(No Model.)

3 Sheets—Sheet 1.

C. J. VAN DEPOELE.

ALTERNATING CURRENT ELECTRIC RECIPROCATING ENGINE.

No. 400,809. Patented Apr. 2, 1889.

Fig. 1.

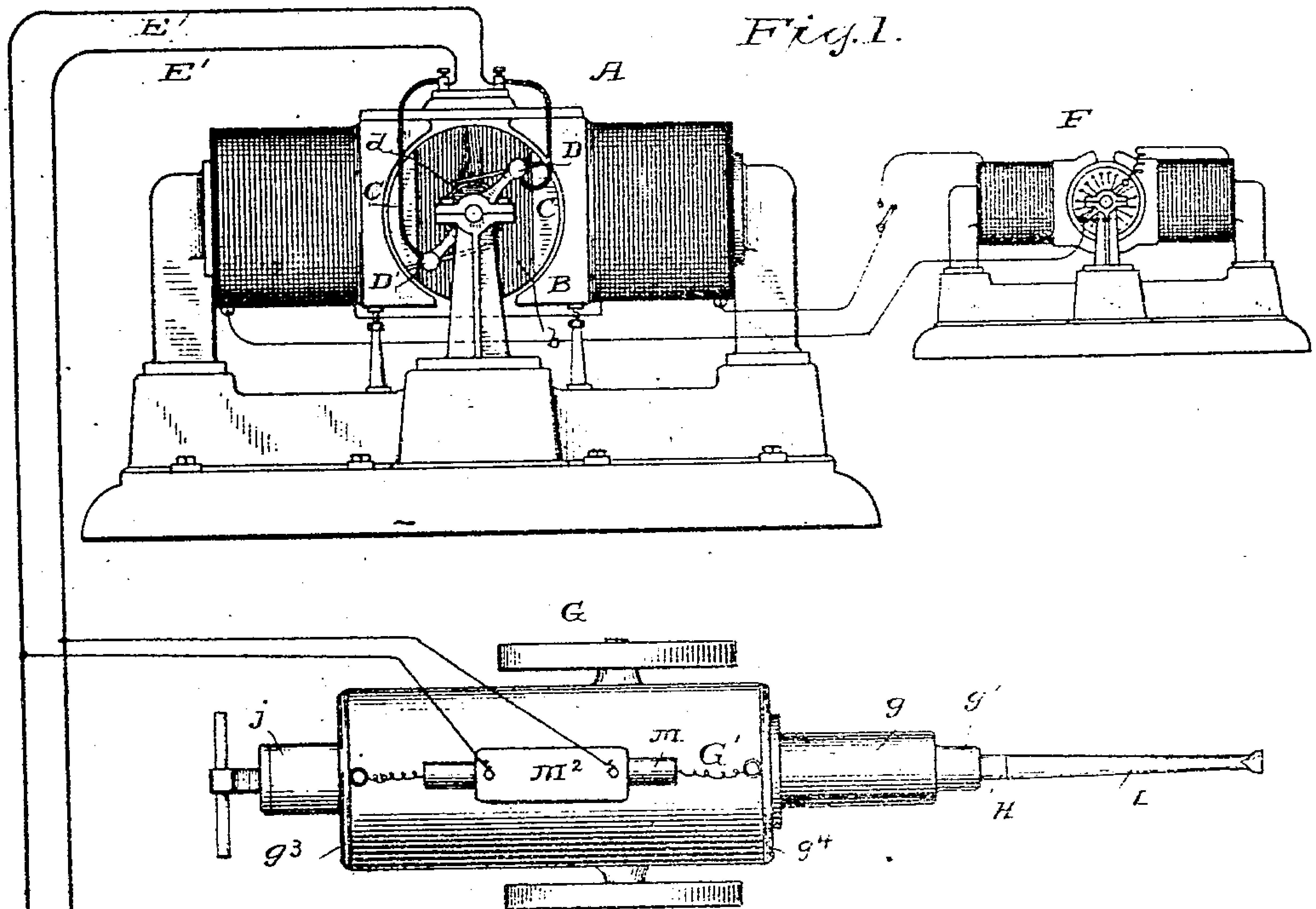


Fig. 2.

