(No Model.) 3 Sheets—Sheet 1.

S. D. FIELD.

ELECTROMAGNETIC SIGNAL RECEIVING INSTRUMENT.

No. 571,351. Patented Nov. 17, 1896.

Fig. 1.

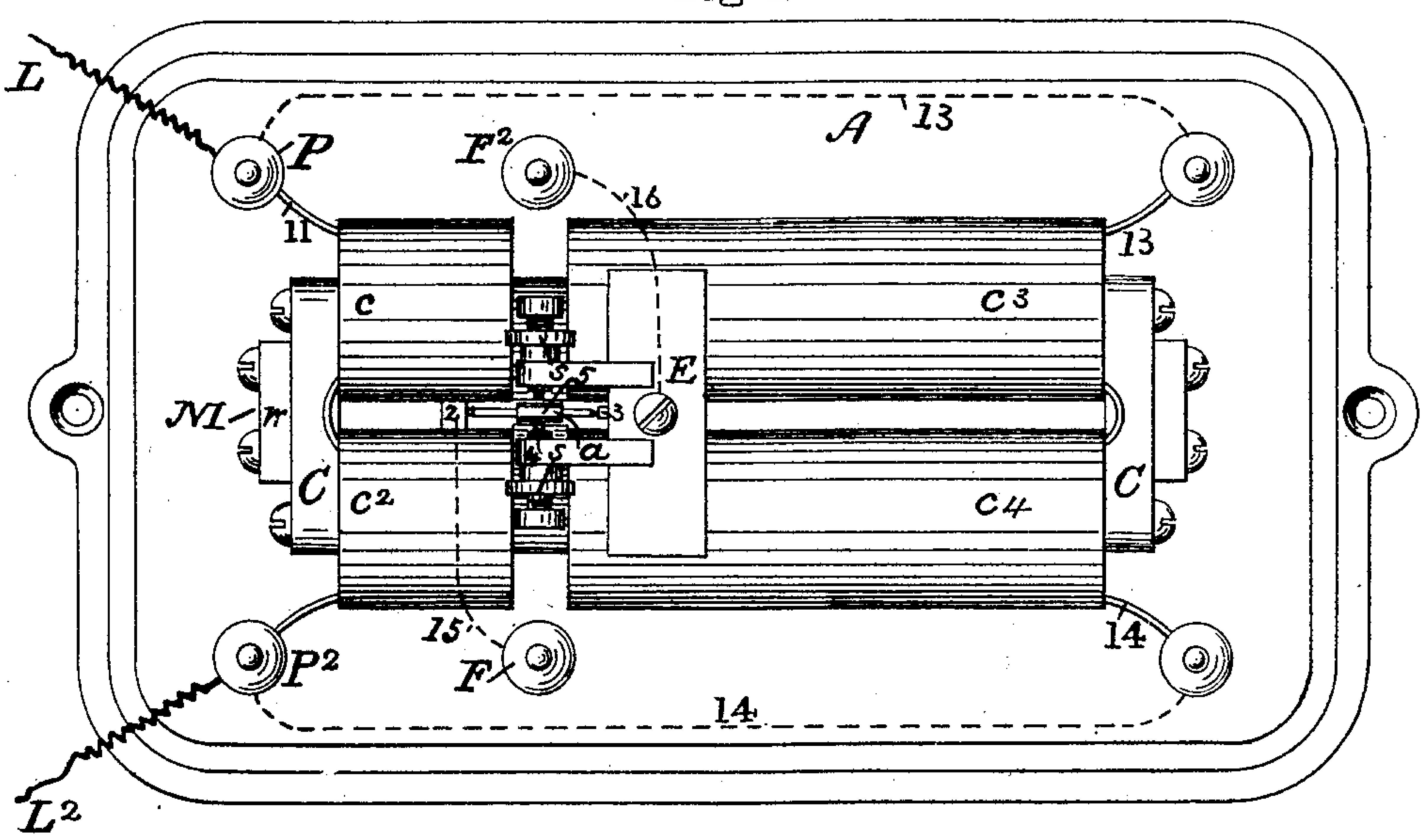


Fig. 2.

