E. F. NORTHRUP.

ELECTRICAL RECORDER.

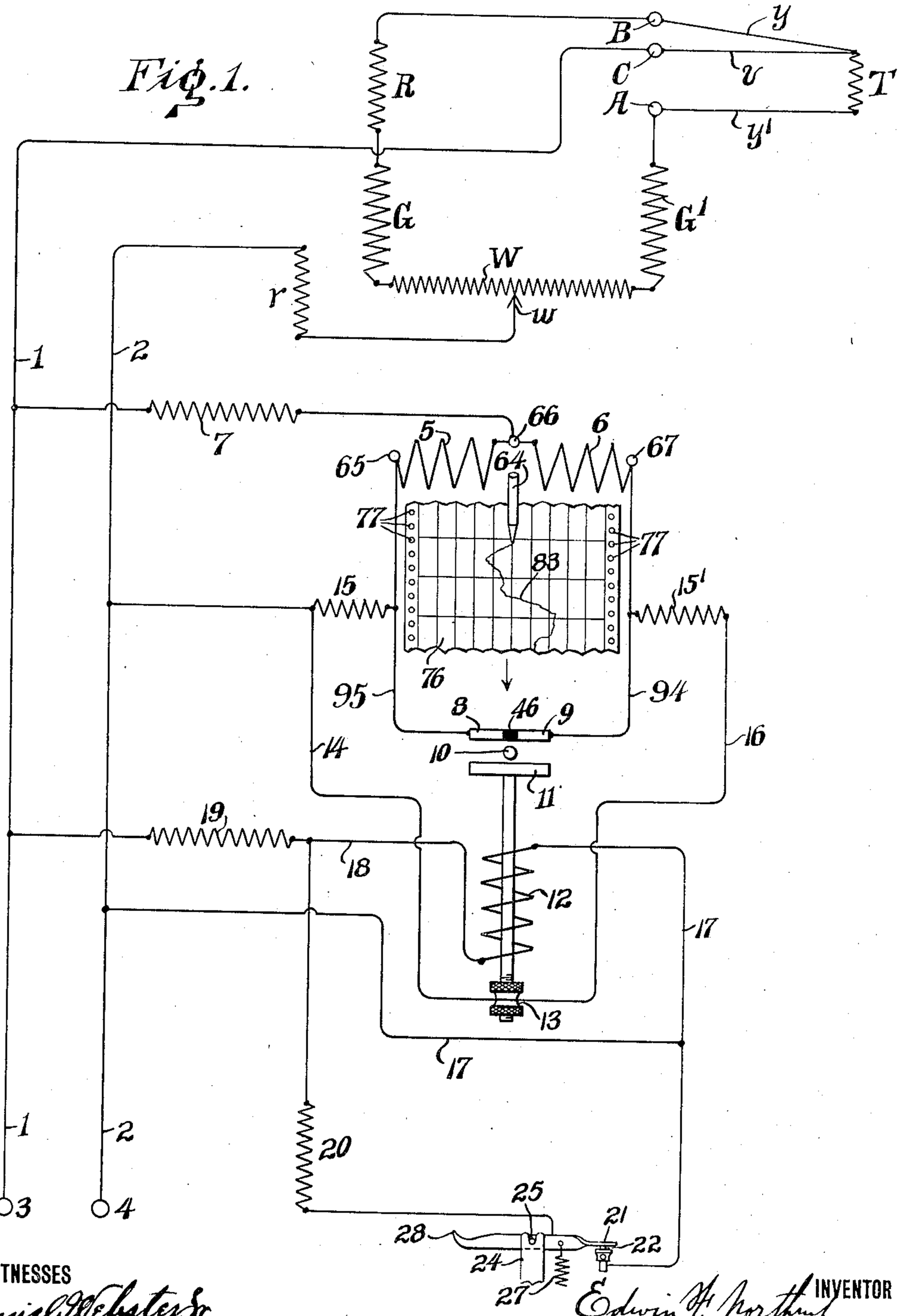
APPLICATION FILED FEB. 16, 1909.

950,555.

Patented Mar. 1, 1910.

4 SHEETS—SHEET 1.

Fig. 1.



WITNESSES

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4 SHEETS—SHEET 2.

Fig. 3.

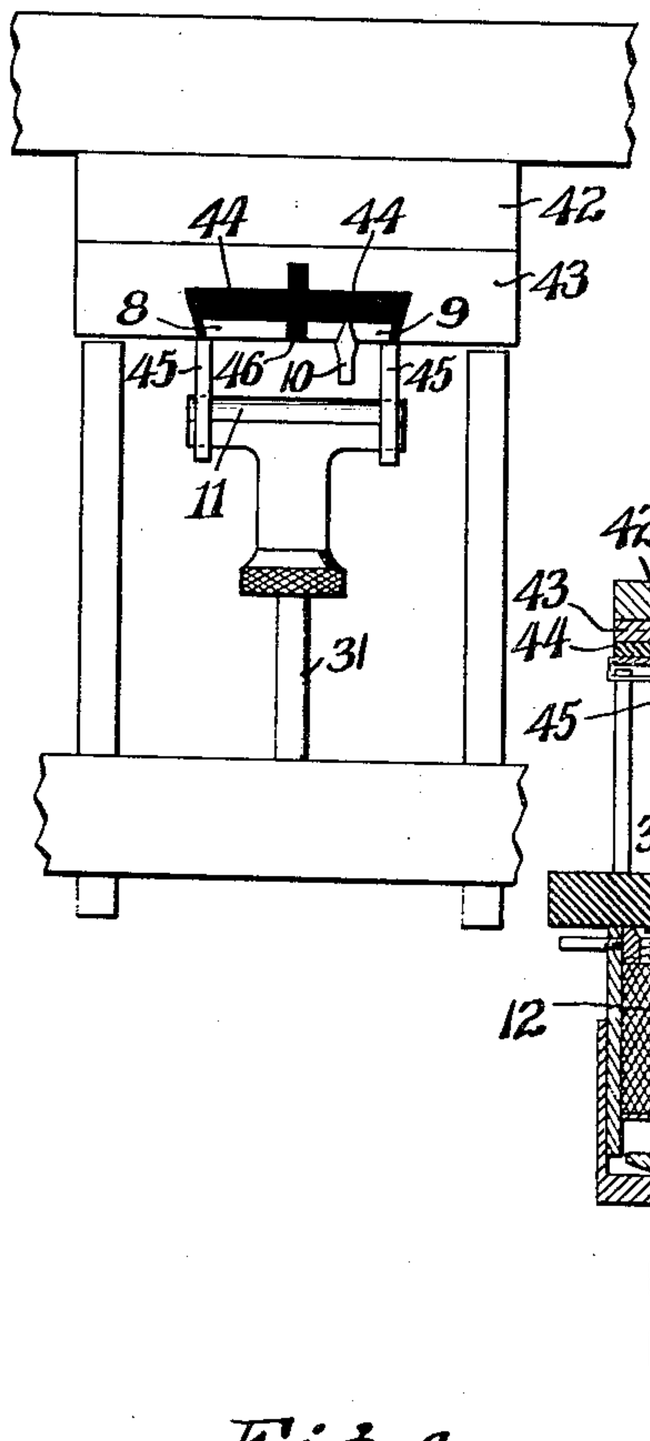

Fig. 2.

