(No Model.) 3 Sheets—Sheet 1.

C. E. DRESSLER.

TELEGRAPHY.

No. 397,977. Patented Feb. 19, 1889.

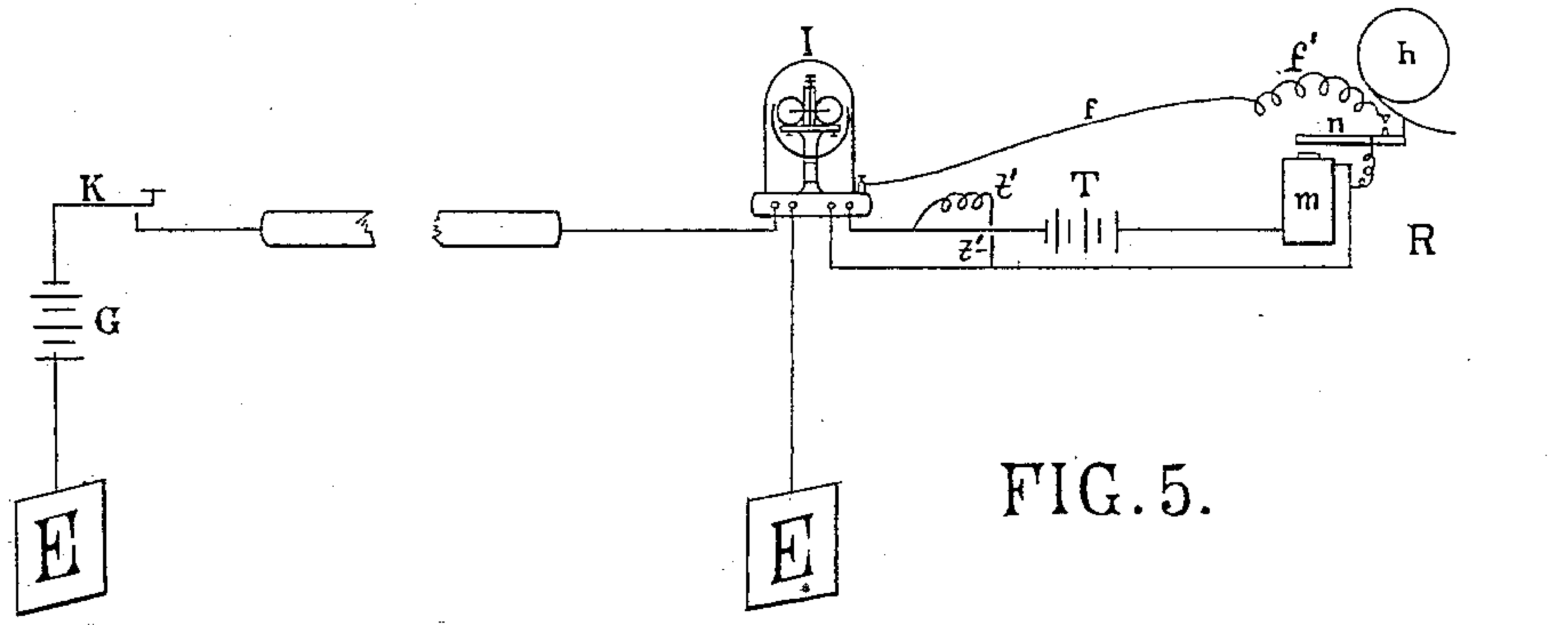

FIG. 5.

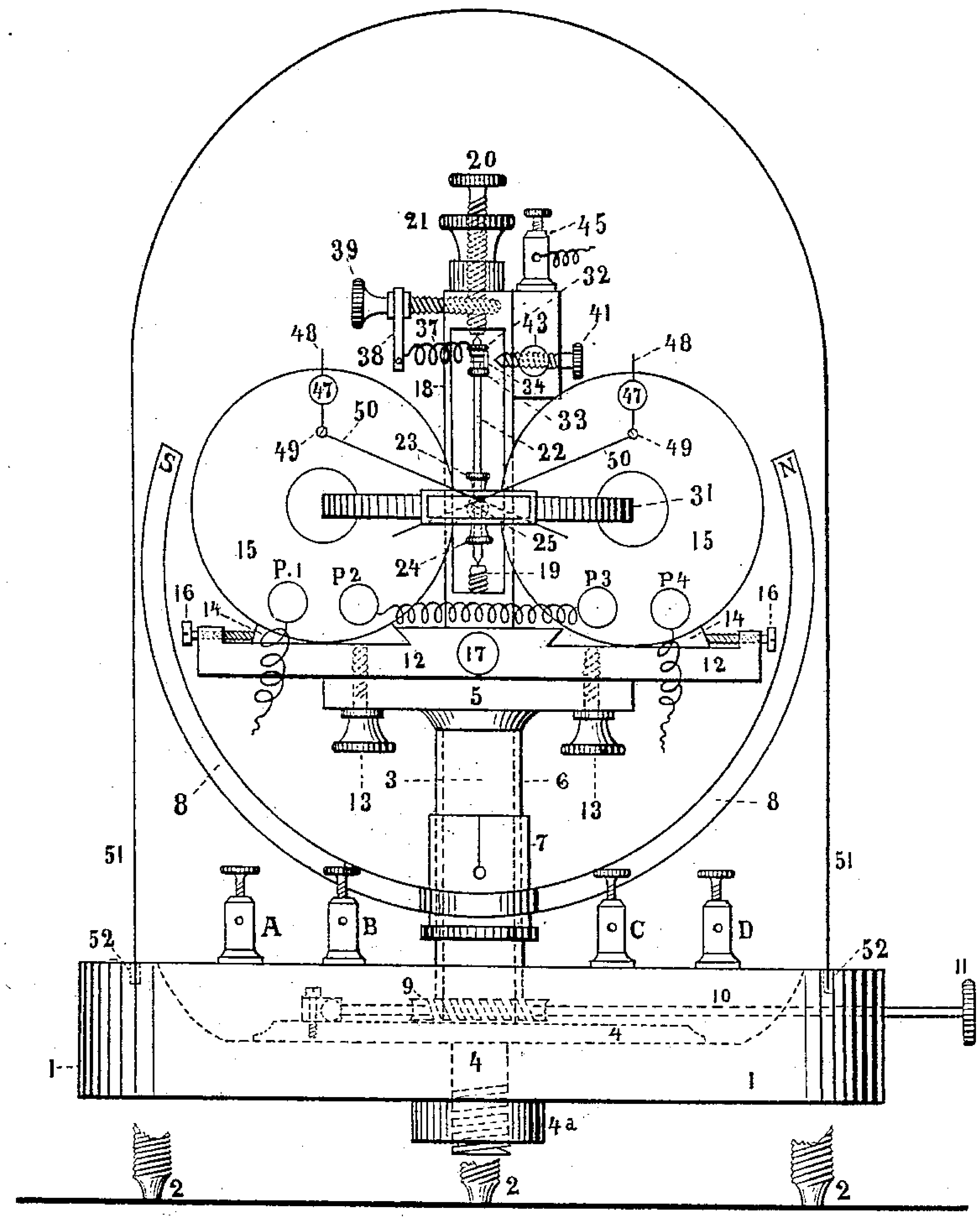

FIG. 1.

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(No Model.) 3 Sheets—Sheet 2.

