No. 808,554. PATENTED DEC. 26, 1905.

L. J. LE PONTOIS.

APPARATUS FOR GENERATING AND UTILIZING POLYPHASE ALTERNATING CURRENTS FOR THE IGNITION OF EXPLOSIVE MIXTURES.

APPLICATION FILED OCT 7 1904.

5 SHEETS—SHEET 1.

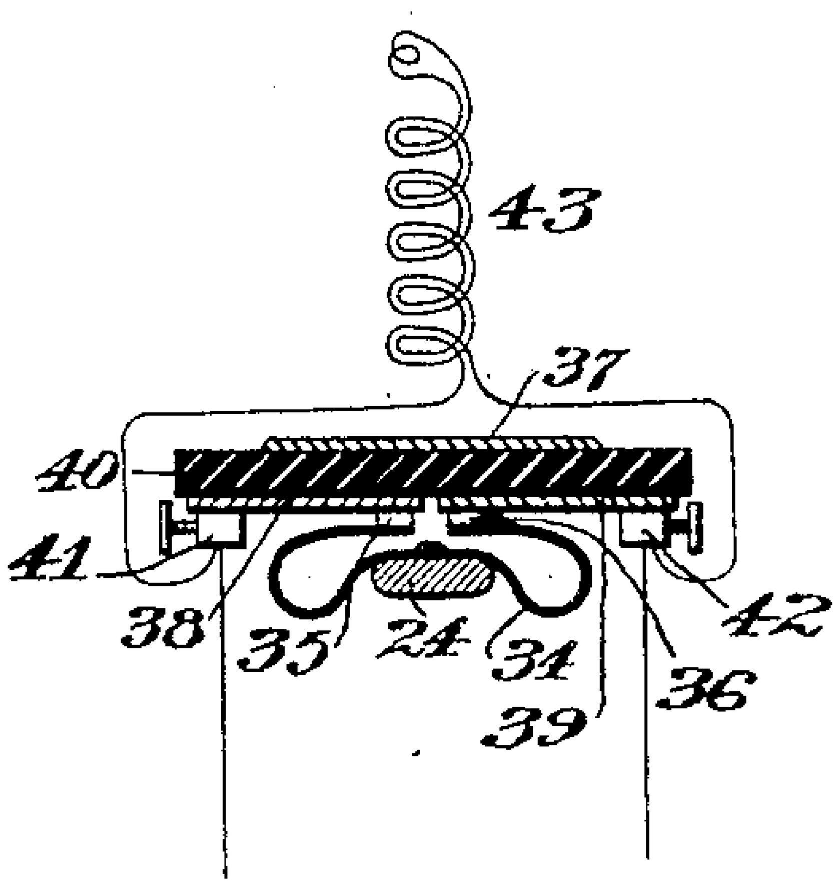

Fig. 8.