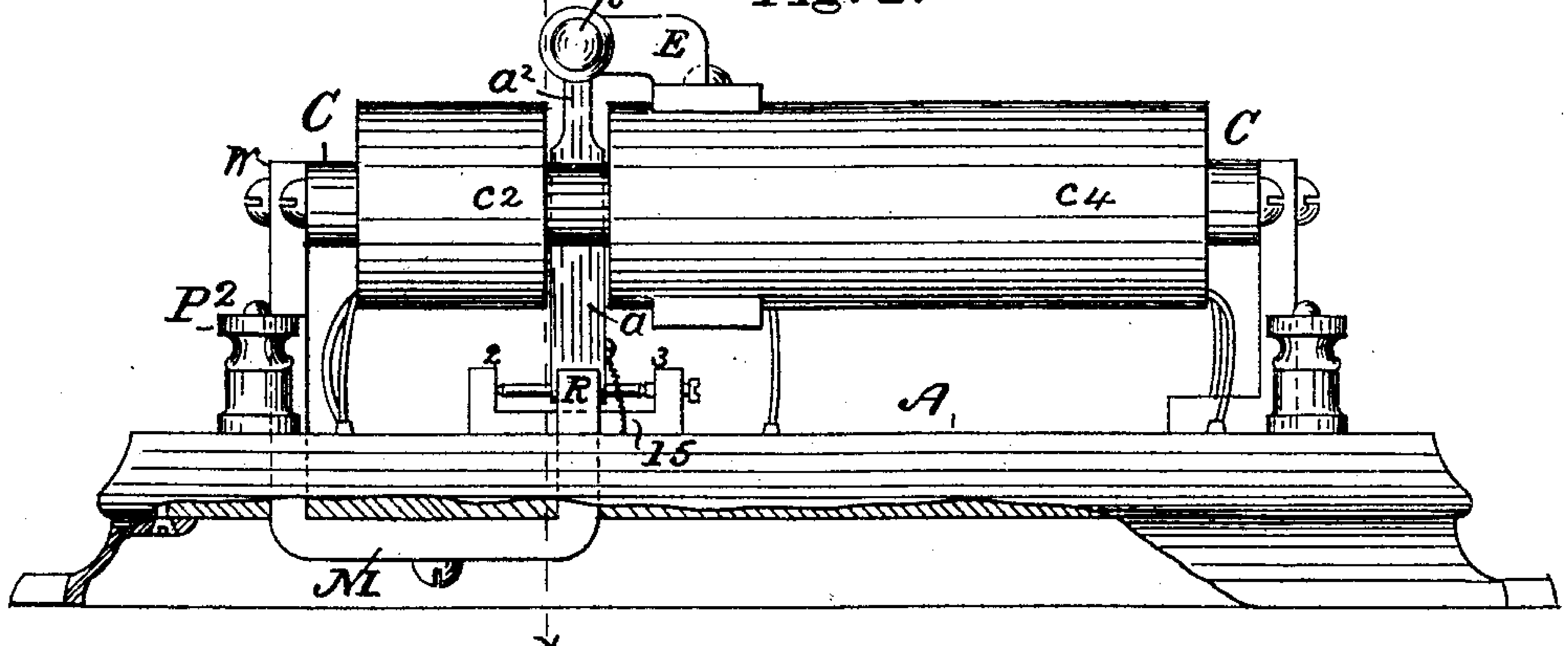
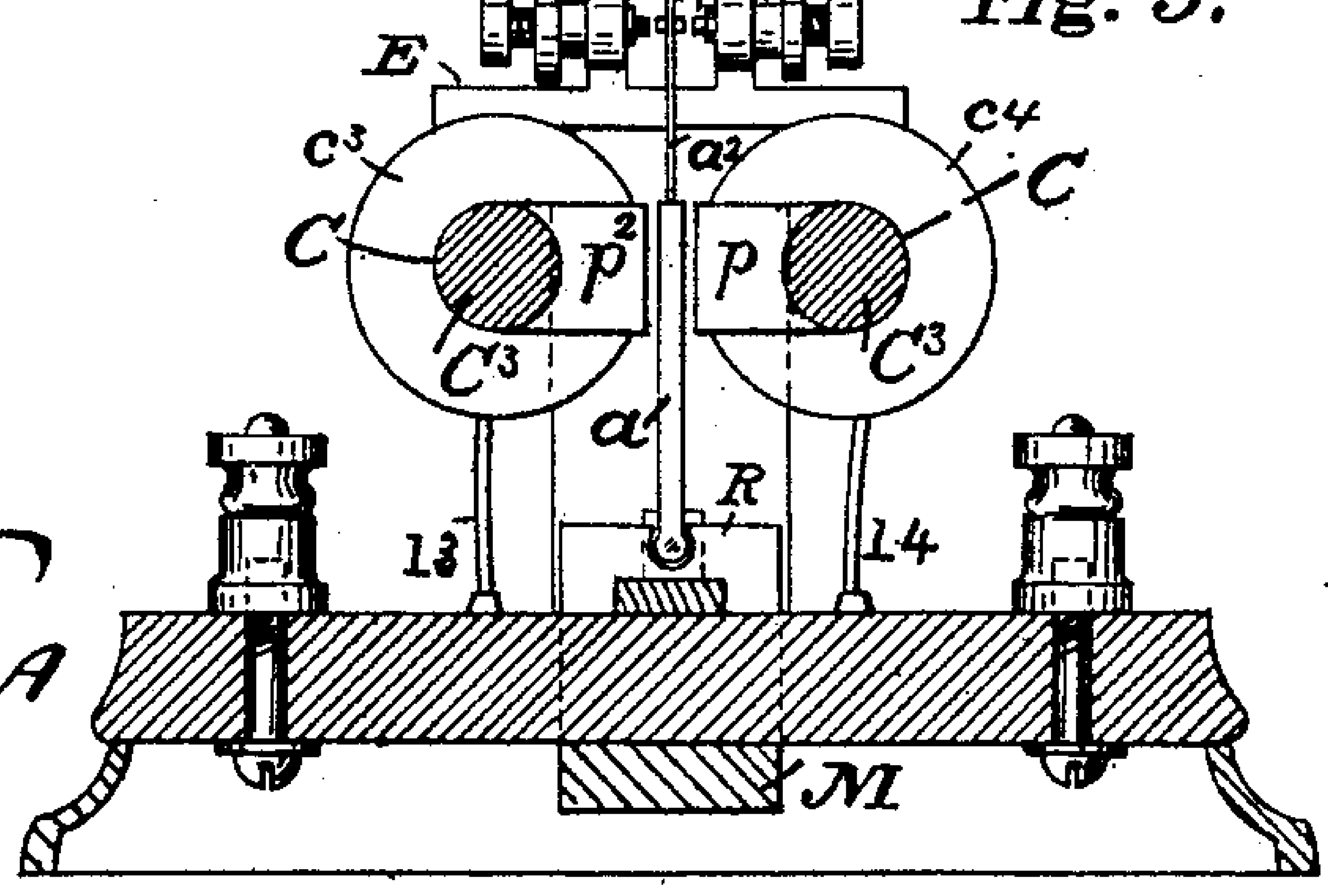


Fig. 3.



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ELECTROMAGNETIC SIGNAL RECEIVING INSTRUMENT.

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Fig. 4.

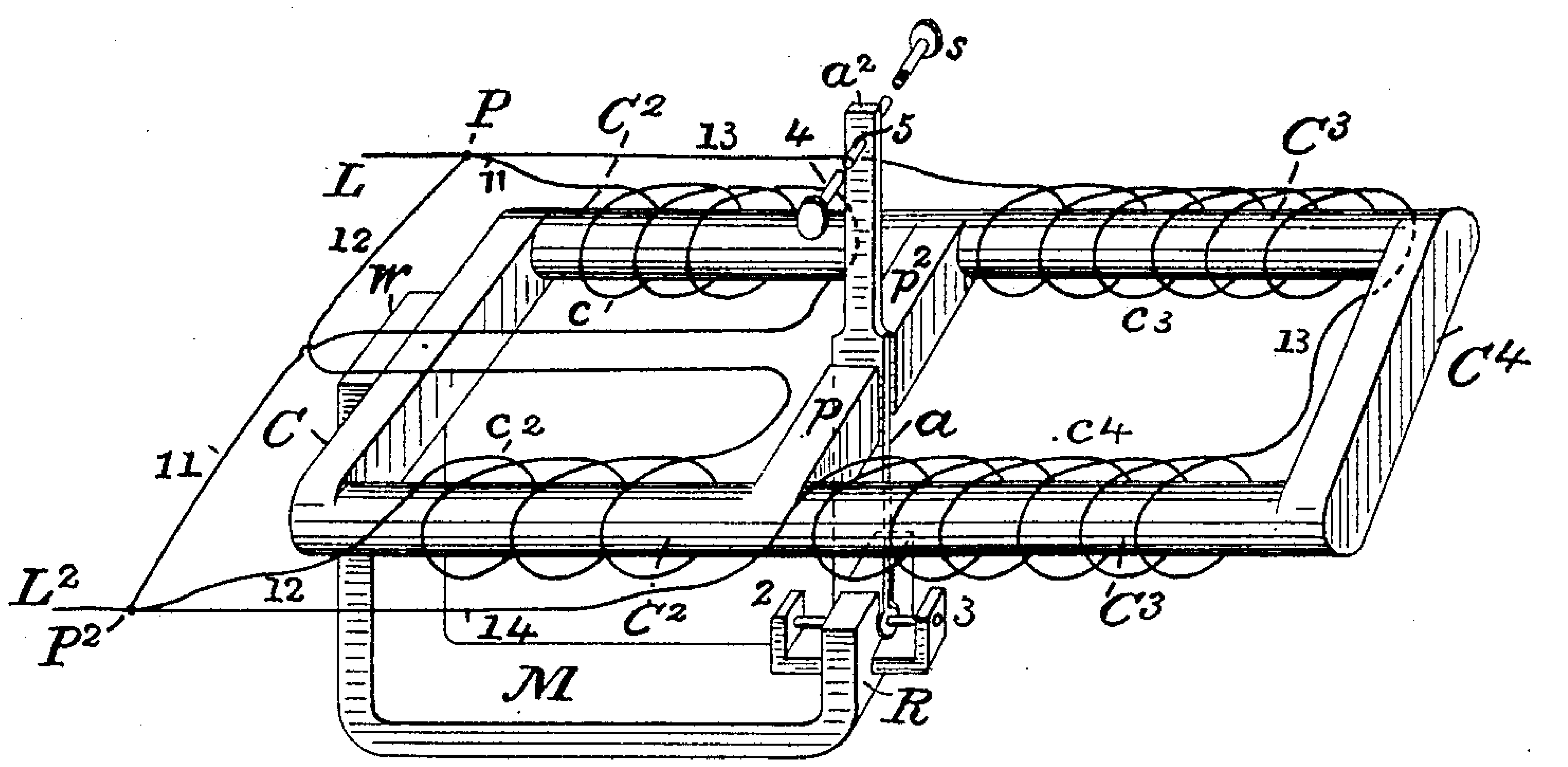

Fig. 5.

