operated in two directions crosswise of each other by said armatures, substantially as described.

16. The combination with an electro-magnet and means for varying the strength of the current passing through the same, of an armature arranged to oscillate in the field of said magnet and fitted with a coil for conducting an electric current and a receiving pen operated by said armature, substantially as described.

17. The combination with an electro-magnet and means for varying the current passing through the same of an armature arranged to oscillate in the field of said magnet, and fitted with a coil for conducting an elec-

tric current, and connections between the coils of the magnet and the coil of the armature so that the same current may be conducted through all and a receiving pen operated by said armature, substantially as described.

18. The combination with two electro-magnets and means for varying the strengths of the currents passing through them, of two armatures mounted on pivots placed respectively between the armature poles of each magnet and arranged to oscillate in the fields of said magnets, and two arms or levers connected together operated by said armatures and extending in two directions crosswise of each other, substantially as described.

19. The combination with the receiving instrument and the electric circuits for operating the same, of devices for shifting the recording surface in said instrument, an electro-magnet for controlling said devices located in a branch of one of said circuits, and means under the control of the operator for sending the current through said branch, substantially as described.

20. The combination with the transmitting and receiving instruments and the electric circuits for operating the latter, of devices for shifting the recording surface in each of said instruments, an electro-magnet located in a branch of one of said circuits for controlling the said shifting devices in the receiving instrument, and means whereby the act of shifting the paper in the transmitting instrument operates to close said branch to permit a part of the current to pass through the same, substantially as described.

21. The combination with the transmitting and receiving instruments and the electric circuits for operating the latter, of devices for shifting the recording surface in each instrument, an electro-magnet located in a branch of one of said circuits for controlling said shifting devices of the receiving instrument, means whereby the act of shifting the paper in the transmitting instrument operates to first break one of the circuits and thereby close the branch of the other circuit, and then close the circuit broken and thereby break the branch, substantially as described.

22. The combination with the transmitting pen and the rod 10 of the flexible connection by which the pen is free to be adjusted to any inclination in any direction, substantially as described.

23. The combination with the transmitting pen and the sliding rods 14, of the cords 16 and pulleys 17, substantially as described.

24. The combination with the transmitting pen and the sliding rods 14, of the cords 16, pulleys 17, 19, cords 20 and rods 21, substantially as described.

25. The combination of a telautographic pen, a rod to which the pen is connected, a shaft, a pulley as 17 mounted upon the shaft, and a cord as 16 passing around the pulley and connected at each end to the pen rod, substantially as set forth.

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

ELISHA GRAY.

Witnesses:
T. H. PALMER,
J. J. KENNEDY.