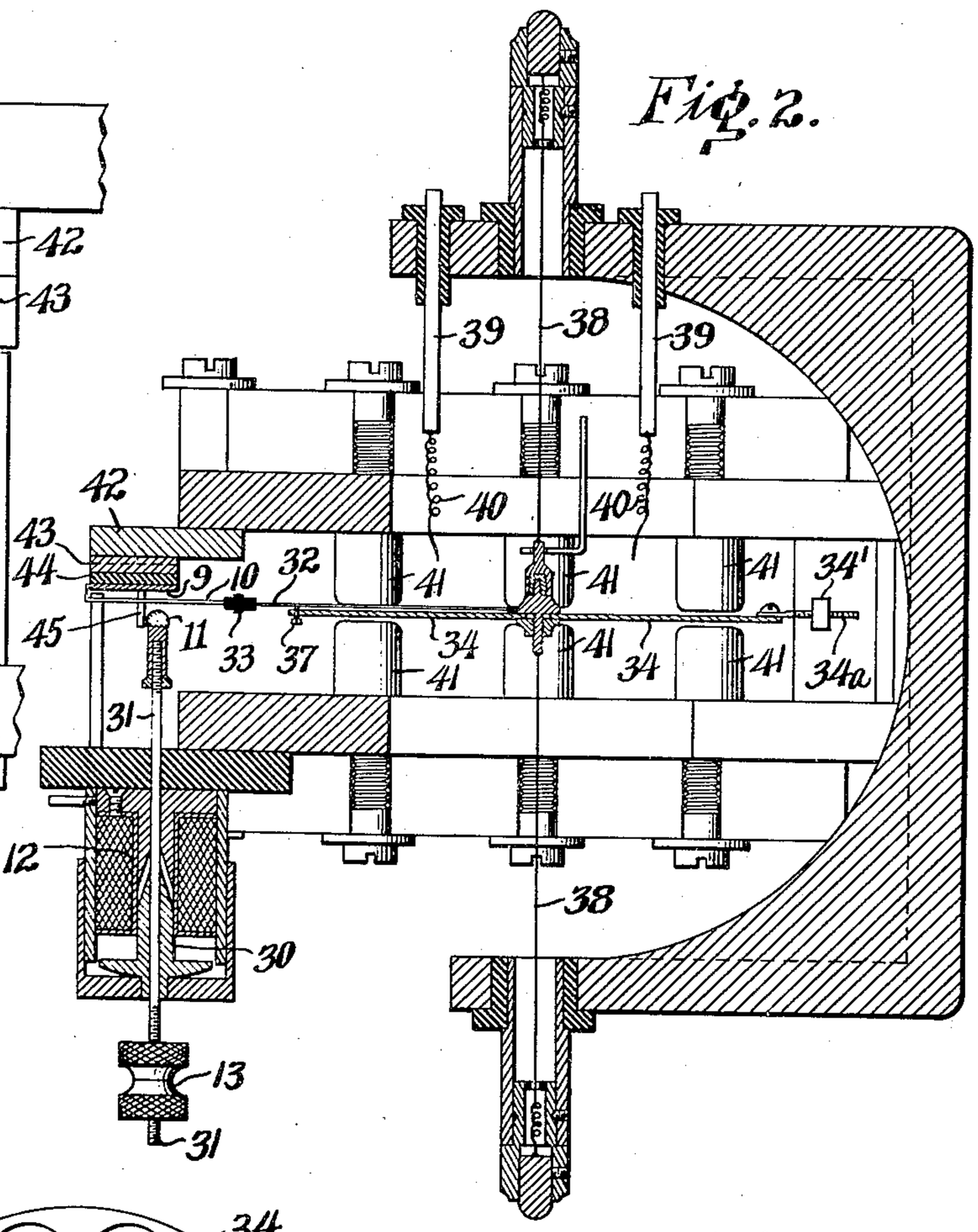

Fig. 4.

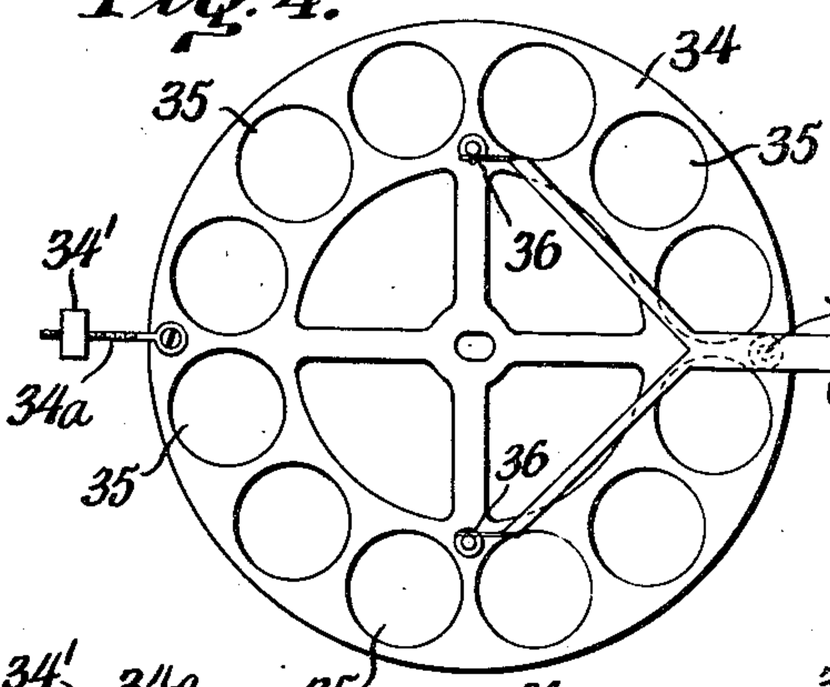

Fig. 14.

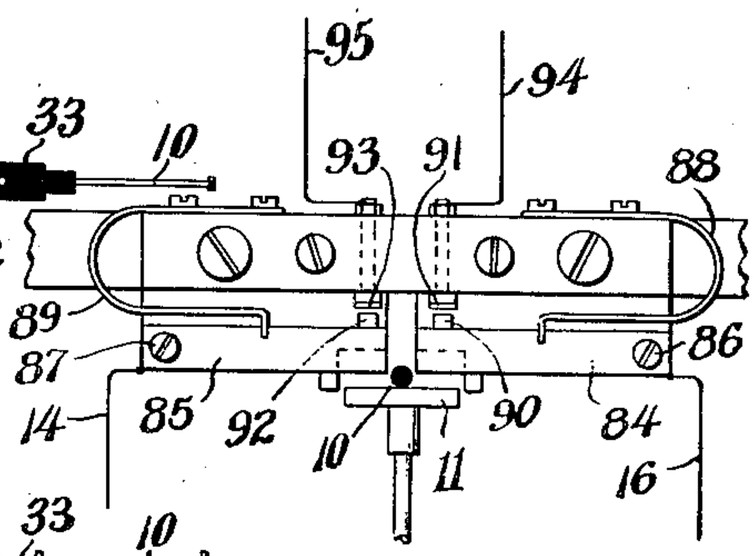

Fig. 5.

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4 SHEETS—SHEET 3.

Fig. 8.

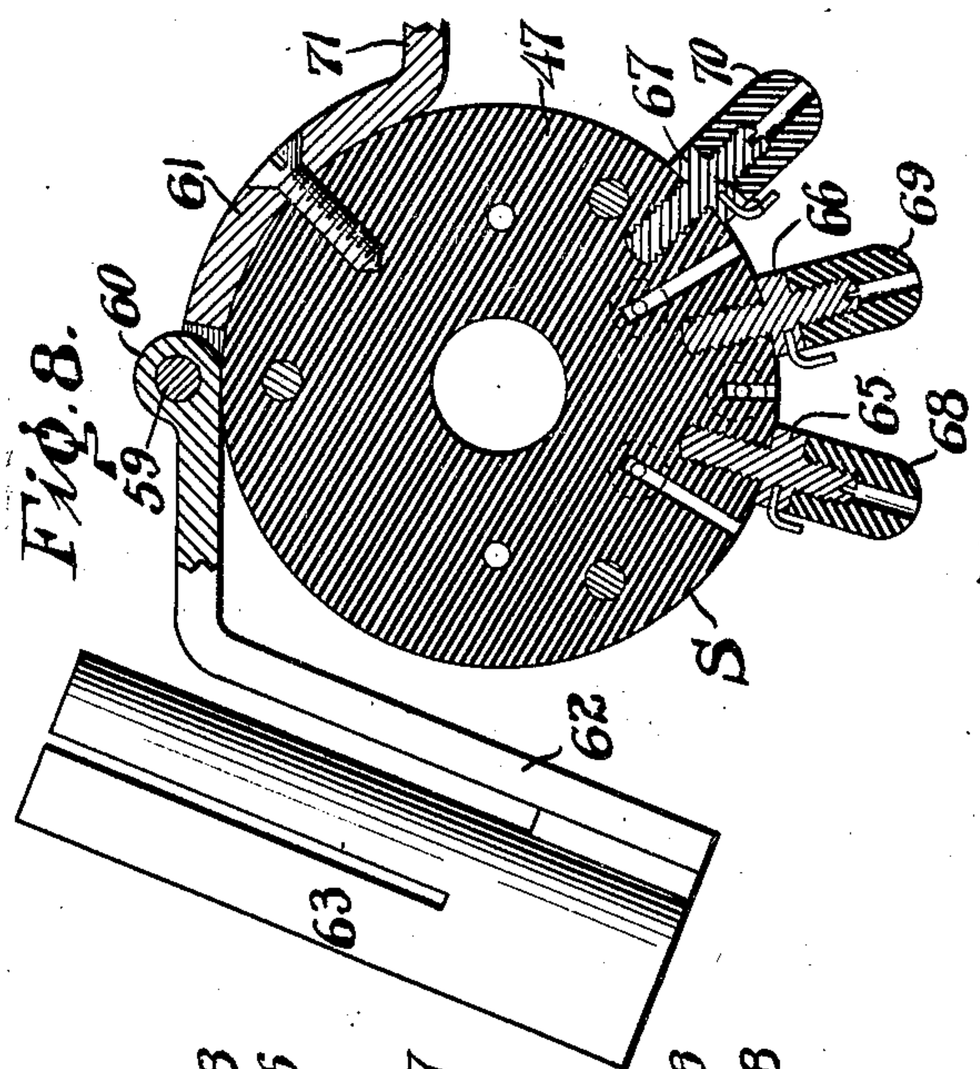


Fig. 9.