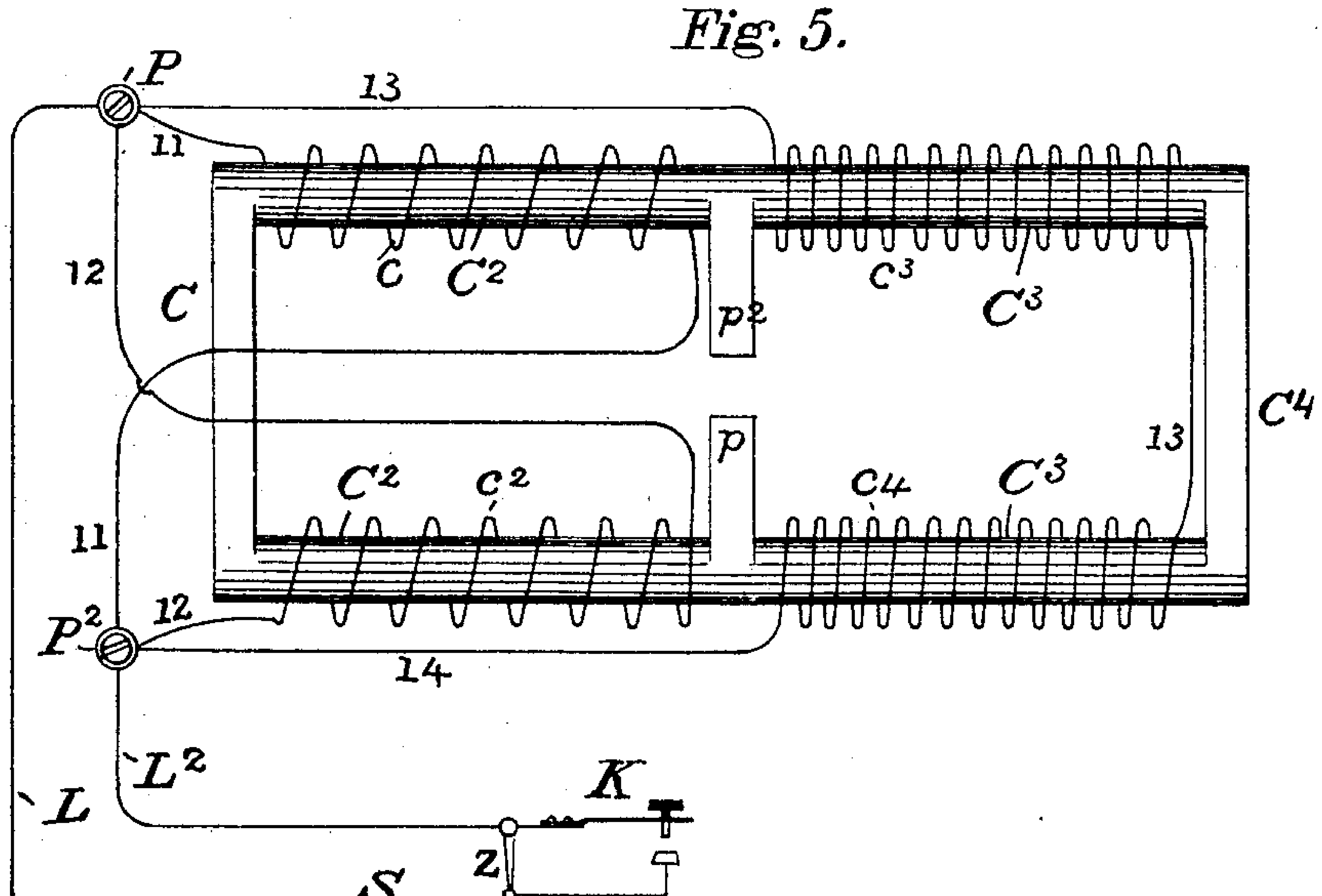

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Fig. 6.

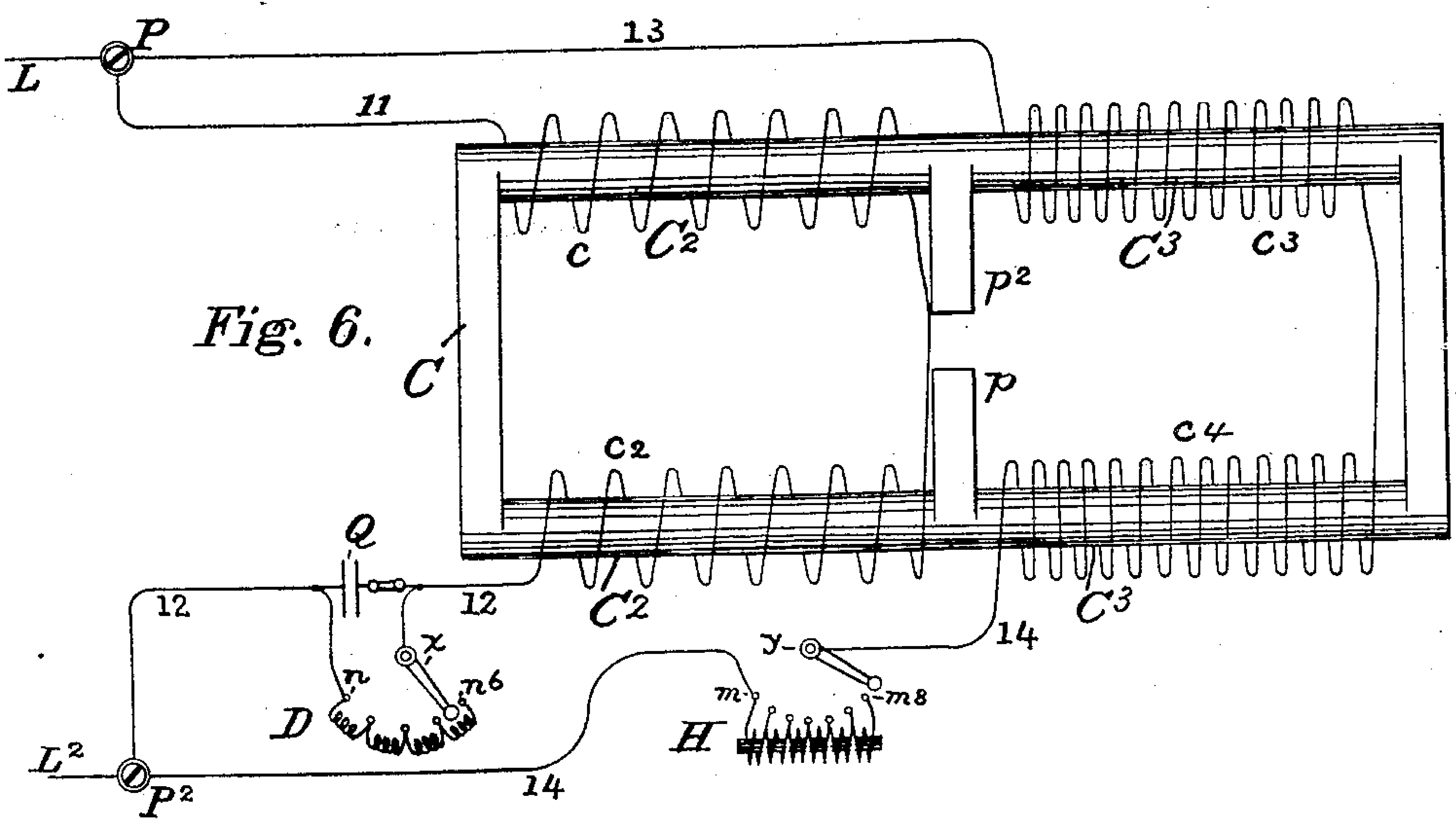


Fig. 7.