C. E. DRESSLER.

TELEGRAPHY.

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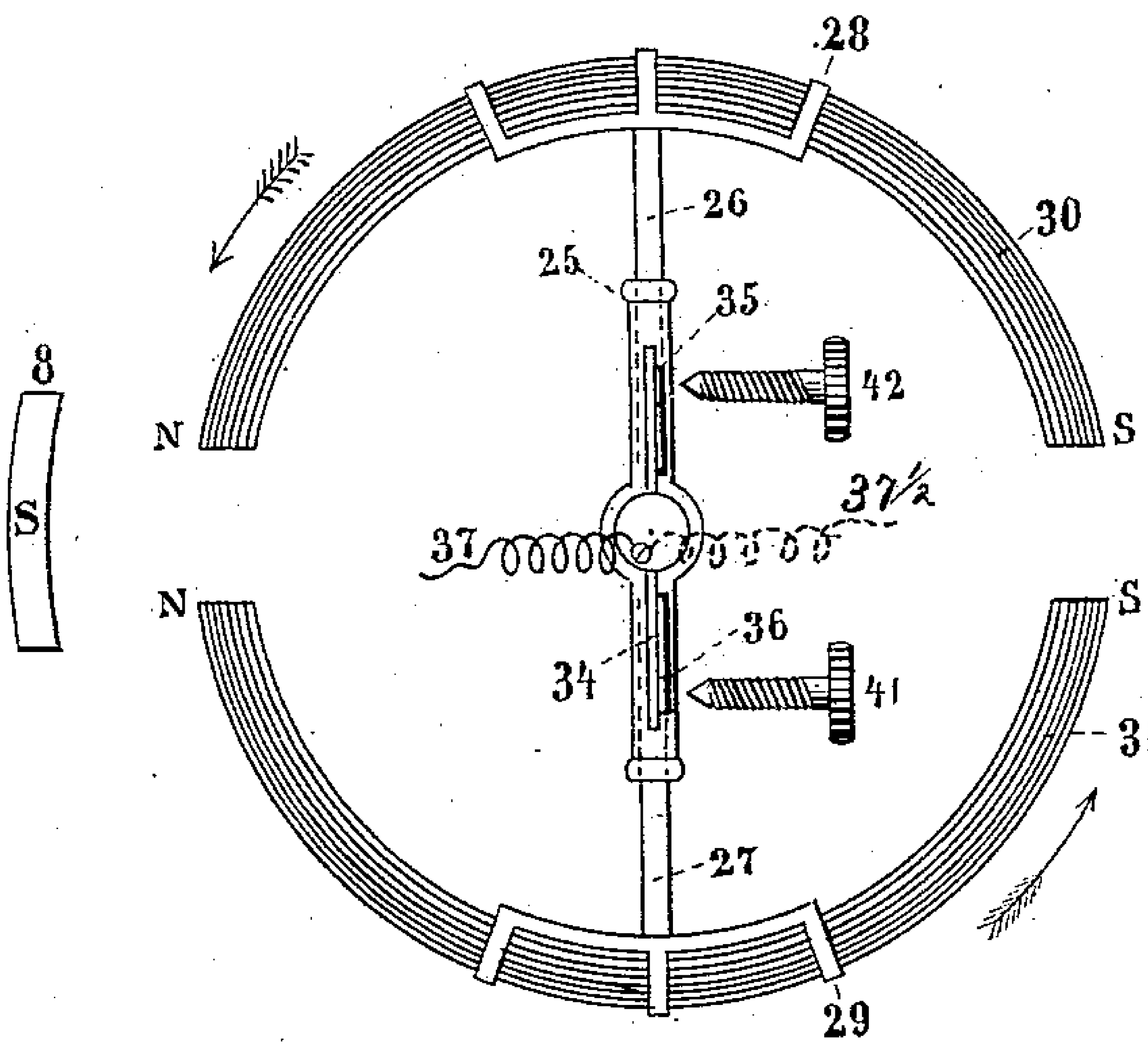

FIG. 3

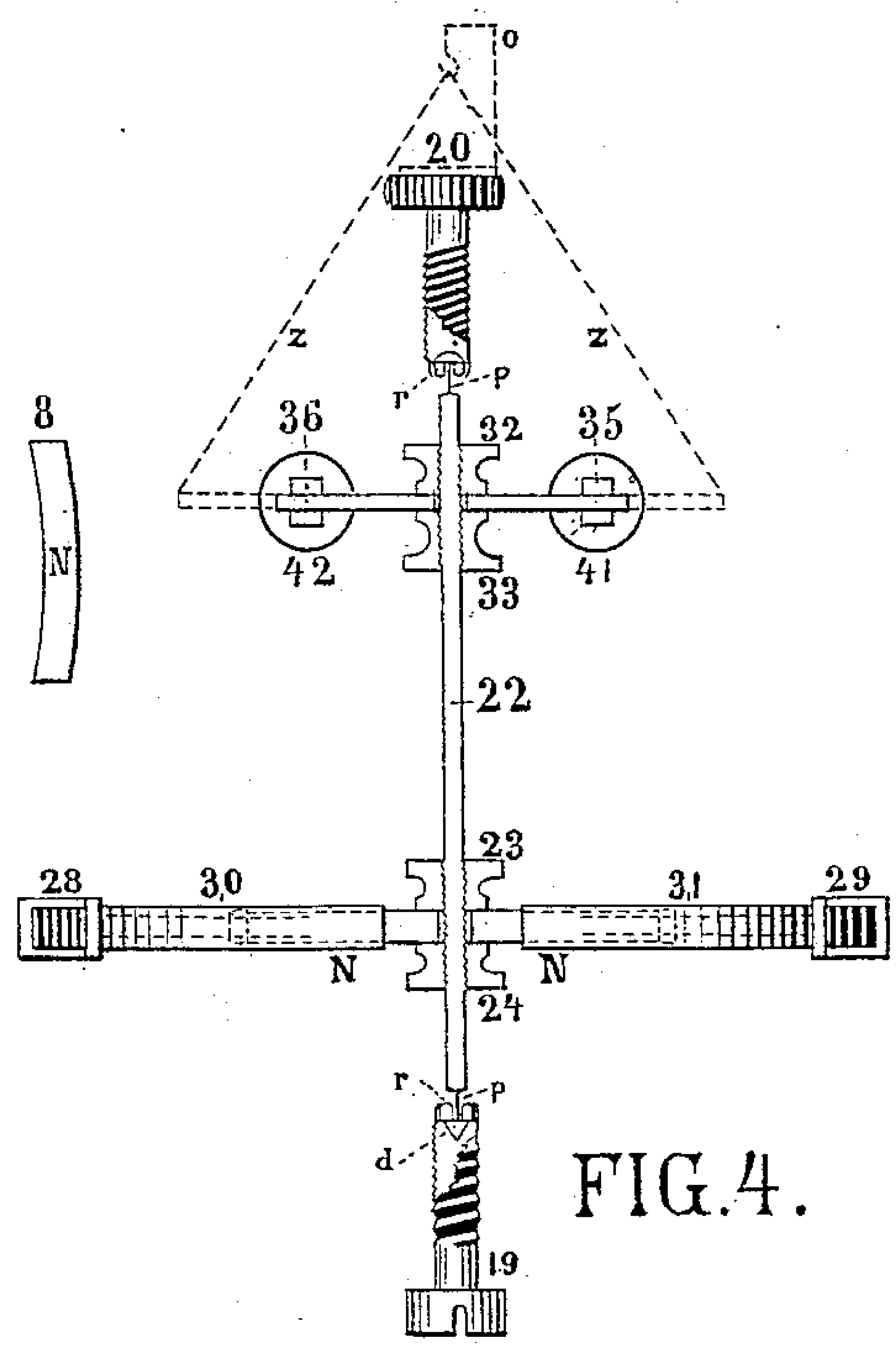

FIG. 4.