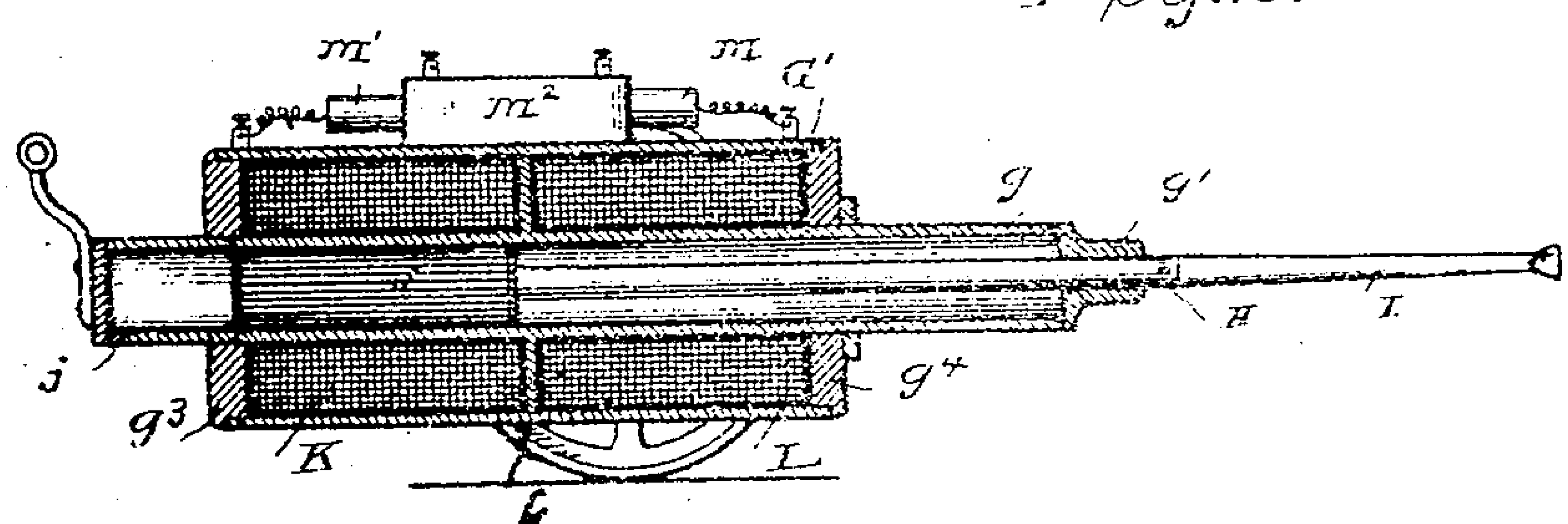
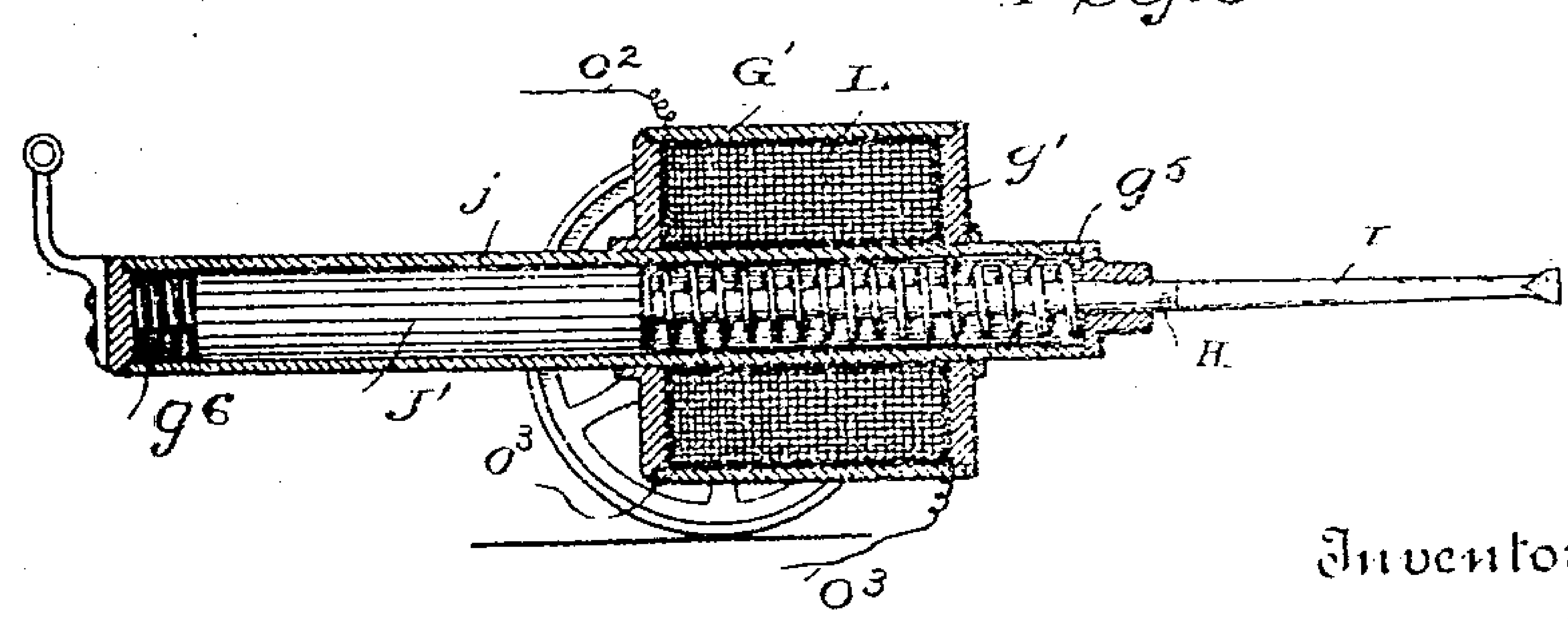


Fig. 3.



Witnesses

H. A. Lamb

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(No Model.) 3 Sheets—Sheet 2.

C. J. VAN DEPOELÉ.

ALTERNATING CURRENT ELECTRIC RECIPROCATING ENGINE.

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Fig. 4.

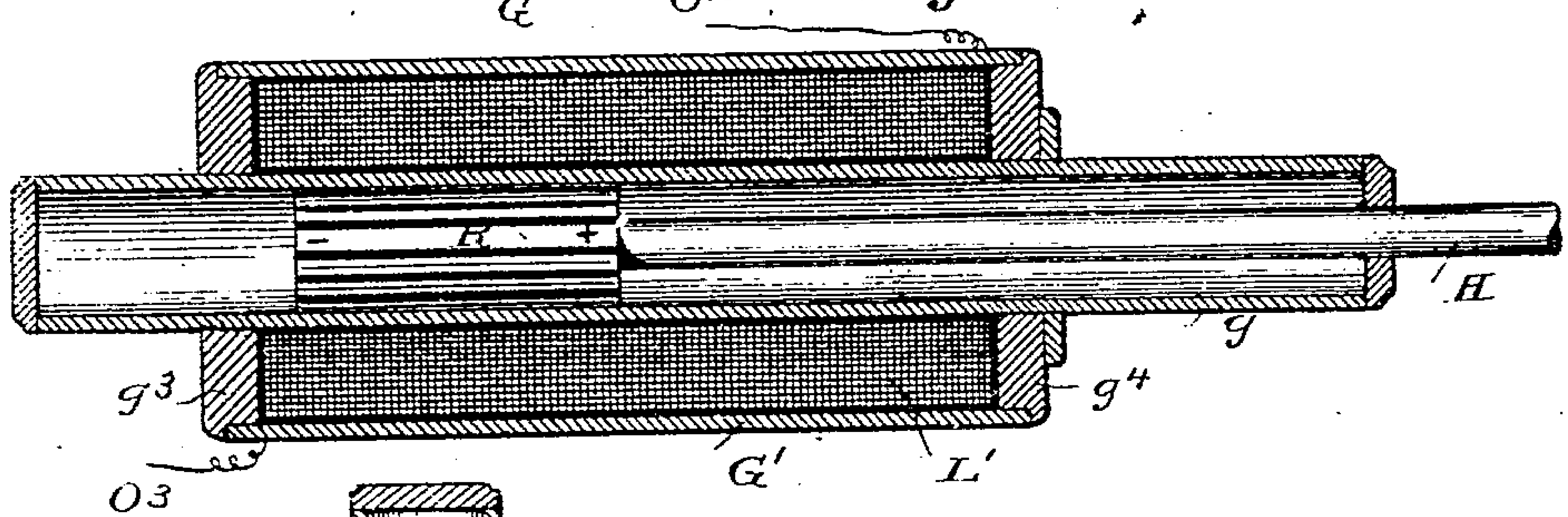


Fig. 5.