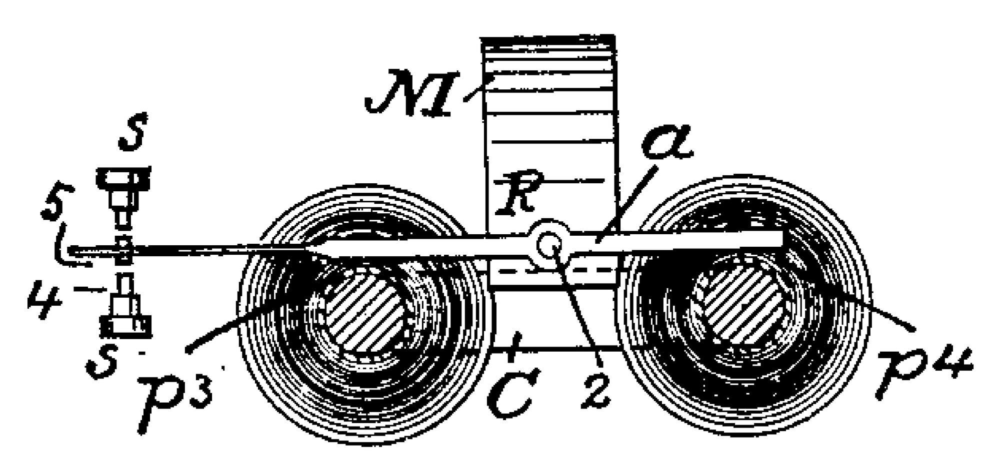


Fig. 8.

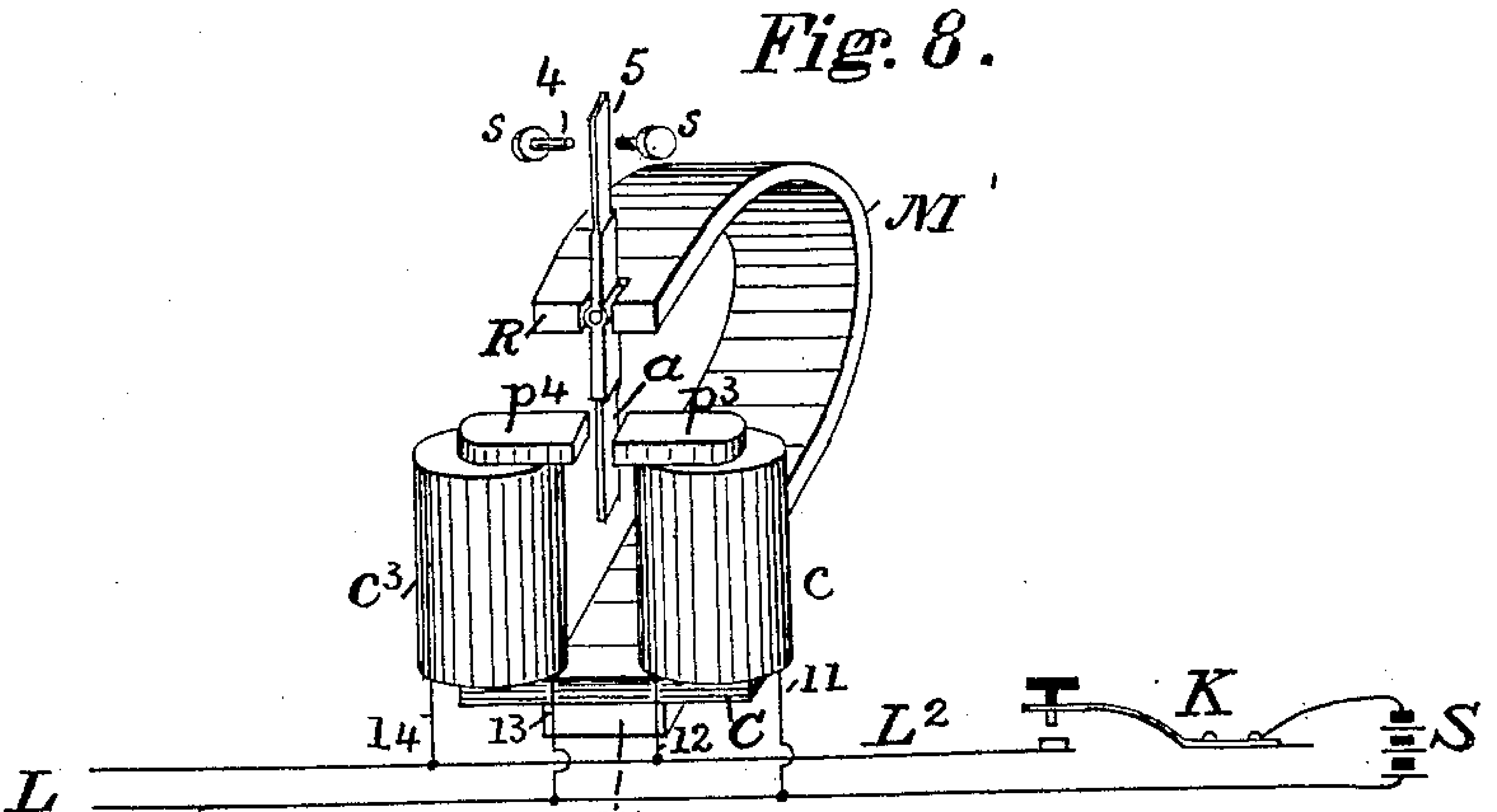
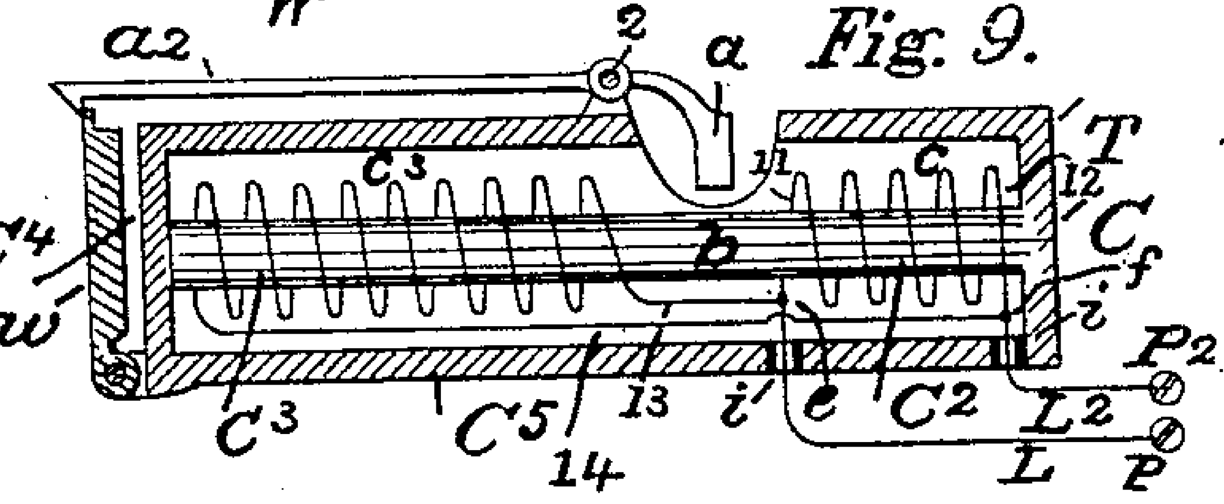


Fig. 9.