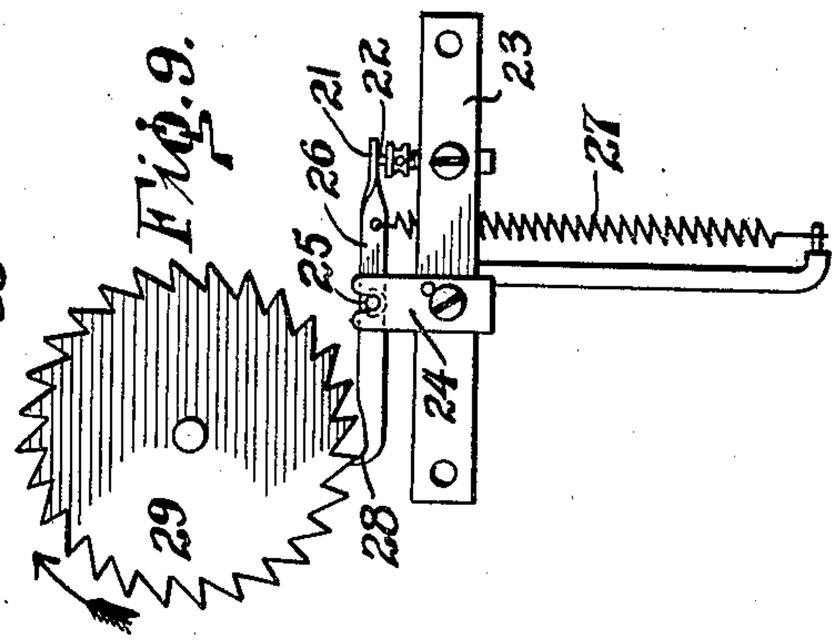


Fig. 6

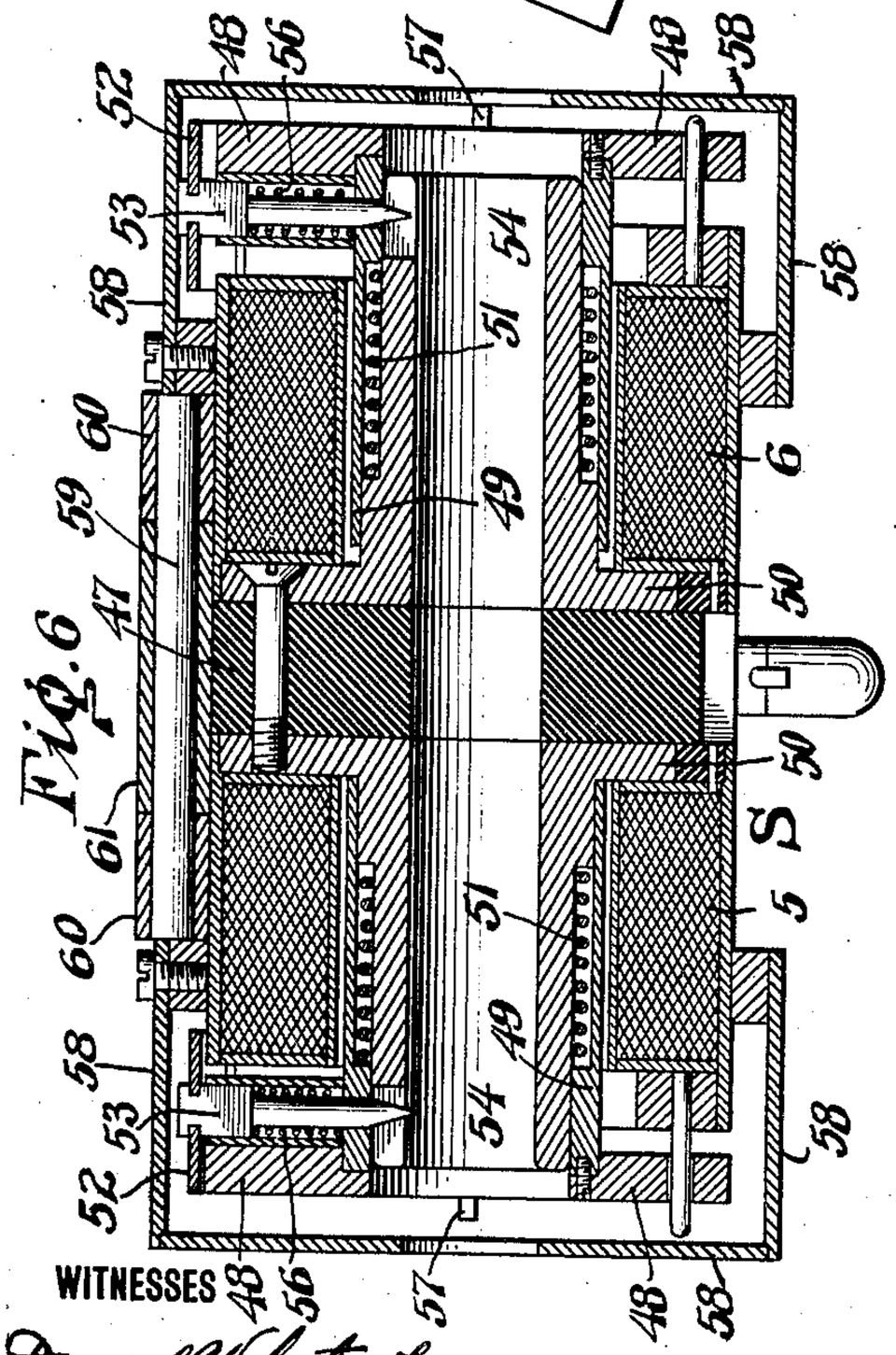
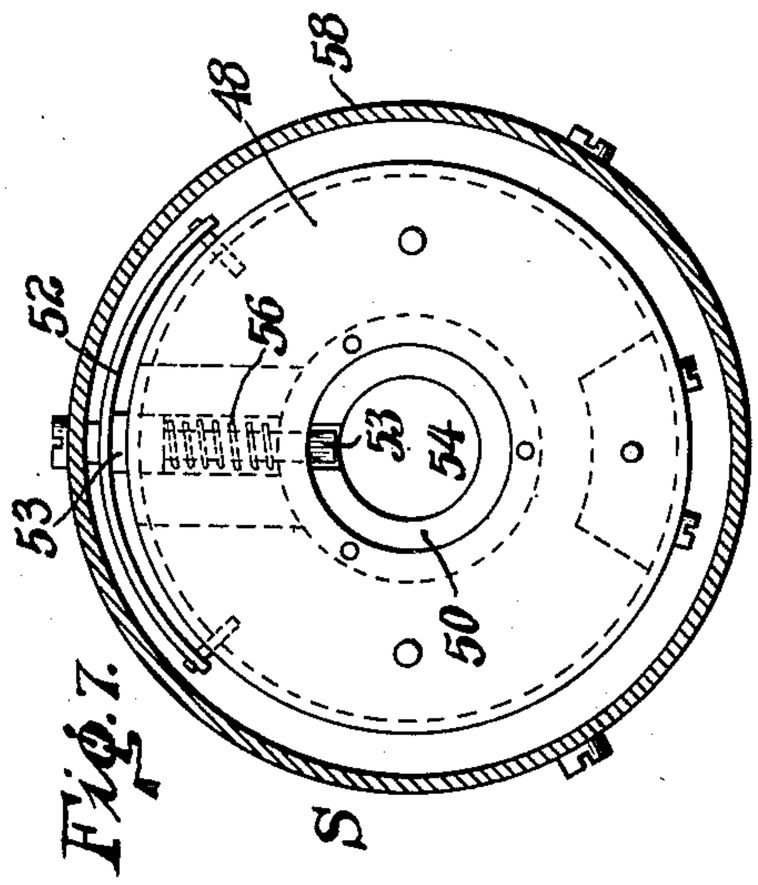


Fig. 7.



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APPLICATION FILED FEB. 16, 1909.

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4 SHEETS—SHEET 4.

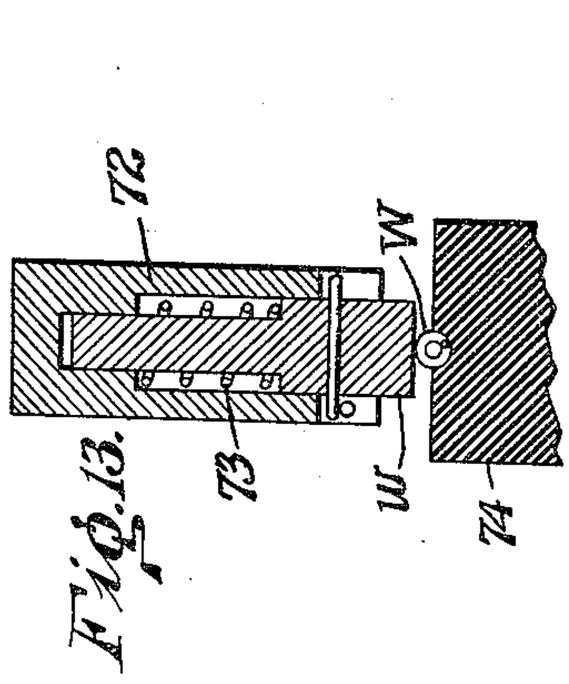

Fig. 13.