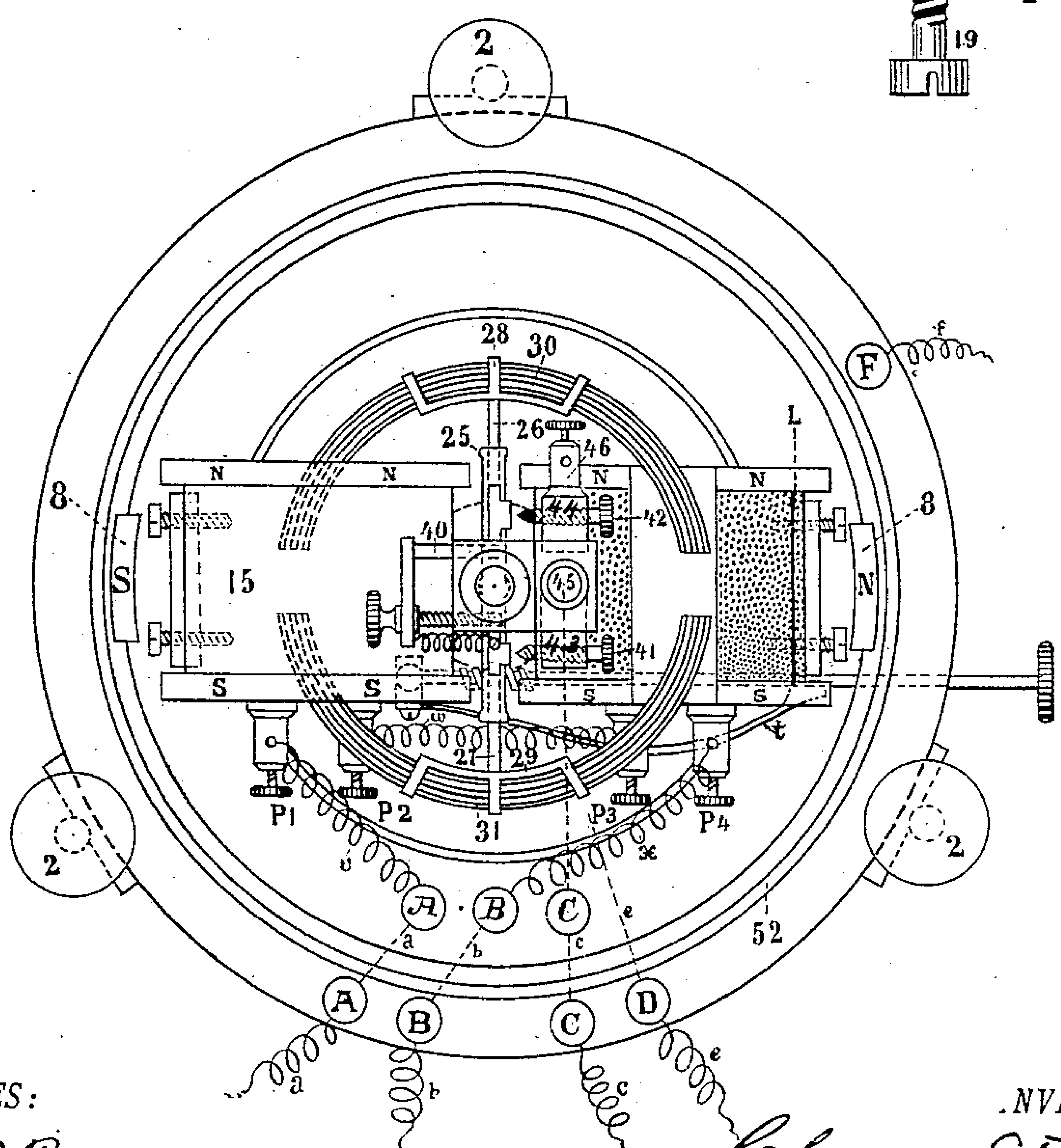

FIG. 2.

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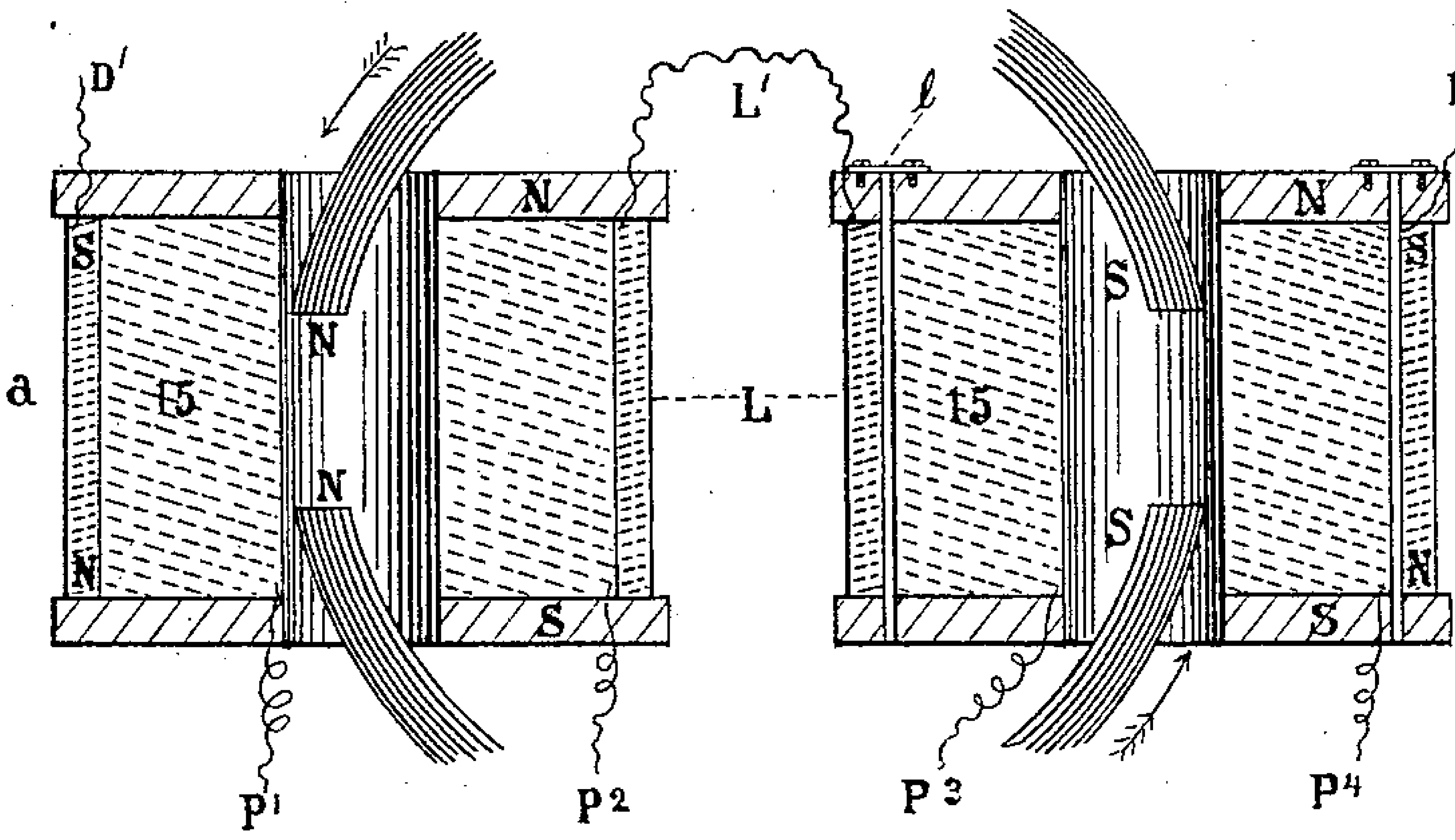
(No Model.) 3 Sheets—Sheet 3.