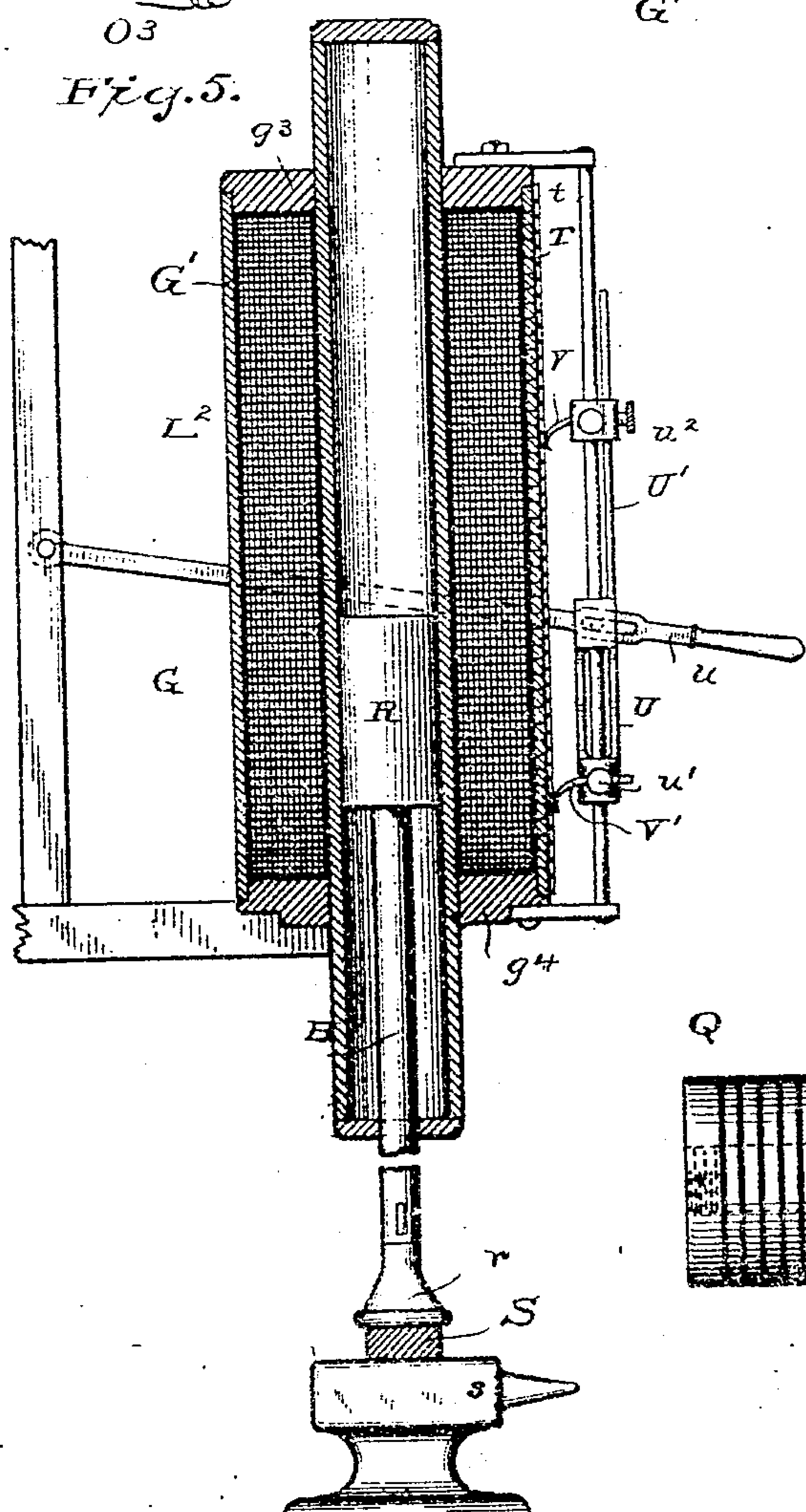


Fig. 7.