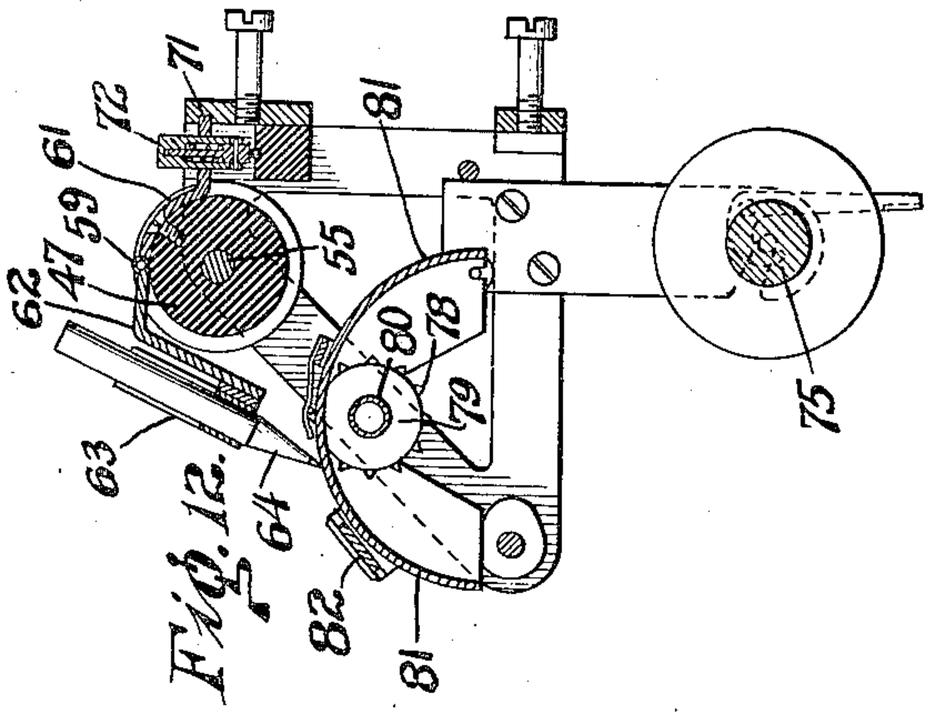

Fig. 12.

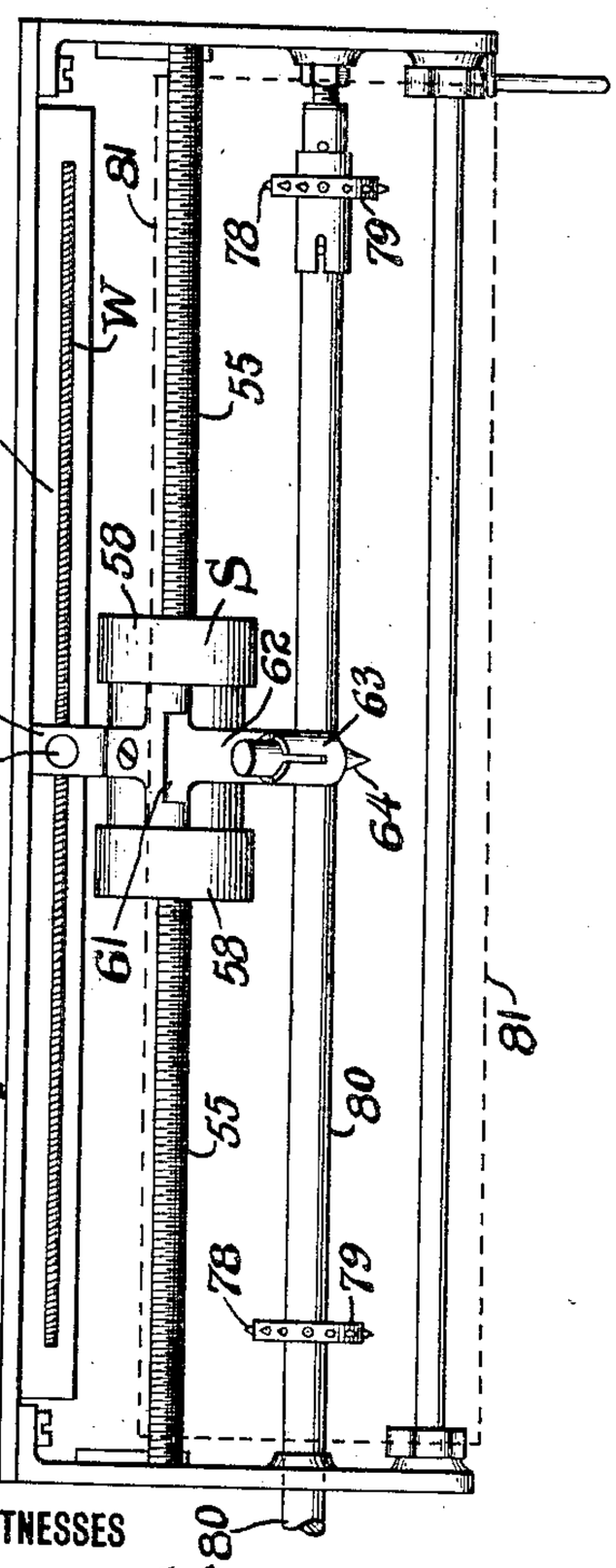

Fig. 10.

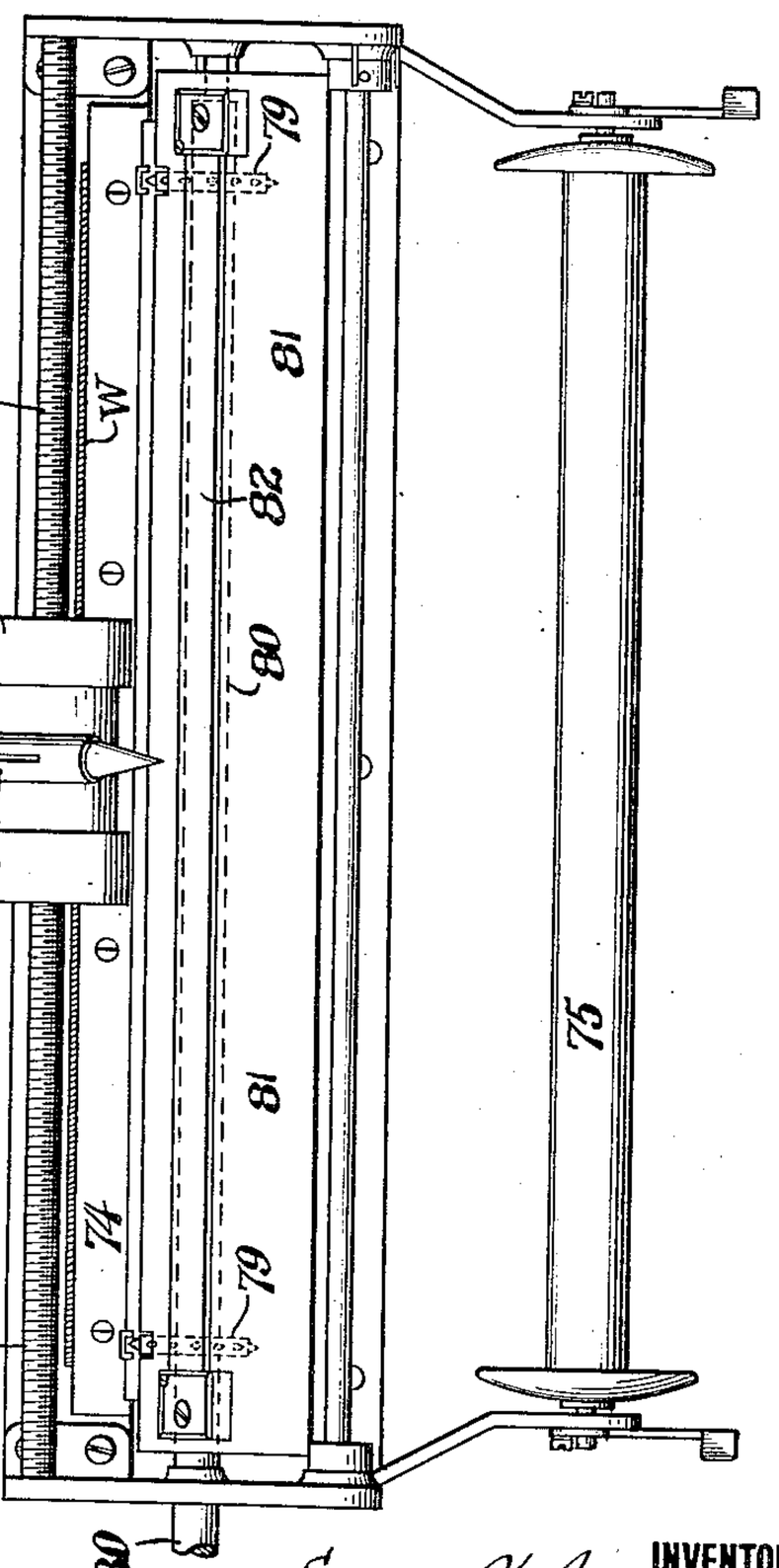

Fig. 11.

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UNITED STATES PATENT OFFICE.

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ELECTRICAL RECORDER.

950,555. Specification of Letters Patent. Patented Mar. 1, 1910.

Application filed February 16, 1909. Serial No. 478,144.

To all whom it may concern:

Be it known that I, EDWIN F. NORTHRUP, a citizen of the United States, residing in the city of Philadelphia, county of Philadelphia, and State of Pennsylvania, have invented new and useful Improvements in Electrical Recorders, of which the following is a specification.

My invention relates to a system of and apparatus for electrically recording physical, electrical, chemical, mechanical, or other quantities.