C. E. DRESSLER.

TELEGRAPHY.

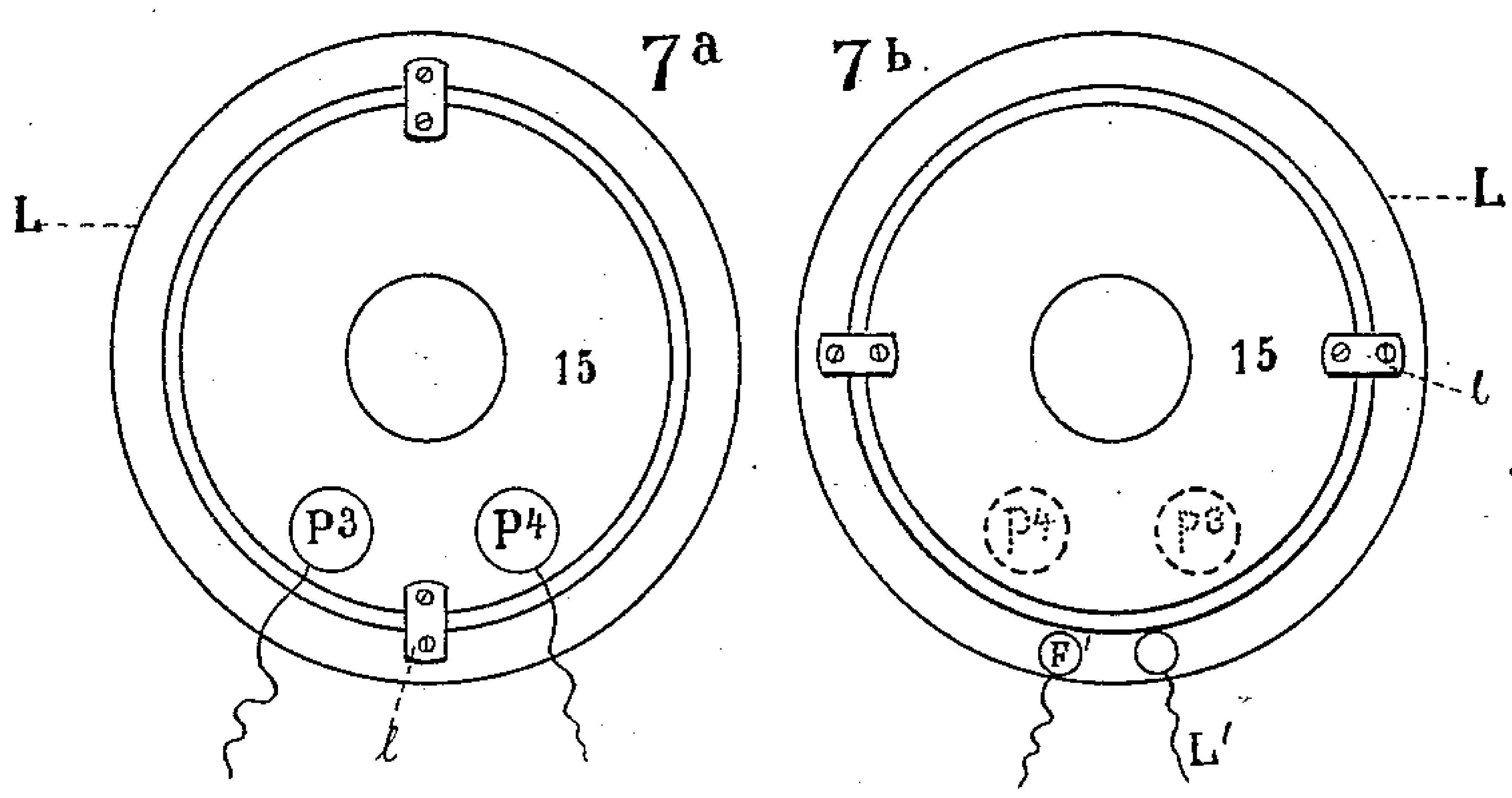
No. 397,977. Patented Feb. 19, 1889.