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UNITED STATES PATENT OFFICE.

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ELECTROMAGNETIC SIGNAL-RECEIVING INSTRUMENT.

SPECIFICATION forming part of Letters Patent No. 571,351, dated November 17, 1896.

Application filed August 11, 1896. Serial No. 602,388. (No model.)

To all whom it may concern:

Be it known that I, STEPHEN D. FIELD, residing at Stockbridge, in the county of Berkshire and State of Massachusetts, have invented certain Improvements in Electromagnetic Signal-Receiving Instruments, of which the following is a specification.

This invention relates to electromagnetic apparatus, and more particularly to electromagnetic signal-receiving instruments or appliances used in the arts of telegraphy and telephony, such as relays and annunciators.

The objects of my invention, briefly stated, are as follows: to provide a receiving instrument which, without special devices applied to the armature to bias, limit, or otherwise control its movement, shall be insensible to the passage through its coils of a steady or non-varying current, but perfectly sensible and fully responsive to intermittences, reversals, or sudden changes in the strength of a current; to provide an electromagnetic appliance which depends for its normal operation upon the difference in time required by exciting-coils of like magnetizing power, but diverse inductance, wound over or placed upon a common iron core, to reach, respectively, their maximum and zero magnetizing values under abrupt changes of a current traversing the said coils; to provide an efficient and accurate self-adjusting relay, and to provide a polarized relay which, without springs or other mechanical armature-biasing contrivances, shall be promptly and rapidly responsive to simple makes and breaks or abrupt changes in strength of current as perfectly and completely as to reversals.

Prior to my invention it was known that an electromagnetic instrument might have the two halves of its winding placed so as to oppose one another magnetically in parallel branches of the working circuit, the self-induction of one branch being much higher than that of the other, so that the said branch might be said to have high self-induction as its characteristic feature. Such an arrangement is described and illustrated in an article entitled "On a New Method of Working Polarized Relays," published in the *Telegraphic Journal and Electrical Review*, London, November 15, 1874, page 361. In the system there described, and in all similar systems of which I am aware, the high self-induction is a function of the circuit and not of the instrument. The two coils of the instrument are necessarily of like resistance, and the arrangement has not constituted a practical advance in the art and has not been commercially used, whereas my invention is an instrument so constructed that regardless of any circuit arrangement it will perform the work required.

My invention does not therefore consist in combining an ordinary relay or other receiving instrument with two parallel branches of a circuit having diverse inductance in such a way that the said instrument shall be irresponsive to steady but responsive to changing currents; but is a relay or other receiving instrument complete in itself, so constructed that it may be placed in any ordinary circuit, and will then in virtue of the diverse inductance of its own coils and its several other features of design and structure and without auxiliary appliances be enabled to accomplish the above-stated objects.

In electromagnetic appliances embodying my invention exciting-coils of like magnetizing power, but of different inductance, are placed upon or wound over a soft iron core and are connected with one another in multiple arc or parallel, being so relatively wound or connected that a point on the said core (if the same be a single bar) between their approximating or adjacent ends or the points (if the core be U-shaped or double) between the two ends of both shall be polarized or assume a definite magnetic polarity, when from any cause either coil acts alone or with superior power on the common core, while the said core is maintained at a magnetic zero or in a state of magnetic neutrality due to the equal and opposite magnetizing action of the two helices when a steady current flows through both. The polarity produced at the said point of the core is north when produced by one of the coils, and south when produced by the other. In providing that two helices of different dimensions shall be able to exercise equal magnetizing effects on an iron core with a current of fixed or steady value it is of course only necessary to so wind and arrange them that each shall have the same number of ampere-turns, and that the ampere-turns of each shall hold similar relations to the said core. Thus if one of them be wound with a longer and finer wire than the other and the current through it be reduced in virtue of the consequent increased resistance, the equality of its magnetizing power can still be readily maintained by causing the current so reduced to pass a sufficient number of times around the core. This being so, any two coils of like magnetizing power may be so constructed that their inductance shall vary or differ to any desired extent. The coil whose inductance is to be low may be formed by winding a relatively short wire over a relatively small portion of the core, while the high-inductance coil in that case will be constructed by winding a much longer wire over the very much larger remaining portion of the core.

Another and, generally speaking, a better and preferable way of making the electromagnets of such electromagnetic receiving instruments as relays and call-bells is to wind substantially equal portions of the core with equal lengths of the insulated magnet-wire, and to arrange the two coils thus formed so that the one which is required to have a low inductance shall be divided at its middle and have its two halves connected in parallel with each other, while the other, requiring to have a high inductance, is left continuous from one end to the other, and is connected in the main circuit in parallel with the two parallel portions of the first.

I have found that magnetizing-coils of different self-inductive value may be placed upon a common magnetic core or group of cores forming a single magnetic system, and may be so connected, relatively, and with the same external circuit and source of current as to be operative only during the variable period of the currents flowing through them. The said coils when wound over their core are joined up in opposition to each other, so that when under the influence of a steady or fully-established current both exert their magnetizing influence upon the said core or system, each neutralizes the effect thereon of the other, the resultant effect being zero. Their useful operation therefore depends upon the difference between the times required to charge and discharge the coils of lesser inductance and greater inductance, respectively. Thus if two conductors of similar specific resistance are coiled upon the same bar of soft iron, coupled in parallel so as to oppose each other, both having the same magnetizing power and both connected with the same external battery or generator, one of them, however, having but one hundred turns, while the other has a much larger number of turns, (say one thousand,) when the external circuit is suddenly closed, permitting the current to flow through both conductors, the first effect is to impress upon the iron bar a momentary magnetization whose polarity is due to the shorter conductor. This polarity, however, is immediately thereafter neutralized, the bar relapsing to its magnetic zero as soon as the current in the longer coil of greater inductance reaches its full value. On opening the main circuit and withdrawing thereby the main current from the two associated coils a reverse operation takes place. The shorter coil again, by reason of its low inductance, is almost instantaneously discharged, thus freeing the core from its influence; but the longer coil, in virtue of its high inductance, is slow in falling to a current zero, and its self-induction—being on the fall of the main current—in the same direction as the said main current, the magnetic polarity due to the said longer coil is impressed alone upon the bar and is prolonged for an appreciable amount of time. Thus the high-inductance coil being the slower, both in charge and discharge, permits, first, the core to be magnetized by a polarity due to the other exciting-coil during the variable state of the appearing or rising current, and, second, magnetizes the core with an opposed polarity, due to its own current, direct and self-induced, during the variable state of the disappearing or falling current, while for the time during which the current maintains its maximum or normal value in both coils the magnetism due to each is canceled by that of the other. I may therefore say that an electromagnetic receiving instrument of any such general construction utilizes and works by reason of the differential time constant of exciting-coils of similar magnetizing value, but different inductance, and may properly regard it as being a differential inductance appliance. In applying these principles to telegraphic relays and other forms of electromagnetic receiving instruments, as electric bells, I have attained the best results by forming the electromagnetic iron core into a closed magnetic circuit having pole-pieces projecting inwardly and toward each other, substantially equal portions of the core being on each side of the said two pole-pieces. In this case the low-inductance coil is on one side of the pole-pieces and the high-inductance coil on the other. Good results have, however, also been attained when the pole-pieces have not been so centrally placed and when the two portions of core on the two sides of the said polar projections have differed considerably in extent. These principles, however, admit of wide structural variation, and in many cases the magnetic-circuit form of core may be dispensed with, either a U-formed core or a simple bar taking its place. In applying the said principles to the skeletons of polarized relays or bells of ordinary style the U-form of core may be utilized, while the bar form is conveniently employed in applying them to annunciator-drops.