My invention resides in a system of and apparatus for continuously recording such magnitudes or quantities as they change or vary with time, the magnitudes or quantities being represented electrically, and the corresponding electrical variations or changes being employed to actuate or control recording apparatus.

As herein shown, my system and apparatus are employed for making a continuous record of temperature variations or changes, but my invention is not limited to temperature recording.

It is characteristic of my invention that a selector is provided for choosing or selecting a path along which energy (mechanical, electrical, or other energy) shall flow or shall be transmitted, the selecting apparatus being suitably controlled or actuated in response to the magnitude to be recorded; and the continuance or amount of energy flow over the selected path is preferably in no way determined by the selector. In or as the selecting apparatus, I may employ a galvanometer, ohmmeter, relay, or any other suitable device which shall control or cause the selection of a path along which energy shall flow or be transmitted, a periodically controlled or operating device coöperating with the galvanometer or other device so that a path may be periodically selected, depending upon the deflection or other condition or operation of the galvanometer or other device. And as a result of the selection of a path, step-by-step recording mechanism is actuated or controlled, the step-by-step mechanism moving always by equal increments, the number of increments of movement being dependent upon or proportional to the number of times energy is transmitted along a selected path before the moving system of the selector returns to zero or balance position.

In one of the forms my invention may take, I employ a differential galvanometer as the selector or a part of the selector mechanism, the current through the galvanometer doing no work other than merely to deflect its moving system. And a periodically operating or actuated device periodically engages a normally freely moving needle or other member carried by the moving system of the galvanometer or other selector, the result of the engagement being the closure of a path along which mechanical, electrical, or other energy may be transmitted to control or actuate the recording mechanism. In making the selection of a path, the selector is required to do no work other than to move its own moving system, whereas the amount of energy transmitted over the path selected may be as great as desired; and the energy so available over a selected path is periodically controlled by any suitable means not connected with the selector.

It is a further feature of my invention that the moving system of the galvanometer or other selector comes to rest or substantially to rest in a time which is slightly less than the period during which the needle or other member carried by the selector moving system is free from control by the periodically operating means. By preference, the moving system of the galvanometer or selector is made aperiodic and the natural period of the moving system of the galvanometer or selector is slightly less than the period during which the galvanometer or selector needle or member is free from the periodically coöperating mechanism.

My invention resides also in the mechanism for moving the pen, pencil, or other marker for producing the record. And my invention resides in other features of system and apparatus hereinafter described and pointed out in the claims.

For an illustration of one of the forms my invention may take, reference is to be had to the accompanying drawings, in which:

Figure 1 is a diagrammatic view of the parts and circuit arrangements involving my invention and as used, for example, in recording temperature. Fig. 2 is a vertical sectional view, some parts in elevation, through the differential galvanometer and the contacting device. Fig. 3 is a front elevation, on larger scale, of a part of the gal-

vanometer, showing the contacting device. Fig. 4 is a plan view of moving coils and support, and a galvanometer needle or pointer carrying a contact. Fig. 5 is a cross sectional view of Fig. 4, some parts being shown in elevation. Fig. 6 is a longitudinal cross sectional view, some parts in elevation, of the step-by-step mechanism for moving the pen or marker. Fig. 7 is an end elevational view of the step-by-step mechanism shown in Fig. 6, the casing being shown in section. Fig. 8 is a central transverse section of Fig. 6, the pen or marker holder being shown partially in elevation. Fig. 9 is an elevational view of the contacts and their actuating mechanism for controlling the periodic contacting device. Fig. 10 is a top plan view of the paper holding and moving mechanism with the associated step-by-step mechanism and movable contact. Fig. 11 is a front elevational view of the parts shown in Fig. 10. Fig. 12 is a transverse sectional view, some parts in elevation, of the parts shown in Figs. 10 and 11. Fig. 13 is a sectional view of the movable contact in operative relation to the associated conductor. Fig. 14 is a front elevational view of a modified arrangement for selecting a path along which energy is to be transmitted.

Referring to Fig. 1, T is an unknown resistance to be measured, or may be any other resistance, and in electric thermometry is the bulb or thermometer resistance. v, y and y^1 are the thermometer leads, G and G^1 are the two differential windings of the galvanometer, R is a fixed resistance, and W is a conductor with which engages the contact w, movable by the step-by-step mechanism, for restoring balance. r is a resistance inserted with either of the conductors 1 or 2 leading from the binding posts 3 and 4 connected to any suitable source of energy, such, for example, as a commercial lighting or power circuit of 110 volts or other pressure. As thus far described, the circuit arrangement is that of my prior application Serial No. 466,242. And the law and principle of this circuit arrangement with the differential galvanometer, as described in my aforesaid application, are different from those of the Wheatstone bridge, potentiometer, or other arrangements wherein a simple galvanometer has its winding and arm of a Wheatstone bridge or the like for giving deflections when there is an unbalanced condition. In a Wheatstone bridge, or like arrangement, the galvanometer and source of energy are interchangeable, whereas in my arrangement above described it is impossible to interchange the source of energy and galvanometer, from the very nature of the galvanometer and its circuit arrangements.

The windings 5 and 6 are those of the two electro-magnets of the step-by-step mechanism which moves the pencil or marker and the contact w over the conductor W. Between the conductor 1 and the common terminal of the windings 5 and 6 there is inserted a suitable resistance 7 for reducing the current flow through the windings 5 and 6. The other terminals of the windings 5 and 6 connect respectively to the contact plates 8 and 9 supported in operative relation with the normally freely moving contact 10 carried by the moving system of the differential galvanometer. A contact 11 is adapted to be moved upwardly to engage the contact 10 to clamp it between contact 11 and either of the contacts 8 or 9, upon the energization of the solenoid or magnet of the contacting device whose winding is 12. From the contact 8 to the binding post 13 extends a conductor 14 in which is connected a resistance 15. And, similarly, from contact 9 to the binding post 13, extends a conductor 16 in which is connected a resistance 15′, the conductors 14 and 16 being in electrical communication through the binding post 13 with the contact 11. The winding 12 is connected across the conductors 1 and 2 by the conductors 17 and 18, a resistance 19 intervening. In shunt to the winding 12 is connected a circuit including the resistance 20 and the contacts 21 and 22 which are normally in engagement with each other, and when so in engagement they shunt the winding 12 to deënergize the same. When the contacts 21 and 22 separate, the winding 12 is energized and operates the contact 11. As seen in Fig. 9, the contact 22 is adjustably mounted upon the support 23. In a bracket 24 there is pivoted at 25 a lever 26 whose outer end carries the coöperating contact 21. The contacts 21 and 22 are normally held in engagement by the action of a spring 27. At the opposite end of the lever 26 there is a hook-like termination 28 with which engage the teeth of the wheel 29 forming part of or associated with a clock mechanism, the direction of rotation being that indicated by the arrow. As the wheel 29 rotates a tooth engages the hook 28 and slightly tilts the lever 26 to separate contacts 21 and 22 a short distance. This distance may be made very short indeed, because the contacts 21 and 22 are in a shunt circuit where practically no sparking will occur. And from the fact that the lever 26 need be shifted only very slightly, there is only slight engagement between the teeth of the wheel 29 and the hook 28, thus introducing a minimum of friction and requiring the clock mechanism to do a minimum of work. And from the relatively slight overlap of the teeth and hook 28, flows a further result that actuation of the lever 26 is nicely timed, and the separation of the contacts 21 and 22 is relatively short.

As seen in Fig. 2, 12 is the winding of a solenoid having the movable core 30 having

attached thereto the rod 31 carrying on its upper end the contact 11, the binding post 13 being attached to the rod 31 for purposes of making electrical connection with the contact 11. Just above the contact 11 is the contact 10 carried by the needle or pointer 32 of the galvanometer, and insulated from the needle or pointer 32 at 33. The needle 32 is in turn carried by the aluminum disk 34 carrying a plurality of flat windings or coils 35. The needle or pointer 32 is pivoted or hinged to the aluminum disk 34 at 36, 36, so that when the winding 12 is energized the contact 11 lifts the contact 10 and clamps it into engagement with either of the stationary contacts 8 or 9, the pointer or needle 32 moving during such action upon its hinges or pivots. An adjusting screw 37 passes through the disk 34 and engages the under side of the pointer or needle 32, so as to determine or adjust its normal elevation. A counterweight 34′ is adjustable upon the screw 34ª carried by the disk 34.

The moving system of the galvanometer has a filar or torsion suspension by means of the conducting wires 38, 38 which are insulated from each other and serve as the terminals of one of the differential windings of the moving system. The insulated studs 39, 39 serve as the terminals for the other differential winding, flexible connections 40, 40 leading from the studs 39, 39 to the other differential winding also carried by the disk 34. The coils 35 are preferably bifilarly wound, that is, each coil 35 is made up of two windings, these two separate windings constituting the differential windings of the instrument. These bifilarly wound coils are differentially wound or connected and are supported in a magnetic field maintained by permanent magnets having the pole pieces 41 which are preferably disposed with respect to the coils in the manner described in Letters Patent of the United States No. 800,873, and the moving system suspension is substantially that described in said Letters Patent. It is to be understood, however, that this invention is not limited to a galvanometer of this type.