FIG. 6a



6b

FIG. 7a 7b



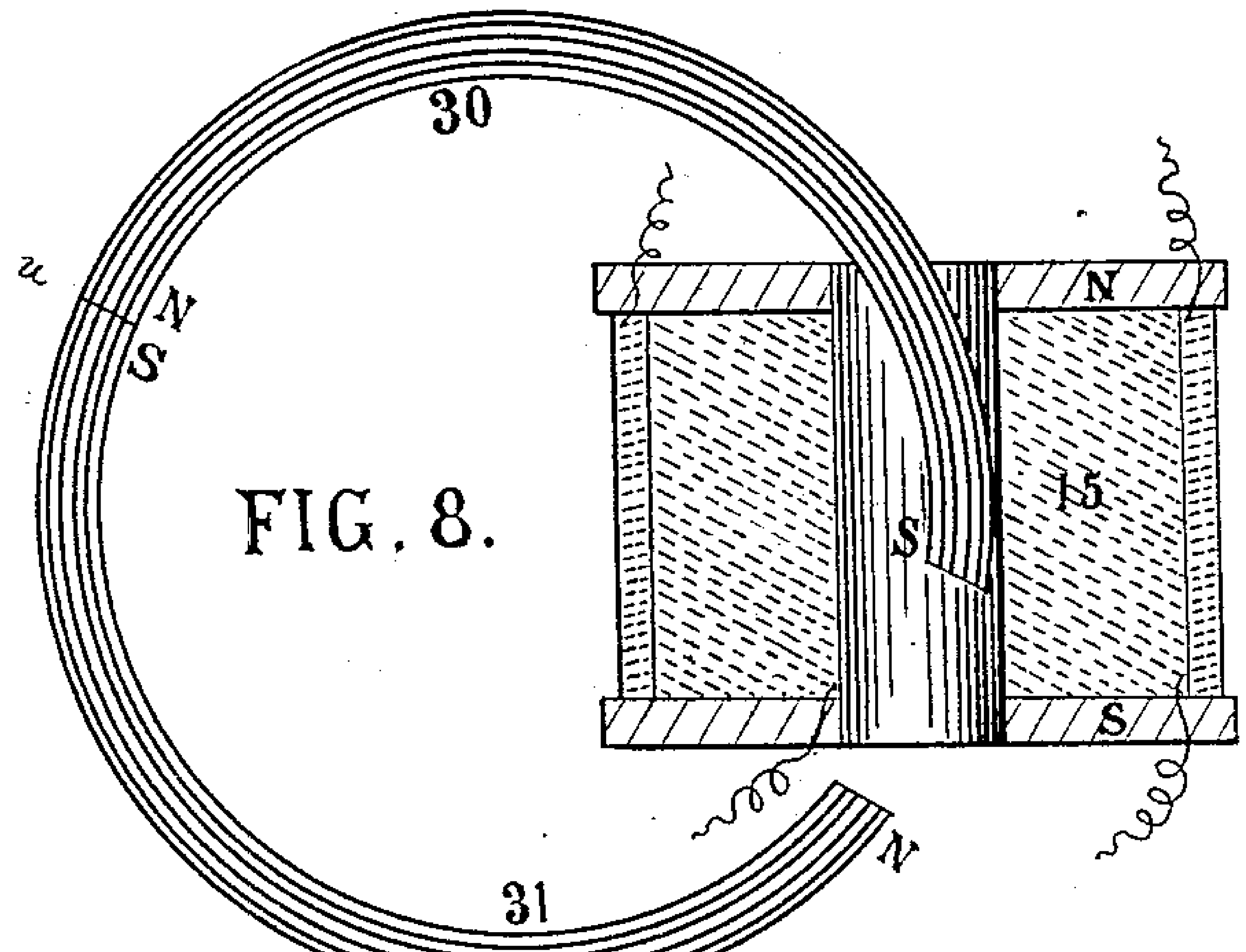


FIG. 8.

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UNITED STATES PATENT OFFICE.

CHARLES E. DRESSLER, OF NEW YORK, N. Y.

TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 397,977, dated February 19, 1889.

Application filed May 26, 1887. Serial No. 239,476. (No model.)

To all whom it may concern:

Be it known that I, CHARLES E. DRESSLER, of the city of New York, in the county and State of New York, have invented a new and useful Improvement in the Art of Transmitting Electro-Magnetic Impulses for Telegraphic and other Purposes, notably for long distances, as in the case of ocean telegraphy through submarine cables, of which the following is a specification.

The object of this invention is to utilize the weakest electric currents possible, (only weak currents, for well-known reasons, being desirable or permissible for passage through sub-ocean cables,) and at the same time to largely increase the speed of transmitting signals or any kind of messages capable of being sent through wires by means of electric energy beyond any speed of transmission heretofore attained in ocean telegraphy. It is also its object to utilize electric energy not only in telegraphy proper, but in relay-circuits in telephony also, whether said energy be intermittent, undulatory, or of varying strength, as the message transmitted may be graphic, vocal, or articulate speech.

The invention consists, first, in the combination of a galvanometer placed in the main electric circuit and a recording or message-receiving instrument placed in another or relay circuit, opened and closed by or otherwise affected in accord with the operation of the galvanometer with which said receiving-instrument is so combined; second, of a galvanometer-instrument for making and breaking or closing and opening or otherwise sympathetically affecting the relay-circuit, the details of which instrument will be hereinafter particularly described.

In the accompanying drawings, Figure 1 is a front elevation of the galvanometer-instrument forming said second part of this invention. Fig. 2 is a plan of said instrument, showing one of the spools or electro-magnetic helices in horizontal section. Fig. 3 illustrates in plan on an enlarged scale, detached, the compound laminated permanent needle-magnets of my said galvanometer-instrument. Fig. 4 shows said needle-magnets mounted on a central vertical rocker-shaft or spindle journaled at top and bottom in anti-friction bearings. Fig. 5 is a sketch illustrating any registering or recording instrument or sounder with its relay-battery as the same may be connected to its controlling or transmitting galvanometer-instrument. Figs. 6^a, 6^b, 7^a, 7^b, 8 show details and modifications hereinafter described.

In said figures the several parts are indicated by numbers and letters, as follows: The number 1 indicates the table or wooden base of the instrument; 2, leveling-screws therefor; 3, a central vertical shaft, (shown partly in dotted lines in Fig. 1,) provided with a bottom flange, 4, (shown in dotted lines,) and a screw-threaded end through the base 1, to which the shaft is secured by a circular nut, 4^a, under the base. Said shaft terminates at top in a neatly-filleted T head or bar, 5. Over said shaft and below said bar is fitted a sleeve, 6, over said sleeve a tight-fitting split socket, 7, and over said socket, body-bound in the eye of its hub, a permanent magnet, 8. The base of said sleeve is fitted with a worm-wheel, 9, and gearing therewith is a worm on the worm-shaft 10, journaled at one end only in a ball-joint, and the worm held in contact with the worm-wheel by the pressure of the spring *t*. Said worm-gearing is bedded and secured in the table 1, hollowed out for its reception. By means, therefore, of said gearing, operated by the thumb-screw 11, the magnet 8, acting as an artificial magnetic meridian, is adjusted radially in a circular path within desired limits independently of the vertical shaft 3. To the T-head 5 of said shaft 3 is secured a bar, 12, by the screws 13, and said bar 12 is provided at each end with dovetail recesses, within which are set the dovetails 14 of the spools or helices 15. Said spools are firmly secured upon said bar by the set-screws 16, which, passing through the angle ends of the bar 12, bite into the dovetails 14, firmly secured by glue or otherwise to the insulated coils of the spools 15, or to any covering with which said coils may be provided—such as velvet or other material commonly used for such coverings. Said spools may be turned and bored out of hard rubber, wood, or other suitable insulating material. Between said spools, set in a step in the bar 12 and concentric with the shaft 3, and secured in said step by the bite of the set-screw 17, rises the slotted frame 18. A bottom and top said frame is provided with adjusting-screws 19 20, the upper screw, 20, passing through a jam-screw nut, 21. Anti-friction bearings, hereinafter described, are inserted in the ends of both adjusting-screws, 19 and 20, and journaled or pivoted within said bearings on fine-pointed ends or pins of hardened steel is a vertical shaft, 22. Said shaft is provided with screw-threads—preferably on a brass sleeve soldered thereon—located opposite to and extending somewhat above and below a horizontal plane passing through the axes of the spools 15. Between the jam-screws 23 24 on said threaded part of the shaft 22 is fixed a double radial arm, 25, the eye in the bars of said arm tightly fitting upon the body and against a shoulder turned on the upper jam-screw, 23, said bars being securely held in place by setting upon the jam-screw 24. Each arm of said double arm 25 forms a tubular split socket for the rods 26 27, fast in the frames 28 29, holding the compound permanent magnets 30 31, of spring-steel, tied together at their poles by wires, or soldered or otherwise secured together, as may be desired. The poles of said magnets are thus adjusted within the hollow cores of the spools 15 by simply sliding the rods 26 27, Fig. 3, in or out of their sockets 25, the leverage of said magnets being thus increased or diminished by this simple adjustment.