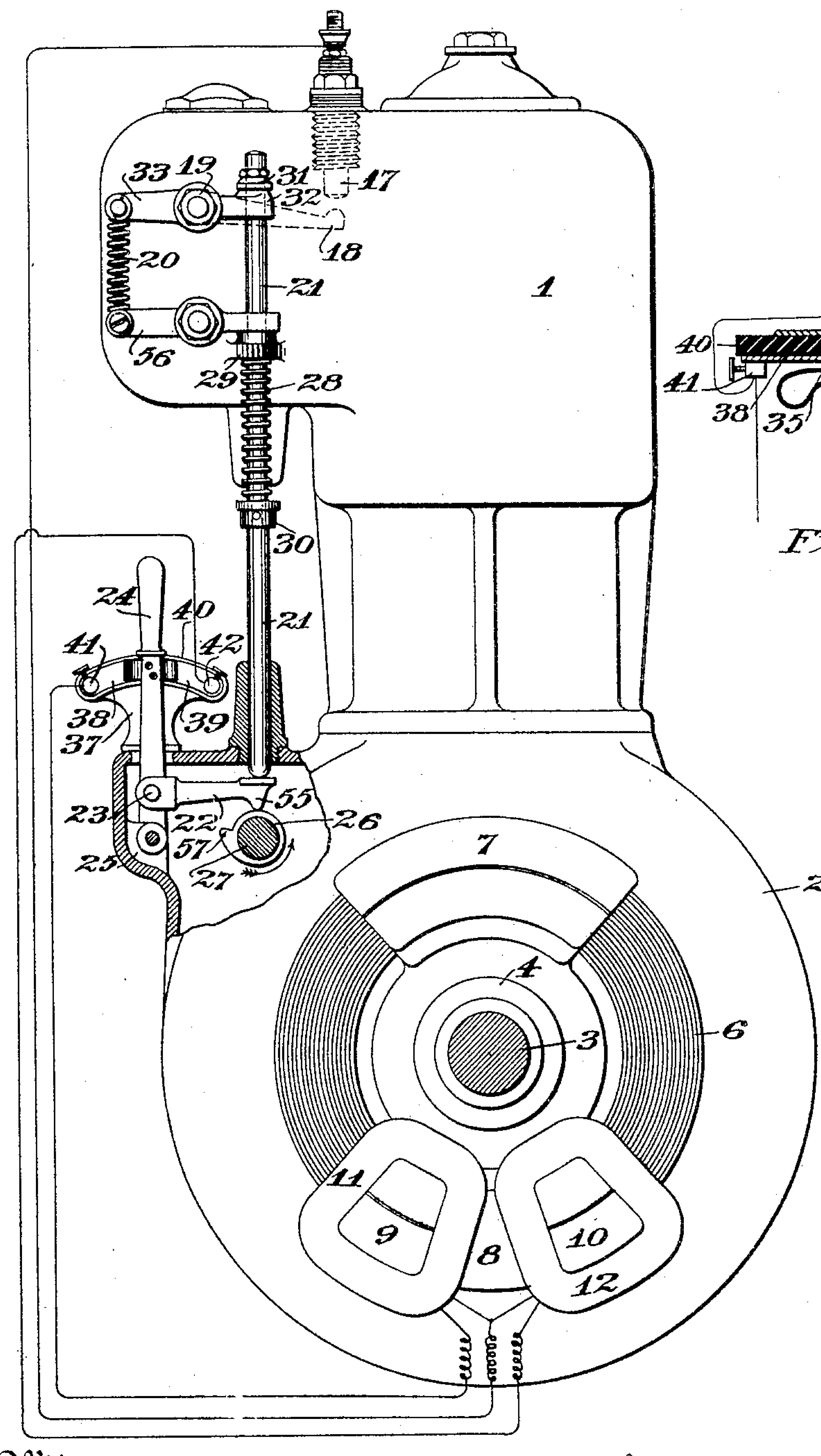

Fig. 1.

Witnesses
Milton B. Kolb.
George G. Schreiber.

Inventor
Leon Jules Le Pontois
By his Attorney
Seabury C. Mastick

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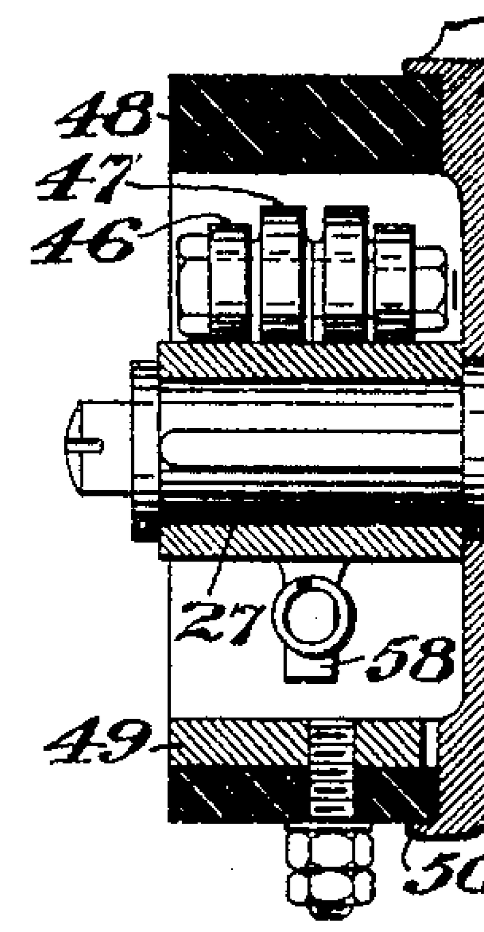

Fig. 10.