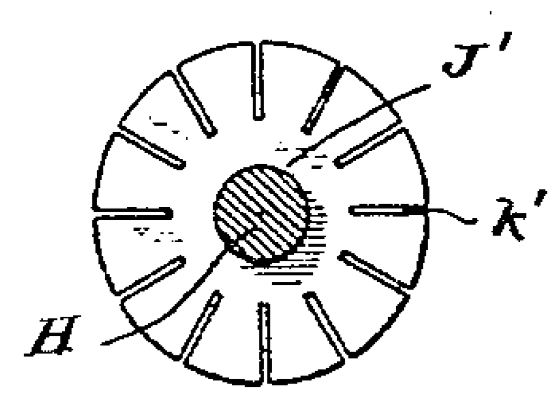


Fig. 8

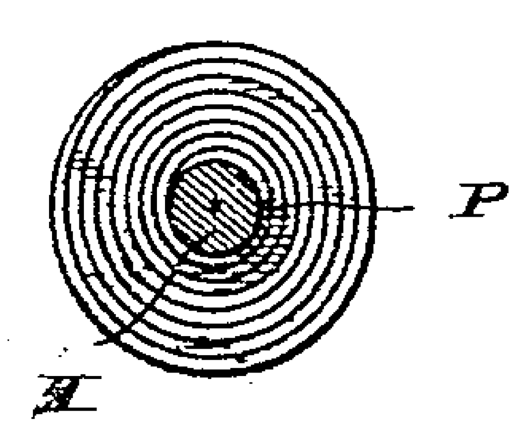
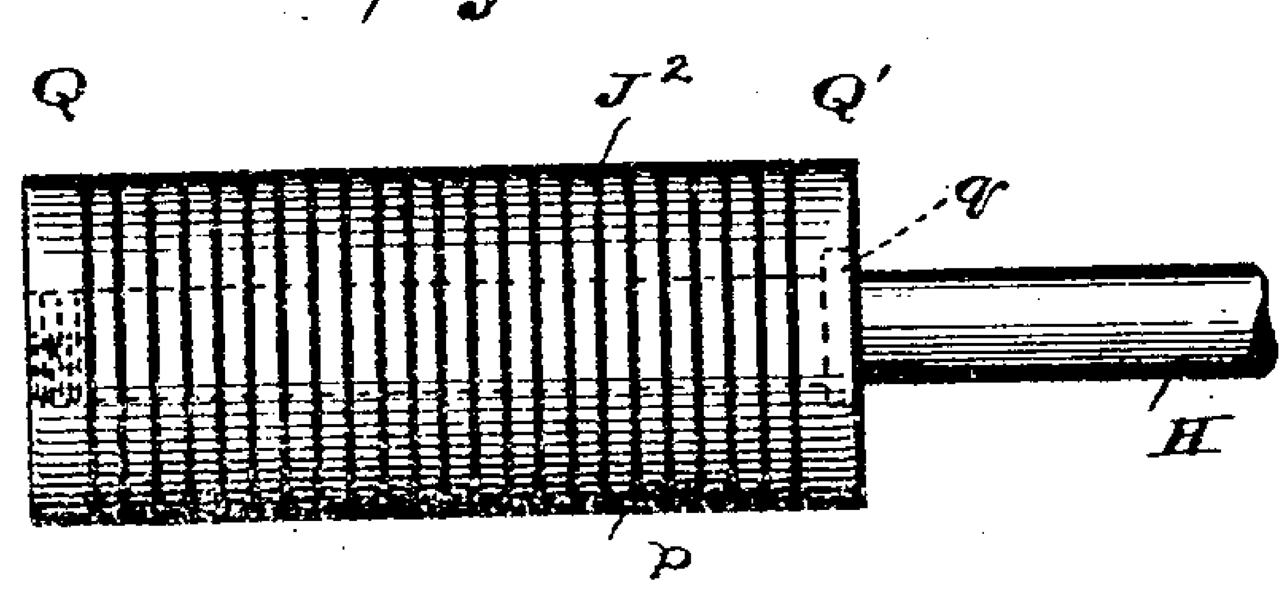


Fig. 6.



Witnesses

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(No Model.) 3 Sheets—Sheet 3.

C. J. VAN DEPOELE.

ALTERNATING CURRENT ELECTRIC RECIPROCATING ENGINE.

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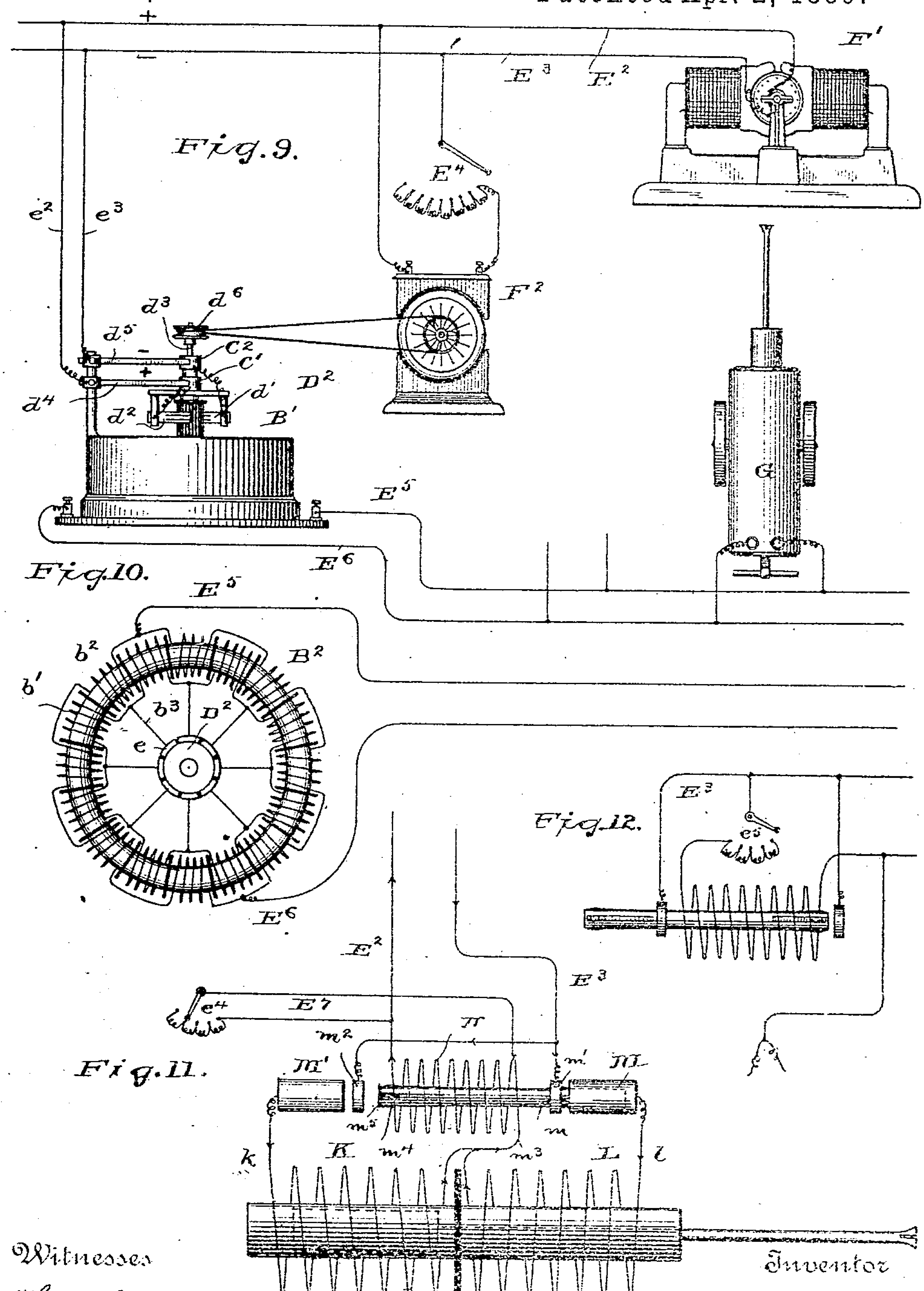

Witnesses
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UNITED STATES PATENT OFFICE.