In the majority of cases it is advantageous to associate with the iron core and its exciting-coils an outside magnetizing or polarizing medium. In polarized relays or bells this takes the form of a strong polarizing permanent or electro magnet having one of its poles secured to or in inductive proximity to the iron of the core, imparting to the same a definite and normal polarity, while its other pole is so placed as to impart an opposite and permanent polarity to a vibratory or oscillatory armature whose free end extends into the field of the polar projections or surfaces of the core.

In adapting standard instruments to circuits having a wide range of electrical proportions I have found it convenient and useful to provide suitable means for accomplishing such change in or adjustment of the relative inductance of the coils as may be desired. I do this by connecting a variable or adjustable resistance in the circuit of one or both of the exciting-coils and by providing the same with a button or plug switch, whereby more or less of the said resistance may be introduced into or excluded from the said circuits. I find that the best results are attained by connecting simple or non-inductive resistance in the circuit of lesser inductance, which is required to act quickly, and by associating electromagnetic resistance-coils or impedance-coils with the circuit of the coil of greater inductance, which is organized to act sluggishly. In some instances also I find it advantageous to bridge the non-inductive resistance by a condenser, which, in a manner well understood, will tend to balance and compensate for such self-induction as is possessed by the shorter coil, accentuating the action of the differential inductance of the two coils.

In the drawings which illustrate the specification, Figure 1 is a plan view of a telegraph-relay embodying the invention. Fig. 2 is a side elevation of the said relay. Fig. 3 is a transverse section thereof on the line y y of Fig. 2. Fig. 4 is a skeleton and diagrammatic view of the electromagnetic core polarizing medium and winding of a preferred form of polarized relay embodying the invention. Fig. 5 is a similar skeleton view of the core and winding only, showing an advantageous arrangement of the latter. Fig. 6 is a diagram of the core, pole-pieces, and winding of an electromagnetic appliance associated with means for varying the resistance and impedance of the exciting-coils. Fig. 7 illustrates a form of core wherein polar projections are dispensed with. Fig. 8 represents the application of the main features of the invention to electromagnetic receiving instruments in which two exciting-coils are wound over the two limbs of a **U**-shaped core, and Fig. 9 illustrates the invention as embodied in an annunciator-drop.

Figs. 1, 2, 3, 4, and 5 may be considered together. Figs. 1 and 2 represent more particularly that form of relay in which the two portions of both coils are in series, while each coil is in parallel with the other, the coil of high inductance being much longer than the other and wound over a much larger portion of the core, the same arrangement of winding being also shown in Fig. 6. Figs. 4 and 5, on the other hand, show a core having equal spool-spaces, the high-inductance coil being in series or continuous between the instrument terminals, while the low-inductance coil is in two portions of equal length and connected in parallel with each other.

A is the base of the instrument, C a continuous or endless iron core having two sections C' C^2 and C^3 C^4.

p p^2 are pole-pieces or polar projections abutting toward each other from points of the main core at the junction of the said two sections.

M is a polarizing-magnet having one of its poles W secured to the end piece C of the core system, and a is an oscillatory or vibratory armature hung on trunnions 2 3 in inductive proximity to the other pole R of said magnet and continuing upward therefrom, so that its free end is adapted to vibrate between the pole-pieces p p^2, the same having a circuit-controlling extension a^2 projecting between two limit-stops s, supported on a bracket E, secured to the frame, one of which limiters carries a contact-stop 4, with which a contact-piece 5, carried by the said extension, coöperates in closing and opening a local circuit. The other limit-stop in the present case is tipped with non-conducting material. So far, then, we have a magnetic-core system, wherein a definite normal magnetic polarity is imparted to the pole-pieces p of the closed-circuit core C by the pole W of the polarizing-magnet M, and an opposed permanent polarity to the armature a by the other pole R of said magnet.

The core C has two magnetizing or exciting coils c c^2 and c^3 and c^4, one for each section of the core. That section of the core C C^2 which is to be quick acting is wound with the coil c c^2, while the other portion C^3 C^4 of the said core-section is surrounded by the coil c^3 c^4.

In the mode of winding indicated by Fig. 5 (which would be that adopted in core-sections of unequal length, such as those of the relay of Figs. 1 and 2) the exciting-coil c c^2 is very much shorter than the coil c^3 c^4. Excellent results have been reached in a relay of this kind where both coils being wound with wire of the same size the conductor of c c^2 had a resistance of one hundred and fifty ohms, while the conductor of c^3 c^4 measured six hundred ohms.

As indicated in Fig. 6, the conductors of the exciting-coils are connected in parallel with one another between the terminals P P^2, and may be traced as follows: The shorter one by wire 11, helices c and c^2 in series, and wire 12, and the longer by wire 13, helices c^3 and c^4, and wire 14. As clearly indicated, these coils are so wound or connected that with the same main current divided between them they develop magnetizations of opposite polarity in each of the two polar projections p p^2, and since the weaker current in the longer coil c^3 c^4, due to its higher resistance, is compensated for by the increased number of turns, these opposite polarities are equal in magnitude, and with a steady current the entire magnetizing effect of each coil is neutralized by the opposing effect of the other. Broadly stated the longer coil has sixteen times the self-induction and therefore sixteen times the reactance of the shorter one, and consequently the current flowing through the shorter is by far the quicker in reaching its normal value when the external circuit is closed or the current caused to flow therein. The result of this is that the shorter coil attains its full magnetizing power with great celerity, and, acting upon the core-section C C^2, develops the appropriate polarity in the projections p p^2 a considerable period of time before the longer and more sluggish coil c^3 c^4 receives its normal maximum of current and can reach its complete magnetizing power and neutralizing effect. When, therefore, the current is caused to pass through the circuit, the armature obeys the shorter coil instantly. When the current ceases, a reverse operation occurs, and as the shorter coil, by reason of its low inductance, promptly loses its current and ceases instantly to excite the core the longer coil, whose high inductance materially prolongs its magnetizing current, now excites the polar projections with a magnetization opposite to that which they first received, so that the armature is oppositely attracted and oscillates over to the other side of the pole-piece field and into a position opposed to that which it assumed in obedience to the shorter coil. These armature movements are identical with those produced by "true reversals" of the main-line current, although for their production with this relay no reversal has occurred or is required, and they can also be brought about equally well by an increase and decrease of the signaling-current, as by makes and breaks or reversals. It is evident, therefore, that all of the stated objects of my invention are accomplished in a relay or other electromagnetic appliance embodying generally the scientific and constructive principles considered above. It is also evident that since such changes of the normal circuit conductor and current as are not due to intentional manipulation, such, for example, as those brought about by conditions of weather, by the gradual weakening and strengthening of the current, and by depreciation of the character of the circuit, are not sudden they must affect both coils alike, and that all changes (as those produced in transmitting signals) which act operatively upon one of the exciting-coils must in like manner act operatively upon the other, for whatever the normal condition of the main circuit and its current the relation of the two coils to one another remains the same. A self-adjusting relay in every sense of the word is thus provided.