At the front of the galvanometer upon a plate 42 is secured a plate 43 upon which is secured insulation 44, such as ivory, upon which are secured the silver or other contacts or plates 8 and 9 insulated from each other and from the frame or parts of the galvanometer.

As seen in Fig. 3, in larger scale, the contact 10 may swing to right or left beneath the contacts 8 and 9, the studs or pins 45 serving as stops and serving also to prevent the T shape head carrying the contact 11 from turning.

As heretofore stated, the clock mechanism driving wheel 29 causes a periodic energization of the winding 12 and, therefore, a periodic clamping of the contact 10 between the contact 11 and either of the contacts 8 or 9, if the galvanometer is deflected. If the galvanometer is in balance, the needle 10 will come opposite the space or insulation 46 and no circuit will be completed to energize or actuate the step-by-step mechanism carrying the marker. The winding 12 is energized, say, every two seconds, and the duration of the clamping of the contact 10 is, say, $\frac{1}{5}$ of a second. The moving system of the galvanometer is strongly damped or aperiodic, and the natural period of the moving system is slightly less than the period during which the galvanometer needle or pointer contact is free of the periodic clamping or contacting mechanism. In consequence, the moving system is "dead beat" and having the natural period, as stated, will immediately move, without oscillations, to a new position, and arrive at that new position and come to rest before the next clamping or contacting operation.

As an example of a step-by-step mechanism which may be employed for moving the pen or marker and the contact *w*, reference is to be had to Figs. 6, 7 and 8, which show a substantially cylindrical device S comprising the two electro-magnets having the windings 5 and 6 secured to the central mass of insulation 47. Each electro-magnet has an armature 48 having the cylindrical shank 49 adapted, when the winding is energized, to move until limited by the engagement with the flange 50. A spiral spring 51 serves to hold each armature in unattracted position. Carried by each member 48 is a loosely mounted iron strap 52 which, upon the energization of the winding, is adapted to be immediately attracted radially to cause the pointed member 53 to project into the longitudinal bore 54 through which extends a roughened or finely screw-threaded rod 55 (as shown in Figs. 10, 11 and 12) a spiral spring 56 serving to retract the pointed member 53 when the electro-magnet is deenergized. In Fig. 6, the winding 5 is shown as energized, the member 49 abutting against the flange 50 and the spring 51 being compressed. The subsidiary armature 52 is also shown attracted and the pointed member 53 projected into the bore to engage between the threads of the screw-threaded member 55, not shown in this figure. The winding 6, of Fig. 6, is shown as deënergized, the armature 48 being in retracted position and the subsidiary armature carrying the pointed member 53 being also unattracted. When either winding is energized, for example, winding 5, the armature 52 and the attracted pointed member 53, having relatively small inertia, are first actuated to grip the roughened or screw-threaded rod or member 55. This fixes the member 48, and further attraction causes the

winding and the remainder of the device to be attracted toward the member 48, until the flange 50 abuts against the end of the shank 49. By this operation, therefore, the whole device has been moved along the rod or member 55 a perfectly definite distance, and upon deënergization of the winding 5, the device remains in position but the spring 51 forces the armature 48 outwardly after the pointed member 53 has been released. Successive energizations of the winding 5 cause similar and equal spacings of the device toward the left as viewed in Fig. 6. Similarly, upon the energization of the winding 6, the device is stepped to the right a perfectly definite distance. The members 48 carry pins 57 which engage the inner end walls of the casing 58. These pins and the flanges 50 limit definitely the extent of movement of the step-by-step device.

Upon a pin 59 carried by the strap 60 secured to the central section 47 of insulating material, is pivoted, at 61, a member 62 which carries the pen, pencil, or other marker holder 63 into which may be slipped the pen, pencil, or other marker 64.

Binding posts 65, 66 and 67 are secured to the central insulating block 47 and provided with rubber or other caps 68, 69 and 70, respectively. These binding posts form the terminals of the two windings 5 and 6, the post 66 serving for the common terminal of those windings. And from these binding posts extend flexible connectors to be connected in accordance with the diagram of Fig. 1.

The strap 61 has a rearward extension 71 in which is mounted the member 72, in which is mounted the contact *w*, the spring 73 allowing the contact *w* to yield resiliently. On a strap of hard rubber or other suitable material 74 is mounted a conductor W which may be a straight conductor or may be a helical conductor constructed and mounted in any suitable manner as described, for example, in Letters Patent of the United States No. 862,842. And this conductor W may be of uniform resistance or cross section, and may also be shunted, all as described in said application Serial Number 466,242.

Upon a roller 75, Fig. 11, is wound and stored a record sheet 76, as of paper, or other suitable material. This sheet may have longitudinal and transverse lines thereon, the distances lengthwise of the sheet representing units of time, while distances measured transversely of the sheet indicate the quantities or magnitudes recorded. In the margins of the sheet 76 are a plurality of uniformly recurring perforations 77 in which engage the teeth or projections 78 upon the rolls or disks 79 (Figs. 10 to 12 inclusive) mounted upon a shaft 80 which is rotated at suitable rate by a clock mechanism or other suitable means, and when a clock mechanism, it may be the same clock mechanism of which the toothed wheel 29, Fig. 9, is a part. The sheet of paper when so fed is unwound from the roller 75 and passes over the outside surface of the hood or half cylinder 81, and under the guide 82, and the pencil or marker 64 rests upon the record sheet or paper. In Fig. 10, the position of this hood or half cylinder 81 is shown in dotted lines.

The operation is as follows: The clock mechanism constantly rotates the shaft 80 at uniform rate, thus feeding the paper from the roller 75 over the hood 81 and under the pen or marker 64, the marker tracing a straight line upon the record until the step-by-step mechanism S is actuated. When the temperature to be measured (taking temperature measurement as an example) changes or varies, the resistance of the thermometer bulb T changes or varies and will thus cause more current to pass through one of the galvanometer coils G or G^1 than through the other, causing the moving system of the galvanometer to deflect from the zero or balance position. In so doing, the moving system does no work, the contact 10 being freely carried through space. Supposing the deflection be toward the right, as viewed in Fig. 3, due to such unbalancing, at the following energization of the winding 12 of the contacting device, the contact 10 is clamped between the contacts 9 and 11, thus short circuiting the resistance 15′ and causing increased current to flow through the winding 6 of the step-by-step mechanism, such current being sufficient to cause the step-by-step mechanism to operate, the pointed member 53 being first attracted into engagement with the roughened or screw-threaded member 55 and then the device S attracted toward the right. This moves the marker or pencil a definite distance or increment across the record sheet 76. Simultaneously, however, the contact *w* is moved along the resistance conductor W in such direction as to tend to restore a balance of current in the two windings of the galvanometer. If this increment of movement of the step-by-step mechanism has been sufficient to restore a balance, the contact 10, carried by the galvanometer pointer, comes to mid position and upon the next energization of the magnet 12, the contact 10 will engage insulating material or, at any rate, will make no contact. If, however, balance has not been restored, the contact 10 will remain to the right, as viewed in Fig. 3, and the next energization of the magnet 12 will cause the step-by-step mechanism S to move another increment to the right. This action keeps up until a balance is restored. And, similarly, if the contact 10 be deflected toward the left, the step-by-step mechanism is moved toward the left until a balance is

reached. And thus moving backward and forward across the sheet, the marker or pencil produces a line record, as 83, indicated in Fig. 1. And the apparatus is so calibrated that the ordinates or transverse distances of the curve or line 83 read in temperature units, so that a record is produced showing what the temperature is at any particular time.

From the foregoing description, it is apparent that I do not use a Wheatstone bridge or potentiometer arrangement, but that I use a differential galvanometer the currents in whose coils or windings produce equal and opposite effects when there is a balance, but which produce a deflection when the currents in the two coils are unequal or when the ampere turns of the two windings are unequal. And it is apparent that there is always current in each of the galvanometer coils, which is an entirely different thing from a Wheatstone bridge arrangement where there is no current when a balance is reached. It is further apparent that the galvanometer is required to do no work, but that the periodic contacting device, which has available as much energy as may be required, intermittenntly engages the contact or member carried by the galvanometer moving system to control a step-by-step mechanism which moves always with equal increments of departure. The intermittent contacts are then all positive and uniform and are in no way dependent upon the current strength in the galvanometer. And the step-by-step mechanism dispenses with a motor or motors and consists of simple electro-magnets which are themselves incapable of producing continued movement, except when controlled by the remote periodic contact maker. It is to be understood, however, that some features of my system and apparatus are useful in connection with a simple galvanometer, and even in connection with a Wheatstone bridge, potentiometer, or other arrangement.

While I have here illustrated one form of step-by-step mechanism, it is to be understood that other forms of step-by-step mechanism may be employed and come within the spirit of the invention.