CHARLES J. VAN DEPOELE, OF LYNN, MASSACHUSETTS.

ALTERNATING-CURRENT ELECTRIC RECIPROCATING ENGINE.

SPECIFICATION forming part of Letters Patent No. 400,809, dated April 2, 1889.

Application filed September 13, 1888. Serial No. 285,294. (No model.)

To all whom it may concern:

Be it known that I, CHARLES J. VAN DEPOELE, a citizen of the United States, residing at Lynn, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Alternating-Current Electric Reciprocating Engines, of which the following is a description.

My invention relates to improvements in reciprocating electric engines. As shown and described, the invention is specifically adapted to that class of drilling-engines known as "mining-machines." I have also used it in connection with a power-hammer. It will be understood, however, that the invention is applicable to many other forms of reciprocating power-motor. Electrically-operated engines, as heretofore constructed, have all been operated by means of a continuous current circulated for desired periods through a coil or coils, the magnetic attraction of which was communicated to the piston or plunger carrying the tool, and by said action reciprocating motion was communicated thereto.

In the operation of the various prior devices the motive current was straightened by means of commutators in circuit with the armature of the generator, and the current by which the reciprocations of the tool were produced was controlled and directed by commutators and switches, all of which were troublesome, expensive, and have not up to the present time been commercially practicable—a result largely due to the rapid destruction of the brushes and contacts due to the sparks accompanying the rupture of an electric circuit. According to my invention, however, the reciprocations are produced by the rise and fall of what are known as "alternating currents," said currents being applied to the engine directly from an alternating-current generator, or of a converter acting to transform continuous into alternating currents and capable of operating at a low speed, so as to produce from one hundred and fifty to two hundred and fifty reversals of current per minute, or thereabout, the pistons of the engines moving to and fro in synchronism with the alternations of the supply-current.

With one form of my invention a single coil is provided for driving the piston forward to make the effective stroke, the piston being retracted by a suitable spring. In another form two coils are provided, the piston being alternately thrown forward and backward; but in this form I also add an electro-magnetic circuit-changing device arranged to alternately put the respective coils in circuit to produce the forward-and-backward stroke. It will be noted, however, that the switching device referred to changes the circuit at the same time that the current changes—that is to say, the switching is effected at the time when there is practically no current flowing, one current having fallen to zero and the other being about to begin. The switching at this moment is not accompanied by sparking and its destructive results—a feature of special value and importance in fiery mines. An additional form of my invention comprises a long single coil, the plunger in this instance being formed of a permanet magnet. It will be evident that with this construction a plus current will draw the plunger forward, the following minus current driving it back again. I have also shown the invention as applied to the operation of a power-hammer. This form of my invention comprises a long solenoid, within which moves a plunger much shorter than the length of the solenoid. Adjustable contacts are provided, which are adapted to move over or be set upon exposed terminals of the main coil, and to thereby limit and regulate the length of stroke of the hammer.

In the accompanying drawings, Figure 1 is a view in elevation showing a generator and exciter therefor and a reciprocating drilling-engine embodying my invention. Fig. 2 is a transverse sectional elevation of the drilling-engine shown in Fig. 1. Fig. 3 is a transverse sectional elevation of a different form of engine also embodying my invention. Fig. 4 is a transverse elevation of a drilling-engine also embodying my invention. Fig. 5 is a transverse partly-sectional elevation of a power-hammer to which my invention is applied. Fig. 6 is an enlarged detail showing one form of plunger. Figs. 7 and 8 are sectional elevations showing different forms of constructing the plunger. Fig. 9 is a diagrammatic view showing the arrangement of a plant for operating by means of a continuous supply-current and an inductional transformer for changing the same to currents of alternating polarity. Fig. 10 is a diagram showing the electrical construction of the converter seen in Fig. 9. Fig. 11 is a diagram of the engine and circuit-changer. Fig. 12 is a diagram showing a different arrangement of the connections for the circuit-changer.

Similar letters denote like parts throughout.

In the drawings, A represents a dynamo-electric generator, the armature B of which is preferably wound with a single coil, *b*, the said coil being placed upon a central iron core formed with enlarged pole-pieces C C. An armature of this construction will emit during each revolution two impulses or currents, one rising from zero to maximum and then falling, and of one polarity, the succeeding current having the same characteristics, but of the opposite sign.

D D′ are the collector-brushes, which bear upon collecting-rings *d d*, each of which is connected to one of the terminals of the armature-circuit. The brushes D D′ are each connected to one of the main-circuit conductors E E′.

F is an exciter supplying currents of continuous polarity to the field-magnets of the generator A.

With the arrangements just described, and in order to secure alternating currents of sufficient quantity with low armature speed, a generator of relatively large size would be required. Therefore in many cases it would be preferable to use a plant organized as in Fig. 9, where I have shown a continuous-current-generator, F′, which may be wound to produce currents of relatively high or low potential, according to the length of the supply-circuit E^2 E^3. Induction-transformers B′ are provided for converting the continuous currents from the generator F′ into currents of alternating polarity. A single converter may be provided for each drilling-engine, or may be made of such size that a single converter located at some convenient point in the line will supply all the engines it is desired to use.