As already stated, the preferable mode of securing the required differential inductance of the exciting-coils is that indicated in Figs. 4 and 5, where the same, or substantially the same, electromagnetic core system is shown, but where the winding is differently arranged. Both sections C C^2 and C^3 C^4 are in these figures shown as being of equal length and spool capacity, and both are wound with a conductor of the same length and size, the high-inductance winding, however, being continuous or with its two spools c^3 and c^4 in series between the terminals, while the two spools c and c^2 are in parallel with each other.

The series winding of the high-inductance coil leads from L through P, wire 13, the coil sections c^3 and c^4 in series, wire 14, and P^2 to L^2, all in series; the associated windings of the low-inductance coil lead from L through P, wire 11, coil section c, and P^2 to L^2, and through P, wire 12, coil section c^2, and P^2 to L^2, respectively, the associated parallel windings of the latter being moreover in parallel also with the series winding of the former. So connected, the instrument works well under average conditions when the length of the series or high-inductance winding is such as to give a resistance of six hundred ohms; the parallel or low-inductance coil will have but one-half the number of turns in series, and since these are in multiple arc with one another, its resistance will be but one hundred and fifty ohms, while the joint resistance of the entire instrument will be but one hundred and twenty ohms.

In Fig. 5 the main circuit L L^2 is shown as including a source of current S, a key K, and a key circuit-closer z.

Referring to Fig. 6, D and H are balancing and regulating resistances in the circuits of the low and high inductance coils, respectively. They are both variable and adjustable, their magnitude being controlled by the switches x and y. In the shorter coil-circuit I preferably employ simple or non-inductive resistance, which can be adjusted by moving the switch between the contact-studs n; that is to say, lessened by moving the switch toward n and increased by moving it toward n^6. In the longer coil-circuit I prefer to use electromagnetic resistance or impedance coils as indicated, and this can be varied by moving the switch y between the studs m m^8. To aid in keeping down the self-induction or inductance of the shorter exciting-coil, I also may use a condenser Q, bridging the neutral resistance D, and this may of course be connected with or disconnected from the working circuit by a switch in a manner well understood.

The relay connections of the usual local or sounder circuit are indicated in Fig. 1. The ends of a loop containing the local battery and sounder may be connected with the bindingscrews F F^2. F is united electrically (say, by wire 15) with the armature a and its vibrating contact-point 5, and F^2 by wire 16 with the bracket E, and so with the fixed contact-point 4. Thus when the armature-point makes contact with the fixed point the local circuit is closed, while when the said points separate the local circuit is opened. When in consequence of the closing of a distant key a current arrives and energizes first the low-inductance coil, the armature swings over toward pole-piece p, bringing the points together and closing the sounder-circuit. At each opening of the key the high-inductance coil, prolonging its action, swings the armature back again toward pole-piece p^2 and opens the local sounder-circuit.

Heretofore in the operation of Morse telegraph systems, where the main circuit when at rest is closed and the main current always flowing, the relay armature has necessarily remained on its front stop, keeping the sounder local circuit always also closed, to the great detriment of the battery power, which is thus kept at work even when the line is idle. An incidental but peculiar and useful attribute of a relay based on the foregoing principles is that it can readily be initially adjusted in such manner that though the main circuit be as usual closed on the conclusion of a message, and the main current allowed to flow therein, the armature will fall back to its insulating stop in a few seconds after the message-impulses have ceased and after the transmitting key has been finally closed, thus opening the sounder-circuit and preventing the waste of its local battery. This I may and do in practice accomplish by so arranging or adjusting initially the relation between the long and short helix that the magnetic effect of the longer one exercised upon the pole-pieces shall, after the current has been steady an appreciable length of time, be a trace stronger than that exercised by the shorter one. This is brought about by the adjustable resistance D, or, if desired, by including in the circuit of the shorter coil a small fixed resistance. The polar projections p p^2 are not an essential feature in the proper construction of my relay or of other electromagnetic appliances. It is evident that this relay is peculiarly adapted to the operative conditions of subaqueous or subterranean cables, it being merely required for any given cable that the helix of high inductance shall be so relatively proportioned that its variable period shall closely coincide with that of the circuit within which it is connected. Fig. 7 represents an arrangement which under some conditions is equally advantageous and which for polarized bells is generally to be preferred. In it a portion of the surface of the electromagnetic core between the approximating ends of the high and low inductance spools may be left bare to form polar surfaces, and the armature a is centrally pivoted at 2 and polarized at its center, so as to present like polarity to both of the said polar surfaces p^3 p^4, the other end of the polarizing-magnet, as in the previously-described form of construction, being secured to the heel-piece of the low-inductance coil.

In Fig. 8 is shown a modified Siemens polarized relay, which while retaining its characteristic form contains the spirit of my invention. The yoke of the **U**-shaped soft-iron core C is affixed to the pole W of the polarizing-magnet M, and to the other pole R thereof is pivoted the heel of the armature a. The free end of the said armature extends between the ends of the pole-pieces p^3 p^4, and a circuit-changing rod a^2 projects upwardly from the heel to the limit-stops s s, one of which supplies the contact-point 4, with which a complementary contact 5, carried on the rod a^2, is adapted to engage. The two coils c and c^3, placed on the two arms of the **U**, respectively, may be relatively wound in the manner indicated by Fig. 6, the low-inductance coil c having a resistance of, say, one hundred and fifty ohms, while the longer one, c^3, of high inductance may be wound up to a resistance of six hundred ohms. A practical way of doing this is to so regulate the size of the spools that they shall both be filled when the conductor of the coil c^3 has a resistance of six hundred ohms, that of the coil c being one hundred and fifty ohms, and when the length of the former shall be twice that of the latter, while its cross-sectional area is one-half of that of the latter. It is obvious that such an arrangement is equivalent to that of Figs. 4 and 5, as described, since the parallel connection of the windings c and c^2 of the two spools in Figs. 4 and 5 amount in effect to a single winding of similar length and twice the size in a single spool.