While the number 10 hereinbefore described has been shown as a contact to close or control an electrical circuit, such member 10 may be used simply as a mechanical device, as shown in Fig. 14, which, when deflected to right or left, and when raised by the member 11, may engage one or the other of the two levers 84 or 85 pivoted, respectively, at 86 and 87. The levers 84 and 85 are pressed downwardly by the springs 88 and 89, respectively. When the moving system of the selector or galvanometer is in zero or balanced position, the member 10 is in a position between the ends of the levers 84 and 85, and when raised by the periodically operated member 11, the member 10 does not engage either of the levers. When the member 10, which may be of insulating material, is deflected, it is raised by the member 11 into engagement with the under side of either one of the levers 84 and 85 and the member 11 then transmits mechanical energy through the member 10 to lift either one of the levers in opposition to its spring. The lever 84 carries a contact 90 which, when the lever is raised as aforementioned, is adapted to engage the contact 91. And, similarly, a contact 92 is carried by the lever 85 which is adapted to engage the contact 93. The two contacts 90 and 92 are electrically connected together since each is in electrical communication with its supporting lever 84 or 85, of metal or other conducting material, which are in electrical communication with each other. From the lever 84 extends the conductor 16, and from the lever 85 extends the conductor 14, these being the same conductors as shown in Fig. 1. And from the contact 91 extends the conductor 94 and from the contact 93 extends the conductor 95 both shown in Fig. 1. The operation is the same as described heretofore in connection with the other figures of the drawing and Fig. 1, except that the member 10 operates simply as a mechanical medium through which the power of the member 11 is transmitted to actuate the levers 84 and 85 to make contacts for controlling the step-by-step mechanism. And while I have shown a system for recording temperatures, it is to be understood that my system and mechanism are applicable for other purposes, as hereinbefore stated.

In place of the galvanometer employed as herein described, I may use an ohmmeter, such, for example as shown in my prior patent No. 835,461.

Herein I claim recording apparatus, while in my copending application Serial Number 524,349, divided herefrom, I claim my apparatus broadly without restriction to recorder apparatus or system.

What I claim is:

1. In a recorder system, the combination with a selector member having a short range of movement in response to the change to be recorded, of a periodically operated selector member coöperating with said member for providing a path along which energy may be transmitted, and a marker controlled by energy transmitted along a selected path and moved an extent dependent upon the extent of change to be recorded.

2. In a recorder system, the combination with a selector member movable in response to a change to be recorded, the extent of movement of said selector member being short and independent of the extent of change to be recorded, of a periodically operating member coöperating with said selector mem-

ber for providing a path along which energy may be transmitted, and a marker controlled by energy transmitted along a selected path and movable an extent dependent upon the extent of the change to be recorded.

3. The combination with a galvanometer, of a member carried by the moving system thereof, a periodically operated member for engaging said member to actuate the same, step-by-step recorder mechanism, and means engaged by said member when actuated for controlling said step-by-step recorder mechanism.

4. The combination with a galvanometer and the movable member thereof, said member having a small range of movement in response to the change to be recorded, of a periodically operating member engaging said movable member to provide a path along which energy may be transmitted, and a marker controlled by energy transmitted along said path and moved an extent dependent upon the extent of the change to be recorded.

5. The combination with a galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for engaging said member to control a circuit, and step-by-step recording mechanism controlled by said circuit.

6. The combination with a galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for engaging said member to close a circuit, and step-by-step recording mechanism controlled by said circuit.

7. The combination with a galvanometer and the movable member thereof, said movable member movable in response to the change to be recorded through a distance disproportionate to the extent of said change to be recorded, of a periodically operating member coöperating with said movable member to provide a path along which energy may be transmitted, and a marker controlled by energy transmitted over said path and movable an extent proportionate to the extent of the change to be recorded.

8. The combination with a galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for actuating said member, a pair of members either one of which is engaged by said member when actuated, neither of said last mentioned members being engaged when said galvanometer is balanced, and recording apparatus controlled when one of said pair of members is engaged.

9. The combination with a galvanometer and the movable member thereof, said movable member deflecting a short distance in response to the change to be recorded, of a periodically operating member coöperating with said movable member to control a circuit, and a marker moved an extent dependent upon the extent of said change to be recorded and controlled by said circuit.

10. The combination with a galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for engaging said member, a pair of contacts one or the other of which is engaged by said member when actuated, and a step-by-step recording mechanism controlled by each of said contacts.

11. The combination with a galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for engaging said member, a pair of circuits one or the other of which is controlled by said member when actuated, and a step-by-step recording mechanism controlled by each of said circuits.

12. The combination with a galvanometer and the movable member thereof, said movable member deflecting a short distance in response to and disproportionately to the change to be recorded, of a periodically operating member coöperating with said movable member to control a circuit, and a marker controlled by said circuit and movable an extent proportionate to the extent of said change to be recorded.

13. The combination with a galvanometer and the movable member thereof, of a contact located to one side of the zero position of said movable member by an amount independent of the extent of the change to be recorded, a periodically operating member cooperating with said movable member to control said contact, a circuit controlled by said contact, and a marker controlled by said circuit and movable an extent dependent upon the extent of said change to be recorded.

14. The combination with a galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for actuating said member, and step-by-step recorder mechanism, said member when deflected and actuated controlling said step-by-step recorder mechanism.

15. The combination with a differential galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for actuating said member, said member when deflected and actuated controlling means for restoring said differential galvanometer to balance condition, and recording apparatus controlled by said member when actuated.

16. The combination with a differential galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for actuating said member, recording apparatus, said member when deflected and actuated

controlling said recording apparatus and means for restoring said differential galvanometer to balance condition.

17. The combination with a differential galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for actuating said member, step-by-step recording mechanism, said member when deflected and actuated controlling said step-by-step recording mechanism and means for restoring said differential galvanometer to balance condition.

18. The combination with a differential galvanometer and the moving system thereof, of a member carried by said moving system, a periodically operating member for actuating said member, step-by-step recording mechanism, said member when deflected and actuated controlling a circuit including said step-by-step recording mechanism and means for restoring said differential galvanometer to balance condition.

19. The combination with a galvanometer and the moving system thereof, of a member carried by said moving system, a fixed contact, a movable contact, means for periodically moving said movable contact and clamping said member carried by said moving system between said movable and stationary contacts, a circuit controlled by said contacts, and recording apparatus controlled by said circuit.

20. The combination with a galvanometer, of a member carried by the moving system thereof, means for periodically clamping said member, and step-by-step recording mechanism controlled by the clamping or unclamping of said member.

21. The combination with a galvanometer and its movable member, of a fixed contact, a movable contact, means for periodically moving said movable contact, the movable member of said galvanometer controlling the completion of a circuit through said contacts, and step-by-step recorder mechanism controlled by said circuit.

22. The combination with a galvanometer and the movable member thereof, of a contact located to one side of the zero position of said movable member, means for periodically controlling a circuit through said contact when said movable member deflects, the extent of deflection being independent of the extent of the change to the recorded, and step-by-step mechanism controlled by said circuit and operating so long as said member remains deflected, whereby a record proportioned to the extent of the change to be recorded is produced.

23. The combination with a galvanometer and the moving system thereof, of a member carried by said moving system, independently operated means for periodically clamping said member, and step-by-step recording mechanism controlled by the clamping or unclamping of said member.

24. In a recorder system, a record sheet and a marker movable with respect to each other, the angle of movement of said sheet with respect to said marker being constant, step-by-step mechanism for moving said marker, and means responsive to the change to be recorded for controlling said step-by-step mechanism.

25. In a recorder system, a record sheet and a marker movable with respect to each other, the angle of movement of said sheet with respect to said marker being constant, a member movable in response to a change to be recorded, and periodically operating means coöperating with said member for moving said marker a distance proportional to the extent of the change to be recorded.

26. In a recorder system, a member movable in response to a change to be recorded, a member periodically coöperating with said movable member to engage the same to provide a path over which energy may be transmitted, and a marker controlled by the energy transmitted over said path and moved a distance proportional to the extent of the change to be recorded.

27. In a recorder system, a member movable in response to a change to be recorded, a member periodically clamping said member, and step-by-step recording apparatus controlled by the clamping or unclamping of said member.

28. In a recorder system, the combination with a member movable in response to a change to be recorded, of means for periodically engaging said member, a record sheet, means for moving said record sheet in a straight line, a marker, and means responsive to the periodic engagement of said movable member for moving said marker in a straight line across said record sheet so long as said movable member is periodically engaged.

29. In a recorder system, the combination with a member movable in response to a change to be recorded, of means for periodically actuating said member when moved in response to the change to be recorded, and step-by-step recording apparatus controlled by said movable member when engaged.

30. In a recording system, the combination with a member movable in response to a change to be recorded, of a periodically operating member engaging said movable member when deflected, and a marker moved a step for each engagement between said periodically operating member and said movable member.

31. In a recording system, the combination with a member movable in response to a change to be recorded, of a periodically operating member for engaging said movable member when deflected to make a con-

tact, a circuit controlled by said contact, and a marker controlled by said circuit and moved a step for each engagement between said periodically operating member and said movable member.

32. In a recorder system, the combination with a differential galvanometer, of a member moved by said galvanometer in response to a change to be recorded, means periodically engaging said member to make a contact when said galvanometer is unbalanced, recording means controlled by said contact, and means controlled by said contact for restoring said galvanometer to balance.

33. In a recorder system, the combination with a member movable in response to a change to be recorded, of a member periodically engaging said movable member when deflected, a marker, means for moving said marker a step for each engagement between said members, and means for causing the return of said movable member to zero position when said marker has moved a distance proportional to the extent of the change to be recorded.