Above the arm 25, and secured like it by jam-screws 32 33 to the shaft 22, is a double arm, 34, preferably of brass and provided with platinum strips 35 36. To one side of the center of the arm 34 is hooked a delicate coiled-wire spring, 37, whose other end is hooked fast in an adjustable cross-head, 38, operated by the thumb-screw 39 and guided by the bolt 40, said thumb-screw and bolt securing said cross-head to the slotted frame 18, said frame being cut away at one side for the location of and to clear said spring. Opposite to the platinum strips 35 36 of the arm 34 are located two contact-screws, 41 42, which may be made laterally adjustable to set opposite different points on the surface of the platinum strips in case said surface should become defective at any particular point. Said contact-screws pass each through brass studs 43 44, set in an insulating-block of hard rubber or other suitable insulating material. To the contact-screw 41 is connected the binding-post 45 only. The stud 44 terminates in a binding-post, 46, Fig. 2, for the contact-screw 42. The contact-screw 42 is tipped with ivory or other non-conducting material, except when the instrument is to be operated to transmit by each oscillation of the galvanometer, or the ivory point may be changed to the other contact-screw if the direction of the electric currents be reversed.

To each end of each spool 15 is secured a binding-post, 47, in which is set a rod, 48, having bars on its end, into which bars is tapped a small screw, 49. Over each of said screws 49 is secured by an eye or loop in its end a small aluminium wire, 50. Instead of said wires bars of the laminæ of mica may be used, or any other suitably light material or any other friction apparatus in the nature of a brake may be employed. Said wires 50 rest in angular directions, crossing, as shown in Fig. 1 at the front, on each side of the center of the double arm 25, and by their friction steady the vibrations or oscillations of the vertical shaft 22, and thus prevent it from trembling or "chattering" under the impulses imparted to the galvanometer needle or magnet. The friction of said aluminium wires may be increased by elevating the rods 48 in their binding-posts, which operation brings the wires at such an angle on the arm 25 as to increase the angle of their elevation, and hence bring more work on said arm 25. The lower bearing for the shaft 22 is composed of a diamond capped by a ruby having a hole drilled through it, so that the lower pivotal end of the shaft 22 rests on top of the diamond within the ruby-walled hole, the two jewels forming the step-bearing for the shaft. In Fig. 4 the letter *d* indicates the diamond, *r* the drilled ruby, and *p* the pivot or pin at the bottom of the shaft 22. The top bearing is similarly made, except that a ruby or other suitable jewel or some vitreous material may take the place of the diamond, the weight of the shaft 22 not being imposed upon its upper bearing.

If desired, the weight upon the step of the shaft 22 may be diminished by using suspension-wires or a thread, preferably of gold, as shown in dotted lines *z z*, Fig. 4. Said wires are secured to any suitable part of the frame 18, as shown at *o*, and will thus further act as a contact-breaker by resisting the twist given them in making contact between the terminals 36 41, and said wires will also act, like the spring 37, as conductors in the relay-circuit. They may therefore be used either in conjunction with said spring 37 or may be substituted therefor.

Instead of the horseshoe-magnet 8, or in addition thereto, a spring, as shown in dotted lines 37½, Fig. 3, may be used and attached to the needle-magnet opposite spring 37 to pull in light opposition to it, the pull of the magnetic field upon the needle-magnet only thus overcoming the difference in pull between said springs; or either or both of the terminals 41 42 may be fixed in spring-supports instead of being set in rigid supports.

The proper connections being now made to the several binding-posts, as hereinafter distinguished, the operation of the machine above described is as follows: In the binding-posts A, Fig. 2, the cable is connected by the wire *a*, the glass shade 51, placed over the instrument, being let into the groove (indicated by the circle 52) on the table 1, intervening between the two posts A A, the wire *a*, connecting said posts, passing beneath the said groove. From the binding-posts B B the wires *b b* similarly lead under the glass shade to the ground-wires for the return or earth currents. From the binding-post 45, near the top of the instrument, a wire, *c*, leads down within the glass shade 51 to the binding-posts C, whence said wire *c*, or a connecting-link, leads under the glass shade to the outer binding-post, C, whence said wire connects with the spools or helices of a relay-instrument, R, operated by a battery, T, as shown at Fig. 5. To the binding-post D is connected a wire, *e*, which, passing from the frame of the instrument at 4^a, for convenience, under the base 1, thence leads from said binding-post D to the relay-battery T, thus completing the circuit between said battery, the galvanometer, and the relay-instrument R. The spool 15 on the left, Fig. 2, is connected to the binding-post A by a conducting-wire, *v*, said spool with its fellow spool, 15, to the right by the wire *w*, and said latter spool to the binding-post B by the wire *x* and by the several binding-posts on said spools P' P^2 P^3 P^4. All the connections being thus made, messages or signals are transmitted as now to be described, the current traversing through the instrument and operating it as follows: The operator's key (*k*, Fig. 5, or other actuating device for affecting the current) being placed at any suitable point between the wires *a* and *b*, so as to make and break the circuit in the usual manner, (or otherwise affect the electric energy,) and, the circuit being closed by said key, the current passes through the wires *a v*, Fig. 2, through both spools 15, connected, as before described, by the wire *w*, and back through the wires *x* and *b* to the ground. The effect of said current is to cause the needle-magnets 30 31, constituting a galvanometer-needle, to rotate to the right, as shown by the arrow, Fig. 3, which closes the circuit between the platinum strip 36 and the contact-screw 41. It will be observed that said compound galvanometer-needle, composed of the magnets 30 31, must move in the path indicated by the arrow, Fig. 3, because its poles are north and south, as respectively marked with the letters N and S, the respective poles of the spools 15 being also marked according to their polarity N and S, as shown on Fig. 2. The polarity of the pernanent magnet 8, which also assists the electro-helices 15, is also indicated by the letters N and S, respectively, as shown on Figs. 1, 2, and 3.

The poles N S of the permanent magnet 8 are elevated above the horizontal plane passing through the compound needle-magnets 30 31. Thus the force of its attraction tends to elevate said magnets, and thus to diminish their weight upon their lower bearing, 19, thus increasing the sensitiveness of said magnets, and to increase correspondingly the useful effect of their field-actuating current. The energy of the horseshoe-magnet 8 also directly assists the field-energy of the helices 15 for the following reasons: Referring to Fig. 3, it will be observed that the north pole N of said magnet 8 is on the right-hand side of the galvanometer-needle 30 31, which needle has on said side its south poles S S and on its left-hand side its north poles N N, opposite which poles N N is the S pole of the magnet 8; hence this opposite and attractive polarity of said magnet acts to turn said needle in the direction indicated by the arrow in Fig. 3, said direction being also that in which said needle turns under the influence of the field force of the helices 15, as already explained; hence the attractive forces of said magnet 8 and said helices 15 act in conjunction upon the galvanometer-needle 30 31. The poles of the magnet 8 are somewhat advanced beyond a vertical plane passing through the center of the galvanometer-needle at right angles to the axes of the helices 15 in order to keep a constant attractive pull on the said needle against the pull on it of the spring 37 in the opposite direction, and this the magnet 8 effects even when no current is passing through the helices 15, though the attractive energy of said magnet be less than that of said helices when excited. The spring 37, while thus acting its part as a spring, also performs the office of conducting the current when contact is made between the points 36 and 41 from the relay-battery, which from said battery entered the instrument at C, thence through the contact-screw 41 to the platinum strip 36, and back through the spring 37 and frame 18, shaft 3 and nut 4^a, and the binding-post D to the relay-battery again. The jeweled bearings of the shaft 22 are non-conductors; hence so long as the galvanometer-needle is so mounted it is insulated from the relay-battery. This insulation, however, is not essential as such. It is obvious that this circuit thus closed will make contact between the electro-magnets *m* of the relay-instrument, Fig. 5, and its armature *n*, thus actuating by means of said instrument any registering, receiving, or recording apparatus or any sounder that may be employed. In said Fig. 5 the other parts are indicated by letters, as follows: The operating-key, *k*; E, the ground-connections; I, my transmitting-instrument or galvanometer, and *h* a roll of paper or any sounding substance to be struck by the armature *n*. It is also obvious that there is no necessary limit to the strength of the relay-battery that may be employed to accomplish the work demanded of it, so far as the invention herein described is concerned, as it cannot be injured by such battery, the usual precaution being observed of introducing a resistance-coil, as at *t'*, Fig. 5, in the circuit between the relay-battery and the instrument to prevent a spark between the platinum strips 35 36 and the contact-screws 41 42, as either or both of said screws may be used to close the circuit.