Fig. 9 illustrates the application of my invention to annunciators. T represents such an annunciator-drop as is used in telephone central stations in manifesting the subscriber's call-signal. The external polarizing medium of the appliances hereinbefore described is dispensed with altogether, and the electromagnetic system of the ordinary "tubular drop," comprising the central cylindrical iron core C^2 C^3, surrounded by an iron shell C^5, to which it is magnetically united, as by end plates C C^4, is provided with the two coils c c^3 of widely-varying inductance, but when wound on the same core and coupled, as shown, in parallel of equal and opposite magnetizing effect. The armature a, pivotally supported at 2, is hung in close proximity to the core at a point b between the approximating ends of the two coils, which point is neutral while a steady current passes over the line. The two main conductors L L^2 pass into the shell C^5 from the posts P P^2 through the insulating bushings i. L divides at e, one of its divisions, 11, forming the quick-acting coil c, being wound over section C^2 of the core, and the other, 13, forming the sluggish coil, being wound over core-section C^3. The other ends 12 and 14 of the two coils reunite at *f* and connect with L^2. Any abrupt change of the line-current, in the form either of a reversal, an appearance, a disappearance, a strengthening or a weakening of current, will cause the magnetizing effect of one or the other of the helices to preponderate, and the polarity thereby produced at the otherwise neutral point *b* will attract the armature *a*, which, elevating its lever a^2, will permit the latter to liberate the shutter *w* and give the signal.

I do not broadly claim as my invention an electromagnetic instrument with two differential windings on its core, the said windings being included in parallel branches of a circuit, one of which branches is characterized by much higher self-induction or inductance than the other, since, as hereinbefore acknowledged, that is old; but,

Having fully described my invention and the best ways known to me of practicing the same, I do claim—

1. The combination in an electromagnetic appliance, of a continuous iron core forming a complete magnetic circuit, with two independent inducing-coils wound over different portions thereof, and connected in parallel with each other in the same circuit, the said coils having similar magnetizing power, and being adapted thereby to develop in the said core opposite and equal magnetizations when the maximum current is fully established through them, but to act thereon successively and oppositely and to develop in polar projections or surfaces of the said core a definite polarity when the current is rising, or being established, and an opposite polarity when the current is falling, or being disestablished; substantially as described.

2. The combination in an electromagnetic appliance, of a continuous iron core forming a closed magnetic circuit, with two independent magnetizing helices connected in parallel with one another in the same electric circuit and surrounding different portions of the said core so as to produce poles between their approximating ends; the said helices being of similar magnetizing power, but different inductance, and adapted thereby to act equally and oppositely on the said core, but at different times, and to develop in the said poles a given magnetic polarity due to one of them when a current is caused to pass through them, and an opposite polarity due to the other, when the said current is withdrawn.

3. The combination in an electromagnetic receiving instrument, of an iron core; independently-acting exciting-helices of similar magnetizing power, but different inductance, surrounding different portions of the said core, and so connected in parallel with one another as to act equally and oppositely thereon, and to maintain the same thereby at a magnetic zero, or in a magnetically neutral state when a steady current is established through both, and to produce a magnetic pole at a point of the said core between their adjacent ends when either is acting alone, or while the current through either is in its variable state; and a working armature mounted in inductive proximity to the said intermediate polar portion of the said core, to be controlled thereby; substantially as described.

4. An electromagnetic receiving instrument comprising an endless iron core with opposite polar projections or surfaces, exciting-coils of similar magnetizing power but different inductance surrounding the said core on different sides of its poles respectively, and connected in the same electric circuit in such manner as to act equally and maintain magnetic neutrality in the core when traversed by a fully-established steady current, but to attain their maximum magnetizing power dissimultaneously under current variations, and to determine thereby successively-opposed polarities in the said poles, and an armature responsive to changes in magnetic polarity mounted or poised in magnetic relation to the said polar surfaces, to be acted upon thereby, substantially as described.

5. A relay or signal-receiving apparatus consisting of reversely-wound magnetizing-coils of different inductance but substantially equal magnetic strength connected in parallel with each other, an electromagnetic core surrounded by the said coils, and a polarized vibratory or oscillatory armature responsive to the action of the low-inductance coil during the variable state of a rising current, and to that of the high-inductance coil during the variable state of a falling current traversing the circuit containing the said coils, substantially as described.

6. The combination in an electromagnetic receiving instrument, of reversely-wound or connected exciting-coils, an iron core forming a closed magnetic circuit, surrounded by said coils, pole-pieces of the said core located between the said coils, a polarizing medium or agent, and a tongue or armature of magnetic material polarized thereby and arranged to vibrate in the field of the said pole-pieces, substantially as specified.

7. A relay or signal-receiving instrument, comprising in combination, an electromagnetic core with approximating pole-pieces or polar surfaces, a vibratory or oscillatory armature poised or hung with its free end in the field of the said pole-pieces, a polarizing medium or magnet imparting a normal magnetization of definite polarity to the said pole-pieces, and a permanent and opposed polarity to the said armature, and exciting-coils of like magnetizing power and diverse inductance, connected in parallel circuit with each other surrounding the said core; whereby the magnetization of the core due to the coil of higher inductance is slower both in rising and falling, than that due to the coil of lower inductance.

8. In a polarized relay the combination of a continuous electromagnetic core forming

a complete magnetic circuit, two independent exciting-coils of like magnetizing power but diverse inductance connected in parallel with each other in a circuit, and surrounding the said core, pole-pieces or polar surfaces arranged in proximity to one another at opposite points of the said core, an oscillatory or vibratory armature hung or poised with its free end between said polar surfaces, and a polarizing-magnet having its poles in inductive proximity respectively to the said iron core and the said armature, whereby a definite polarity is maintained in the latter, and a normal and opposed polarity is imparted to the polar surfaces of the former, substantially as herein described.

9. An electromagnetic instrument having two pole-pieces or polar surfaces, an armature having its free end in the field of said poles, an external polarizing medium, and two independent exciting-coils or windings of like magnetizing power, but different inductance, surrounding the core represented by said poles in such manner as to excite opposite magnetizations therein, and connected in separate parallel branches of the same circuit, substantially as described.

10. A polarized relay having its electromagnetic core wound with two independent magnetizing coils or windings of equal and opposite magnetizing power, but unequal inductance, the said coils being connected in parallel with one another, substantially as described.

11. The combination in an electromagnetic receiving instrument, of reversely-wound magnetizing-coils connected in parallel with each other in an electric circuit, surrounding iron cores, and adapted to be mutually reactive; with a vibratory armature, a polarizing-magnet therefor, and means for varying the relative inductance of the said coils.

12. The combination in an electromagnetic receiving instrument, of an iron core with pole-pieces, or polar surfaces, a vibratory armature hung with its free end in the field of said poles and adapted to respond to magnetic changes produced therein, and a polarizing-magnet, imparting opposite polarity to the said core and armature respectively, with reversely-wound or connected magnetizing-coils connected in parallel with each other, surrounding, and adapted to magnetize the said core dissimultaneously and oppositely, and an adjustable resistance in the circuit of one or both of the said coils, subtantially as described.

13. The combination in an electromagnetic receiving instrument of an iron core with pole-pieces or polar surfaces, an armature mounted to vibrate between the said pole-pieces, and a polarizing-magnet imparting opposite polarity to the said core and armature respectively, with reversely-wound or connected exciting-coils of similar magnetizing power and dissimilar inductance surrounding the said core, and connected in parallel with one another, an adjustable resistance in the circuit of the coil of lesser inductance, and an adjustable impedance in the circuit of the coil of greater inductance, substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 28th day of July, 1896.

STEPHEN D. FIELD.

Witnesses:
THOMAS D. LOCKWOOD,
JOSEPH A. GATELY.