As seen in Fig. 10, the converter comprises a core, B^2, upon which are wound primary and secondary circuits b' b^2, the conductors of said primary and secondary circuits being of such relative sizes as will produce secondary currents of the desired intensity. Where the supply-current is of small quantity and high tension, the primary conductor b' should be of small diameter and the secondary conductor b^2 of relatively large diameter. The converters will, however, be wound according to the conditions to be met. As a means of interrupting the continuous current and passing it through the coils of the transformer in a manner to produce the gradual rise and fall of potential suitable to the operation of the drilling-engines, each division of the primary winding is connected, as by terminals b^3, with insulated sections of a fixed commutator, D^2.

A pair of commutator-brushes, d' d^2, bear against opposite sides of the commutator D′ and are separately connected with the positive and negative conductors of the main supply-circuit. The commutator-brushes d' d^2 are rotatably mounted with respect to the commutator D^2—as, for example, by being secured upon a vertical spindle, d^3, which is also provided with positive and negative contact-cylinders C′ C^2, electrically connected with the brushes d' d^2, against which cylinders bear contact springs or brushes d^4 d^5, connected by branch supply-conductors e^4 e^5 with the supply-conductors E^2 E^3. An electro-dynamic motor, F^2, is placed in circuit with the main conductors E^2 E^3 and an adjustable resistance, E^4, and is mechanically connected to a pulley, d^6, upon the spindle d^3, and when supplied with current will operate to rotate said spindle and commutator-brushes at any desired speed, causing the converter to produce currents of alternating polarity, the rapidity of which can be controlled and regulated by the speed of the motor F^2. The currents produced in the secondary coils of the converter flow out through conductors E^5 E^6, connected to the secondary coils at opposite points thereon. One or more drilling-engines, G, are connected in the secondary circuit E^5 E^6, as indicated, according to the capacity of the converter and the requirements of the work to be done.

G′ represents an iron cylinder, within which the actuating coil or coils of the reciprocating engines are arranged.

g′ is a bushing or packing placed in the extremity of the projecting tube *g*, and serving as a guide and support to the piston-rod H, to the outer extremity of which is attached a cutting-chisel or other tool, I. The iron cylinder G′ is provided with iron heads g^3 g^4.

J is the piston or plunger, secured to the rear end of the piston-rod H, and arranged to be reciprocated within a central non-magnetic metallic tube, *j*, between the exterior of which and the interior of the cylinder G and suitably insulated therefrom is placed the motor coil or coils.

As shown in Fig. 2, two coils, K L, are employed, one for the forward and the other for the backward movement. Said coils are divided by a central insulating-partition, *k*, and their outer terminals are connected to fixed contacts M M′, which are conveniently supported upon the exterior of the cylinder, representing, respectively, the outer terminals of the motor-coils K L. A reciprocating circuit-changing device for directing the current alternately into the said motor-coils is conveniently disposed within a box or casing, M^2. If found desirable, the relative sizes of the two coils, when two coils are used, may be other than that herein shown, the preponderance in size and power being given to the coil imparting the forward or power stroke.

In Fig. 3 one coil is entirely dispensed with, the coil there shown serving merely to impart forward motion to the plunger to perform its stroke. With this construction a light flexible spring, g^5, is coiled about the forward end of the piston-rod, between the end of the plunger and the end g' of the casing G′, for the purpose of retracting the plunger J′ when the stroke has been made. If desired, a second but smaller and lighter spring, g^6, may be placed in the rear end of the tube j to serve as a cushion for the plunger J′, thereby lessening the jar of its sudden retraction and easing it in its forward movement. With this construction no circuit-changing devices are required, the current being admitted to one end of the coil through conductor O^2 and returned through the conductor O^3. The plunger J′ consists of a solid piece of soft iron, in which are formed longitudinal grooves or slots k for the purpose of facilitating the demagnetization thereof and also to prevent the circulation of Foucault currents therein.

Fig. 8 shows a cross-section of an alternative form of plunger, which is constructed of a long strip, P, of soft iron of the requisite width, which is rolled upon the piston-rod H, each layer being separated by a suitable layer of insulating material—desirably paper.

Fig. 6 shows a piston or plunger, J^2, formed of disks p, of soft iron, each separated by a suitable layer of insulating material, the said disks being securely united between the heads Q Q′, the head Q being centrally secured thereto and adapted to engage the rear end of the piston-rod H to force the disks tightly against the head Q′, which rests against a collar, q, or other fixed extension upon the piston-rod, as indicated by dotted lines.

In Fig. 4 I have shown another form of my invention, differing from those already described only in that the plunger R is composed of a single piece of steel permanently magnetized. A single motor-coil, L′, supplies the moving force to the plunger R, which will be thrown forward by an impulse of one polarity, and on account of its permanent magnetism will be repelled and thrown rearward by the next succeeding wave or current of opposing sign, and these alternating movements will continue so long as current of alternating polarity is supplied.

In many varieties of work of which reciprocating engines are capable, whether in the form of a drill or of a power-hammer, it is desirable to vary the length of the stroke, and also especially in drills and hammers it is desirable to adjust the striking-point of the tool nearer to or farther from the point of power. For example, in beginning to drill a hole the drill strikes upon the surface, and as it penetrates it is necessary to feed the same forward. This can be accomplished in the case of a mining-machine such as is shown in Figs. 1, 2, and 3 by moving the engine upon its supporting-wheels nearer to the work in accordance with the penetration of the tool. In many instances this adjustment is insufficient, and I have therefore shown in Fig. 5 a simple yet effective means of not only lengthening or shortening the stroke itself, but of causing the blow to be delivered nearer to or farther from the cylinder in a closed position. Fig. 5 shows an arrangement such as just referred to, which, for convenience of illustration only, is seen as applied to a power-hammer. In this form of my invention the motor-coil is made somewhat longer, as indicated at L^2. The coil L^2 is provided with an interior metallic non-magnetic lining and an exterior iron casing, as described with reference to preceding figures. A steel plunger, R, of either described form, but somewhat shorter in proportion to the length of the cylinder, is provided, and to the lower end of the piston-rod H is attached a hammer adapted to strike upon the work S, which is supported on a suitable anvil, s.