A binding-post, F, Figs. 2 and 5, is shown, to which is connected the wire *f*, which is so led as to be put in circuit with the relay-battery T by the contact with said wire of the armature *n* of the relay-instrument R whenever said armature is held in contact with its magnets *m*. Said wire *f* may be provided with an adjustably-variable resistance-coil, as at f', Fig. 5, to change or diminish the force of the current from the relay-battery T for the following reason: From the binding-post F a wire leads to a binding-post, F′, at the back of the helices 15, Fig. 7^b, opposite and similar to the binding-post P^4 in front, Fig. 7^a. Thence an insulated wire is wound in several coils, as shown at L, Figs. 2, 6^a, and 6^b, on the outside of one helix 15, in the opposite direction to its main coils already described, terminating in another binding-post opposite to post P^3. Thence the same connection is continued, as at L′, Figs. 6^a, 6^b, and 7^b, to a binding-post opposite binding-post P^2, thence in reverse over in coils around the exterior of the other helix or spool 15 to a binding-post, as at D′, opposite P′, and thence to the frame 18 of the instrument, whence the circuit is complete back through the binding-post D to the relay-battery T. Said relay-battery is thus utilized to generate an outer and reverse field-current, which, while the nearer and stronger interposed cable-current is closed, has no effect upon the galvanometer; but when the cable-current is broken the outer reverse relay field-current will act in the opposite direction upon the galvanometer and prevent the possible sticking of its contact-points 36 41 after the field-current has been broken by the operator. Said relay reverse current can always be sufficiently reduced in strength by means of the interposed resistance-coil f' on the wire f, Fig. 5, hereinbefore described. The exterior reverse coils on the spools 15 are indicated by a black line of separation marked L in the right-hand spool of Fig. 2 and by the letter L, Figs. 6^a and 6^b, each set of inner and outer coils being therein shown in cross-section. Instead of reversing said outer coils on the spools 15 said coils may be employed by winding them upon separate spools, as shown in Figs. 6^b, 7^a, and 7^b. Said Figs. 7^a and 7^b represent front and rear views, respectively, of the same spool 15, set within a circumscribing outer spool of coiled wire, L, said inner and outer spools being secured together by metal strips l, thereto fastened by screws, as shown in said figures. It is obvious, however, that other means may be adopted in place of said strips l.

I do not confine myself to the precise details of the construction of the several parts, nor to their respective relative arrangements or juxtapositions herein described and shown, as it is evident to those skilled in the art that many mechanical details may be varied without in any wise departing from the principles underlying and controlling the operation of my invention.

By a sounder or recording, registering, signaling, or receiving instrument I include any known "receiver" capable of operation by electric energy, and by the term "operator's key" k, I include any transmitter capable of affecting the electric current, for the battery-current utilized in this invention may be either intermittent, undulatory, or of varying resistance, according as it may be desired to vary the character of signal or message transmitted, whether graphic, vocal, or articulate speech.

The advantage of making the needles or magnets 30 31 lamellar is of course to increase their strength as magnets, the aggregate magnetic strength of their several plates being much greater than if said magnets were solid and of equal weight. The desired weight of the magnets can also, by reason of their lamellar structure, be conveniently adjusted, so as to obtain only the necessary inertia and momentum to effect sufficiently strong contact of terminals without at the same time adding too much friction to the bearing parts. If desired, but one coil instead of two coils—such as 15—may be employed, thus reducing the magnetic force one-half, when, if desired, the poles of the opposite arcs on one side of the magnets may be united, as shown at u, Fig. 8, or by any interposed magnetic conductor, or said opposite arcs on one side may be entirely dispensed with, and either one or both coils be used with a single arc.

The main battery supplying the field-current through the coils 15 need not consist of more than one gravity-cell, as my said galvanometer will with but one such cell, even against a resistance of more than one hundred thousand ohms, open and close or otherwise affect or operate the circuit of a relay-battery regardless of the strength of said battery or of the work which it may be required to perform, while it is well known that in practice the resistance of the longest submarine cables is far below the resistance above named.

It is obvious that my said galvanometer may be duplicated or added in series as relay-instruments one to the other or others to any extent deemed desirable and with electric currents of any suitable feebleness or strength.

I do not confine myself to the use only of a permanent magnetized needle, as said magnetized part may be made electro-magnetic, if preferred. Neither do I confine myself to the use of a permanent horseshoe-magnet, as 8, as such may also be made electro-magnetic, if preferred, by any well-known arrangement for the purpose.

I herein disclaim the use of a filament—such as silk or animal-hair—for imparting spring-tension to the galvanometer magnet or needle 30 31.

The galvanometer or needle-detector in its various modifications is so delicately organized an instrument that its chief excellence has heretofore lain in its ability to indicate or detect comparatively feeble currents of electricity by vibrations of its delicate and delicately-balanced magnetic needle. Hence when used as a receiving signal-instrument in the early days of telegraphy the galvanometer gave their names to the so-called "dial-telegraphs" or "needle-instruments," its indications given being the mere disturbances of its needle's polarity, caused by the passage of the line-current through the coils of the instrument in proximity to the needle, said current being reversed to reverse the direction of the needle's departure from its magnetic meridian or zero-line. To such a receiving-galvanometer the addition of a resonator or sounding apparatus has been proposed in which the vibrating needle, by striking directly said apparatus, gives its signals by loud sounds, so that the needle need not be watched by the eye. Another form of receiving-galvanometer is the "reflecting-galvanometer" for submarine cables, in which greater sensitiveness is secured than in either of those above mentioned by suspending a very delicate magnet or "needle" carrying a mirror by a fine filament of silk—a non-conductor of electricity—the reflections of a ray of light from a powerful lamp cast by said mirror into a darkened room enabling the signals thus made to be read by any conventional or prearranged code. The difficulty, however, heretofore experienced in endeavors to adapt the galvanometer as an instrument to either, by means of its delicate needle, directly transcribe or indirectly transmit through a relay-battery circuit graphic messages is not due to any inability to impart mere motion to said needle. Certain voltaic currents can effect this result; but in attempting to adapt said needle to perform said offices under the influence of very weak voltaic currents in a long primary circuit exciting its galvanometer-coils certain difficulties are at once met. If the needle is to do the work of or operate a pencil or stylus solely by the energy of the primary circuit, it is manifest that said energy must be derived from sufficient battery-power to directly accomplish such work. On the other hand, if the needle is to perform only the office of a circuit-closer in a relay-circuit, a primary circuit of battery-power just sufficient to such purpose is all that is required; but with a voltaic current only sufficient for the latter purpose great difficulty has been experienced in adapting the needle to act its part in affecting the relay-circuit in the desired manner—that is, synchronously and sympathetically with the movements imparted to the needle by the current of the primary or line circuit acting upon it within and by the influence of the field-energy of the galvanometer-coils. This difficulty, I have discovered, is largely, if not entirely, caused by the inability of the needles, as heretofore constructed and combined, to act sufficiently and efficiently the part of relay-circuit closers, both in failing to make good contact and failing to present sufficient area of conducting material to conduct a strong enough relay-current to do the work required of operating "sounders," or printing, writing, or other signal or receiving devices.