34. In a recorder system, the combination with a member movable in response to a change to be recorded, of a member periodically engaging said member to make a contact, a circuit controlled by said contact, a marker controlled by said circuit, means for moving said marker a step for each engagement between said members, and means for causing the return of said movable member to zero position when said marker has moved a distance proportional to the extent of the change to be recorded.

35. In a recorder system, the combination with a member moved in response to but disproportionately to a change to be recorded, of a member periodically engaging said member, a marker, means for moving said marker a step for each engagement between said members, and means for causing the return of said movable member to zero position when said marker has moved a distance proportional to the extent of the change to be recorded.

36. The combination with the moving system of a galvanometer, of means for dampening the movement thereof, means periodically coöperating with said moving system, and step-by-step recording apparatus controlled by said periodically operating means.

37. The combination with the moving system of a galvanometer, of means for dampening the movement thereof, means periodically coöperating with said moving system, and a step-by-step marker moving by equal increments under the control of said periodically operating means.

38. The combination with the moving system of a galvanometer, of means periodically coöperating with said moving system to control step-by-step recorder mechanism, the natural period of the moving system of said galvanometer being less than the period between successive coöperations between said moving system and said means.

39. In a recorder system, the combination with a member moved in response to but disproportionately to a change to be recorded, of a member periodically engaging said movable member when deflected, and a marker moved by equal increments in response to the periodic engagements of said members a distance proportional to said change to be recorded.

40. In a recorder system, the combination with a member moved in response to but disproportionately to a change to be recorded, of a member periodically engaging said movable member when deflected, a marker moved by equal increments in response to the periodic engagements of said members a distance proportional to said change to be recorded, and means for causing the return of said movable member to zero position when said marker has moved a distance proportional to the extent of said change to be recorded.

41. Step-by-step recording mechanism comprising an electro-magnet, an armature therefor, an associate armature, a member actuated by said associate armature, a fixed member adapted to be engaged by the member actuated by said associate armature, and a marker operated by said magnet.

42. Step-by-step mechanism comprising an electro-magnet, a fixed member, a member engaging said fixed member immediately upon energization of said magnet and a marker operated by said magnet.

43. Step-by-step recording mechanism comprising a fixed member, an electro-magnet and its armature, means for clamping said magnet or its armature to said fixed member immediately upon energization, the attraction between said magnet and its armature causing subsequent movement relative to said fixed member, and a marker operated by said magnet.

44. Step-by-step recording mechanism comprising an electro-magnet and its armature, a fixed member extending axially through said magnet, means for clamping said magnet or its armature to said fixed member immediately upon energization of said magnet, the attraction between said magnet and its armature causing subsequent movement with respect to said fixed member, and a marker operated by said magnet.

45. In recording apparatus, the combination with an electro-magnet, recording apparatus controlled thereby, a circuit in shunt to the winding of said electromagnet including separable coöperative contacts, a member for moving said contacts relatively to

each other, and a clock wheel for periodically engaging said member to move the same through a relatively slight distance.

46. The combination with a magnet having a winding, of a circuit in shunt thereto, separable coöperative contacts connected in said shunt circuit, a member for separating said contacts, a clock wheel for periodically engaging said member to move the same through a relatively slight distance, and recording apparatus controlled by said magnet.

47. In an electrical recorder, the combination with a member movable in response to physical changes, of periodically operating means for engaging said member to make a contact, step-by-step mechanism controlled by said contact and moving by equal increments, and a marker controlled by said step-by-step mechanism.

48. In an electrical recorder, the combination with a resistance subjected to the variations in a quantity to be recorded, of a differential galvanometer, a contacting member controlled by said galvanometer, a periodically operating member for engaging said contacting member to make a contact, a step-by-step marking mechanism controlled by said contact, and means controlled by said step-by-step mechanism for restoring said differential galvanometer to balance after a change in the quantity recorded.

49. In a recorder system, the combination with a differential galvanometer and its movable member moved in response to but disproportionately to the change to be recorded, of a second member periodically cooperating with said member to select a path over which energy may be transmitted, and a marker moved a step for each engagement between said periodically coöperating members in response to the energy transmitted over the selected path and moved an extent proportional to the extent of said change to be recorded.

50. In a recorder, the combination with circuit or resistance balancing means comprising a resistance with a movable contact, of a winding of a differential instrument and a resistance changing in response to the changes to be recorded connected in one branch, the other winding of said instrument and a fixed resistance in another branch, a source of current, and a recorder controlled by the movable member of said differential instrument.

51. In a recorder, the combination with circuit or resistance balancing means comprising a resistance and a movable contact, of a winding of a differential instrument and a resistance changing in response to the changes to be recorded connected in one branch, another winding of said differential instrument connected in another branch, a source of current, and recording apparatus controlled by the movable member of said differential instrument.

52. In a recorder, the combination with circuit or resistance balancing means comprising a resistance and a movable contact, a winding of a differential instrument and a resistance changing in response to the changes to be recorded connected in one branch, another winding of said differential instrument and a fixed resistance connected in another branch, a source of current, and recording apparatus controlled by the movable member of said differential instrument.

53. In a recorder with elimination of lead error, the combination with a resistance adjustable by a movable contact, of a winding of a differential instrument a lead and a resistance connected in one branch, another winding of said differential instrument and a fixed resistance and a second lead connected in another branch, a connection from the resistance end of said second lead to said movable contact, said leads being similar in material, cross section and length and disposed in proximity to each other throughout their lengths, and a marker and means for moving said movable contact controlled by the movable member of said differential instrument.

54. The combination with a galvanometer, of a member carried by the moving system thereof, a periodically operating member for engaging said member, said member when deflected and engaged controlling recorder mechanism and means for restoring said galvanometer to balance condition.

55. The combination with a galvanometer, of a member carried by the moving system thereof, a periodically operating member for engaging said member, said member when deflected and engaged controlling step-by-step mechanism, a marker moved by said mechanism, and a contact moved by said mechanism.

56. The combination with a galvanometer, of a member carried by the moving system thereof, a periodically operating member for engaging said member, said member when deflected and engaged controlling step-by-step mechanism, a marker moved by said mechanism and a resistance controlled by said mechanism.

57. The combination with a galvanometer, of a member carried by the moving system thereof, a periodically operating member for engaging said member, said member when deflected and engaged controlling step-by-step mechanism, a marker moved by said mechanism, and a galvanometer balancing resistance controlled by said mechanism.

58. In a recorder system, a member having small range of movement and movable in response to and disproportionately to a

change to be recorded, a member coöperating with said movable member to periodically engage the same to select a path over which energy may be transmitted, and a marker controlled by the energy transmitted over said path and moved a distance proportional to the extent of said change to be recorded.

59. In a recorder system, a member having small range of movement and movable in response to a change to be recorded, a member coöperating with said movable member to periodically engage the same to select a path over which energy may be transmitted, and recording apparatus and means tending to restore said movable member to balance condition controlled by the energy transmitted over said path.

60. In a recorder system, the combination with a marker, of a member movable in response to a change in a quantity to be recorded, a second member periodically engaging said movable member when deflected, and means controlled by the periodic engagement of said members for moving said marker to produce a record of all the changes in said quantity to be recorded.

61. The combination with a member having small range of movement and movable in response to a change to be recorded, of a periodically operating member, a contact located to one side of the zero or normal position of said member, said periodically operating member engaging said movable member to control said contact when said movable member is deflected, and a step-by-step recorder controlled by said contact.

62. In a recorder system, the combination with a marker, of a member movable in response to a change to be recorded, a periodically operating member engaging said movable member when said movable member is to one side of the zero or normal position of said movable member, and means for moving said marker in one direction or the other, dependent upon the direction of deflection of said movable member from the zero, said means for moving said marker being controlled by the engagement of said movable member and said periodically operating member.

63. In a recorder system, the combination with a marker, step-by-step mechanism for moving said marker, and means responsive to the change to be recorded movable to either side of a zero or normal position, said step-by-step mechanism controlled by said means to move said marker in one direction or the other.

64. In a recorder system, the combination with a single marker, of step-by-step mechanism for moving said marker, a member responsive to the changes to be recorded movable to either side of a zero or normal position, and a member periodically engaging said movable member to control said step-by-step mechanism, said step-by-step mechanism moving said marker in one direction or the other depending upon the direction of deflection of said movable member, whereby said single marker records all changes to be recorded.

In testimony whereof I have hereunto affixed my signature in the presence of the two subscribing witnesses.

EDWIN F. NORTHRUP.

Witnesses:
ERNEST RIEBEN,
WARREN W. CLARK.

Corrections in Letters Patent No. 950,555.

It is hereby certified that in Letters Patent No. 950,555, granted March 1, 1910, upon the application of Edwin F. Northrup, of Philadelphia, Pennsylvania, for an improvement in "Electrical Recorders," errors appear in the printed specification requiring correction as follows: Page 4, line 40, the word "strap" should read *strip;* page 5, line 51, the word "number" should read *member*, and same page, lines 117–118, the word "selector" should be canceled and inserted before the word "member," second occurrence line 118; page 7, lines 58–59, the word "proportioned" should read *proportional;* page 8, line 99, before the word "mechanism" the word *recording* should be inserted; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22d day of March, A. D., 1910.

[SEAL.]

C. C. BILLINGS,
Acting Commissioner of Patents.