Upon the exterior casing, G, of the coil L^2 is arranged a vertical series of terminals, T. Upon a vertical guide-rod, t, secured in proximity to the vertical series of terminals T, is placed a vertically-movable sleeve, U, having an upwardly-extending part, preferably in the form of a rod, U′. The sleeve U is connected to a pivoted lever, u, by which it can be moved up and down the entire length of the cylinder G′. Brush-clamps u' u^2 are secured upon the sleeve U and rod U′, and by means thereof brushes V V′ may be secured at any desired distance apart. Current being admitted to the coil L′ through the clamps V V′ and the terminals T, upon which they rest, the piston R, being a permanent magnet, will move up and down in synchronism with the speed of the generator with a length of stroke equal to the distance between the brushes V V′. When a thicker piece of work than that shown at S is upon the anvil, and it is desired that the stroke of the hammer shall descend a less distance, the brushes V V′ are, by means of the sleeve U, moved vertically upward until the desired effect is produced—that is, until the stroke of the engine is elevated or lowered to the proper distance. By this means also the force of the blow may be materially varied and controlled with the greatest ease.

In the form shown in Figs. 2, 3, and 4 the preferred length of piston is about that of the actuating-coil. In Fig. 5, however, the piston is made considerably shorter in order to allow of a longer range of stroke. Otherwise the conditions are unchanged.

As seen in Fig. 11, the circuit-changing device may consist of a solenoid, N, within which is placed an iron plunger, m. The plunger m is about one-third longer than the coil N, so that on the passage of a current through said coil its projecting end will be attracted with considerable force, and by its momentum the opposite end of said plunger will be projected a similar distance beyond the opposite end of the solenoid instead of stopping in a central position with respect to the coil. As seen in Fig. 11, contact devices are placed adjacent to each end of the solenoid N. The contacts M M′ are preferably short metal tubes or cylinders, from which conductors $k\ l$ extend to the coils K L. Additional contacts, $m'\ m^2$, are placed between the extremities of the main contacts M M′ and the ends of the solenoid N, and are preferably annular and of the same internal diameter as the cylinders M M′. The supply-conductor E^2 or E^3 is connected to both the contacts $m'\ m^2$ and the inner terminals of the coils K L are joined by conductor m^3, connected to one end of the coil of the solenoid N, its other extremity being connected directly to the return supply-conductor E^2. The solenoid is thus connected in series with both of the coils K L. The solenoid N is spanned by a shunt, E^7, which includes an adjustable resistance, e^4. The plunger m should be of a size to easily fit within the contacts M M′ $m'\ m^2$, so that it may pass in and out with facility. It is, desirably, further provided with contact-springs m^4 at each extremity. The contacts M M′ may also with advantage serve as air-cushions for said plunger to prevent it striking forcibly against their heads, and, if desired, the plunger may also be provided with a small washer, m^5, of rubber or equivalent material, at its extremity to more accurately fit the bore of the contacts M M′. With the parts in the position shown in Fig. 11 the circuit is completed from conductor E^3 through the contact m', plunger m, contact M, conductor l, coil L, conductor m^3, solenoid N, and conductor E^2. Upon the passage of a current impulse the coil L will attract the magnetizable piston J, (shown in dotted lines,) drawing it rapidly forward to make the power-stroke. Simultaneously the coil N will attract the end of its plunger m, drawing it out of contact M, and forcing it into the opposite contact, M′. The piston J moves in one direction and the plunger m in the other at the same time, and their travel will ordinarily occupy the period of one phase of the current, so that by the time one phase of current goes down the parts will be in position for the reverse movement. The contacts M M′ are designed to be of sufficient length to maintain the circuit of the coil through which the current may be passing until the piston has completed its movement; but it will be evident that if said contacts are of the full length of the piston, being one-third longer than the solenoid, they would always remain in contact with both of them. I therefore provide the auxiliary contacts $m'\ m^2$, so that the plunger m, when in one position, will be entirely free from the other contact. At the same time as the piston starts again in the opposite direction, the distance between the main and auxiliary contacts being small, the springs upon the extremities of the plunger will close the circuit between the main and auxiliary contacts, which connection will be maintained until the plunger has completed its reverse movement.

The movements of the plunger m and the rapidity with which the phases of current succeed each other should be so timed and adjusted to the weight of the parts and the character of the work that the completion of each reciprocation of both plunger and piston will coincide with each phase of the current. When this is the case, no sparking will occur and the engine will work smoothly. The speed at which the plunger m moves can be regulated to the circuit, and the rapidity of the phase of current by means of the resistance e^4. The solenoid may, however, be connected in multiple arc with the supply-circuit, as indicated in Fig. 12, a resistance-switch, e^5, being there shown for regulating the strength of the currents passing through the solenoid and the resultant speed at which the plunger will be moved.

It will be apparent that many changes may be made which are not shown or described in this specification, the same being chiefly for purpose of illustration. I propose, however, to modify the several forms shown, as that can be done in many particulars without departing from the scope or nature of the invention.

The currents by which my reciprocating engine is operated are hereinbefore referred to as "alternating;" but it will be understood that pulsating, interrupted, intermittent, or defined currents—that is to say, currents having a definite rise and fall, whether the succeeding currents be of alternate or similar polarities and however produced—are included in the terms used in referring to the actuating force. A great advantage incident to the use of such currents is found in the fact that the circuit-connections to the motor-coils for producing reciprocatory motion in a movable magnetic plunger can be changed when one current has fallen to zero and before the succeeding one has attained volume enough to cause a spark, thereby entirely eliminating the objectionable features of systems including circuit-changing apparatus.

It will be obvious also that by suitably winding and connecting the motor-coils intermittent or defined currents, whether of alternating or constant polarity, will serve to produce the desired reciprocations of the piston.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a system of electro-magnetic reciprocating engines, a source of electricity giving defined phases of current in a closed circuit, engines having motor-coils placed in said circuit and energized by the said defined currents, and a magnetic piston or plunger placed under the influence of the said coils, substantially as described.

2. A reciprocating electric-engine system comprising an engine having two or more motor-coils and a magnetic piston adapted for reciprocation within said coils, an electric generator adapted to produce rising and falling defined electric impulses, and circuit-connections between the motor-coils and generator, whereby electric impulses are supplied to the

motor-coils in alternation, substantially as described.