Electro-magnets are not suited to take the place of either the galvanometer-coils or of the spring-power used by me. There is no elasticity, bending, or spring-like action in the action of an electro-magnet, and, while for many purposes an electro-magnet can be demagnetized quickly enough by breaking the circuit, yet, compared with the galvanometer-coil, "residual magnetism" remains in the electro-magnet and its demagnetization is too slow. Neither can the electro-magnet—an instrument of greater potential energy—be energized by so weak a current as can the galvanometer-coil to accomplish the same necessary deflection of the magnetic needle.

In the invention herein described a galvanometer-instrument is so constructed, arranged, and adapted as to be capable of receiving and transmitting electric impulses, started by any known means over a primary voltaic circuit of great length and of single-cell power, whether by ordinary telegraphic instruments or by telephonic instruments, and of also transmitting such impulses through a second or relay circuit to a receiving-instrument, whether a telegraphic or telephonic receiver; and the relay-battery sufficient to work a Morse sounder or dot-and-dash-key instrument can be operated by a battery of less than ten gravity-cells, so that, even leaving out of consideration any question of saving in expense of total battery-power, the durability of submarine cable—a matter of great importance—can be not only much prolonged by the use of so weak a battery-current through it, (that of a single gravity-cell,) but a cable of any given diameter in such case is rendered practically of much larger area of cross-section proportionally to the difference in strength of current passing over it; hence there must be less resistance to the current's passage, and, what is of still more importance, less internal inductive disturbance and interference from following or successive signal-currents, and hence greater speed of word-transmission, and the message will be received, as may be desired, either in printed words or in the Morse or other alphabet, this work being done by the relay-battery power only.

Having thus fully described my said improvements in the art of transmitting electro-magnetic impulses for telegraphic and other purposes, as of my invention I claim—

1. In an electric system for the transmission of sign or sound communications, whether graphic, vocal, or articulate, in combination with a primary voltaic battery, a second or relay voltaic battery, and a receiving-instrument operated by said relay-battery, a galvanometer consisting of a coil or coils of insulated wire and a magnetic needle pivoted to oscillate between the terminals of said relay-battery and provided with a spring or springs forming the conducting element between said needle and one terminal of the relay-battery when the needle closes circuit with the other terminal of said battery, whereby said needle

is caused to transmit said communications through the circuit of said relay-battery, substantially as and for the purposes set forth.

2. In an electric system for the transmission of sign or sound communications, whether graphic, vocal, or articulate, in combination with a transmitting-instrument for controlling its operation, a galvanometer consisting of a coil or coils of insulated wire and a magnetic needle provided with a torsional spring secured to said needle and with a spring radially secured to said needle, and a receiving-instrument in a relay-circuit, whereby said needle is caused to transmit the signals or sounds affecting it to said receiving-instrument through the relay-circuit, substantially as and for the purposes set forth.

3. A magnetic galvanometer-needle mounted in insulated bearings and provided with an electric terminal, in combination with an electric conductor-spring opposed to said needle's movement from its neutral position, and electric terminals in a relay-battery circuit, whereby when the circuit is closed between said terminals said spring-conductor forms part of the circuit between the poles of the relay-battery, substantially as and for the purposes set forth.

4. A curved magnetic galvanometer-needle provided with an electric terminal, in combination with an electric terminal in a relay-circuit and a spring opposed to said needle's movement from its neutral position, substantially as and for the purposes set forth.

5. In combination with a galvanometer consisting of a coil or coils of insulated wire devoid of magnet-cores and a magnetic needle provided with a spring opposed to said needle's movement from its neutral position, a horseshoe-magnet, all combined and arranged so that the resistance of said spring to said needle's movement is diminished by the field energy of said magnet and the field energy of said coil or coils augmented by the field energy of said magnet, substantially as and for the purposes set forth.

6. The combination of a magnetized galvanometer-needle provided with an electric terminal, a positive field-energy coil, and a negative field-energy coil, said coils devoid of magnet-cores and energized the one by a main circuit and the other by a different circuit, and an electric terminal in a relay-circuit, whereby should said terminals in the relay-circuit stick or adhere after the main circuit is broken one of said coils is thereby immediately energized to break said contact by its opposing field force, substantially as and for the purposes set forth.

7. The combination of a magnetized galvanometer-needle, a positive field-energy coil or coils, and a negative field-energy coil or coils, said needle pivoted to oscillate within the magnetic fields of said coils, and said coils devoid of magnet-cores and energized by different voltaic circuits and annularly located one within the other, substantially as and for the purposes set forth.

8. A magnetized galvanometer-needle provided with a spring of conducting material and with one or more contact-terminals in a relay-circuit, in combination with one or more field-coils positively energized and one or more field-coils negatively energized, all of said coils devoid of magnet-cores, whereby said needle is adapted to operate in the magnetic fields of said coils, substantially as and for the purposes set forth.

9. A laminated galvanometer-needle built up of separate magnetized laminæ of like polarity superposed upon each other and secured together, as and for the purposes set forth.

10. In combination with galvanometer-coils, a curved magnetized galvanometer-needle composed of two laminated arcs built up of magnetized laminæ superposed upon each other and secured together with their poles facing each other, and said coils between said facing-poles, whereby a galvanometer-needle of increased magnetic power is obtained for deflection by the united field force of said coils, substantially as and for the purposes set forth.

11. A magnetized galvanometer-needle composed of curved arcs adjustably connected to the arms of an oscillatory shaft, whereby the leverage of said arcs and the equilibrium of the needle are accurately adjusted, substantially as and for the purposes set forth.

12. In combination with a magnetized galvanometer-needle, a friction apparatus, whereby said needle is prevented from moving by the brake action of said apparatus until the force of the field energy acting upon the needle exceeds such brake action, substantially as and for the purposes set forth.

13. In combination with the oscillatory shaft of a magnetized galvanometer-needle, one or more friction rods or bars, whereby the oscillations of said needle are steadied and controlled, substantially as and for the purposes set forth.

14. In a machine for transmitting electric energy, one or more adjustable galvanometer-coils of insulated wire provided each on its periphery with a dovetail piece, in combination with a magnetized needle composed of two curved arcs, and a supporting frame or frames dovetailed to receive said piece or pieces, whereby said coil or coils are adjustably set in position relatively to the opposite poles of said arcs, substantially as and for the purposes set forth.

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Witnesses:
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