3. An electro-magnetic reciprocating engine comprising a solenoid or solenoids composed of one or more coils and in circuit with a source of electricity giving defined phases of current, and a magnetic piston under the influence of the coils and arranged to be reciprocated thereby in accordance with the current phases sent through the coils of the engine, substantially as described.

4. An electro-magnetic reciprocating engine comprising a coil or coils in circuit with a source of alternating or defined electric currents, a piston arranged to move longitudinally within the said coil or coils under the influence of the phases of the supply-current, and a tool-holding piston-rod attached to the piston, substantially as described.

5. An electro-magnetic reciprocating engine comprising an actuating coil or coils in circuit with a source of alternating or intermittent currents, a non-magnetic lining or tube within the coil or coils, and a piston adapted to be reciprocated within the interior tube under the influence of alternating phases of current circulating in the motor-coils, substantially as described.

6. An electro-magnetic reciprocating engine comprising a motor coil or coils in circuit with a source of alternating or defined electric currents, and an iron plunger adapted to be reciprocated within the coil or coils under the influence of the alternating currents, the mass of said plunger being laminated or subdivided, substantially as described.

7. In an electro-magnetic reciprocating engine, a motor-helix in circuit with a source of alternating or defined electric currents, a plunger attached to the tool-holding devices adapted to be reciprocated within the helix under the influence of and in accordance with the phases of current circulating therein, a series of terminals extending from the coils of the helix, and a movable contact for adjusting the length of the stroke of the plunger by cutting out a greater or less portion of the motor-helix, substantially as described.

8. In an electro-magnetic reciprocating engine, a motor-helix in circuit with a source of alternating or defined electric currents, a piston attached to the tool-holding devices and adapted to be reciprocated within the helix under the influence of and in accordance with defined currents circulating therein, a series of terminals extending from the coils of the helix, and movable contacts for cutting out a greater or less portion of the motor-helix, whereby the length of the stroke may be adjusted and whereby also the operative position of the plunger may be determined, substantially as described.

9. In a reciprocating electric engine, the combination of motor-coils in circuit with a source of defined electric currents, a piston arranged within said coils and actuated alternately thereby, and a circuit-changing device arranged and operating to connect the supply-circuit alternately with the said coils at the zero-point between the current phases, substantially as described.

10. In a reciprocating electro-magnetic engine, the combination of motor-coils, a piston moving within said coils under the influence of current flowing therethrough in alternation, a circuit-closing plunger, a solenoid for imparting reciprocating motion thereto, said solenoid being of less length than the plunger, and two sets of main and auxiliary contacts at opposite ends of the path of the circuit-closing plunger, said sets of main and auxiliary contacts being electrically connected to the outer terminals of the motor-coils, respectively, substantially as described.

11. In a reciprocating electro-magnetic engine, the combination, with motor-coils and a magnetically-actuated piston arranged to be moved back and forth within said coils by the influence of currents circulating in said coils in alternation, of a reciprocating circuit-changing device comprising a solenoid, an iron plunger therefor of a length exceeding that of the solenoid, main contacts located at opposite ends of the path of the plunger and electrically connected to the motor-coils, respectively, and auxiliary contacts located between the inner extremities of the main contacts and the solenoid, but separated therefrom, whereby the extremity of either end of the plunger will be out of contact with one of the main contacts when in its opposite position, substantially as described.

12. In a reciprocating electro-magnetic engine, the combination, with motor-coils and a magnetically-actuated piston moving within said coils, of a circuit-changing device for directing the supply-current through said coils in alternation, comprising a solenoid, a reciprocating plunger, contacts representing the motor-coils and located in the path of the plunger, and an adjustable resistance for regulating the speed of the circuit-changing device, substantially as described.

13. In a reciprocating electro-magnetic engine, the combination of a source of intermittent or defined current, motor-coils, and a piston arranged to be reciprocated within said coils by the passage of said currents therethrough in alternation, and a circuit-changing device comprising a solenoid in circuit with said intermittent currents and having a reciprocating plunger arranged to close the main circuit upon the motor-coils in alternation, said plunger and piston operating simultaneously and completing their respective movements during each phase of current, substantially as described.

14. In a reciprocating electro-magnetic engine, the combination of motor-coils, a piston moving in said coils, and a circuit-changing device comprising a solenoid, a reciprocating plunger therefor, and tubular contacts arranged to receive the ends of the plunger, the diameter of said tubes being adjusted to re-

tard the free escape of air and form an air-cushion to absorb the momentum of the plunger, substantially as described.

15. In a reciprocating electro-magnetic engine, the combination, with a motor coil or coils and a magnetically-actuated piston moving in said coils under the influence of currents flowing therethrough, of an inductional transformer in circuit therewith for producing defined currents of alternating polarity, an electro-dynamic motor mechanically connected to circuit-changing devices in said transformer for controlling the flow of the primary current therethrough, and means for regulating the speed of the motor and thereby controlling the action of the transformer, substantially as described.

16. In a reciprocating electro-magnetic engine, the combination, with a motor coil or coils and a magnetically-actuated piston moving in said coils under the influence of currents flowing therethrough, of a source of continuous current, an inductional transformer for producing defined currents of alternating polarity, an electro-dynamic motor mechanically connected to circuit-changing devices in said transformer for controlling the flow of the primary current therethrough, and an adjustable resistance for regulating the speed of the motor and thereby controlling the action of the transformer, substantially as described.

17. The combination, with an electro-magnetic reciprocating engine, of a source of continuous current, an inductional transformer comprising primary and secondary coils, a commutator the sections of which are connected to the continuations of the coils of the primary circuit, rotatably-mounted commutator-brushes in circuit with the source of continuous current, and an electro-dynamic motor connected to and acting to rotate the brushes upon the commutator to distribute the primary current and render the secondary coils active, substantially as described.

In testimony whereof I hereto affix my signature in presence of two witnesses.

CHARLES J. VAN DEPOELE.

Witnesses:
FRANKLAND JANNUS,
MARTIN R. KAYS.