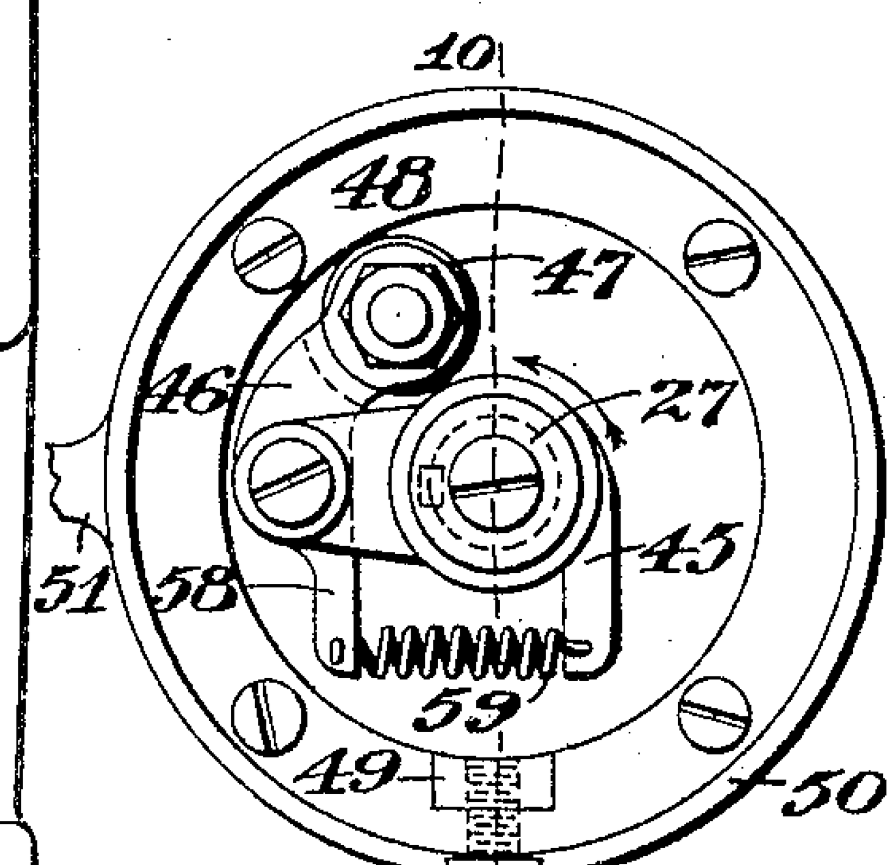

Fig. 9

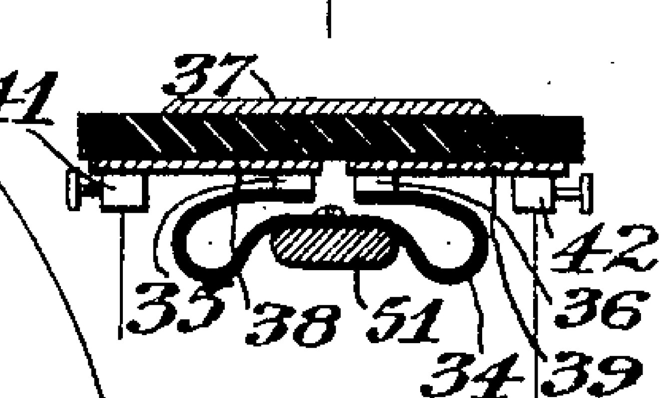

Fig. 7.

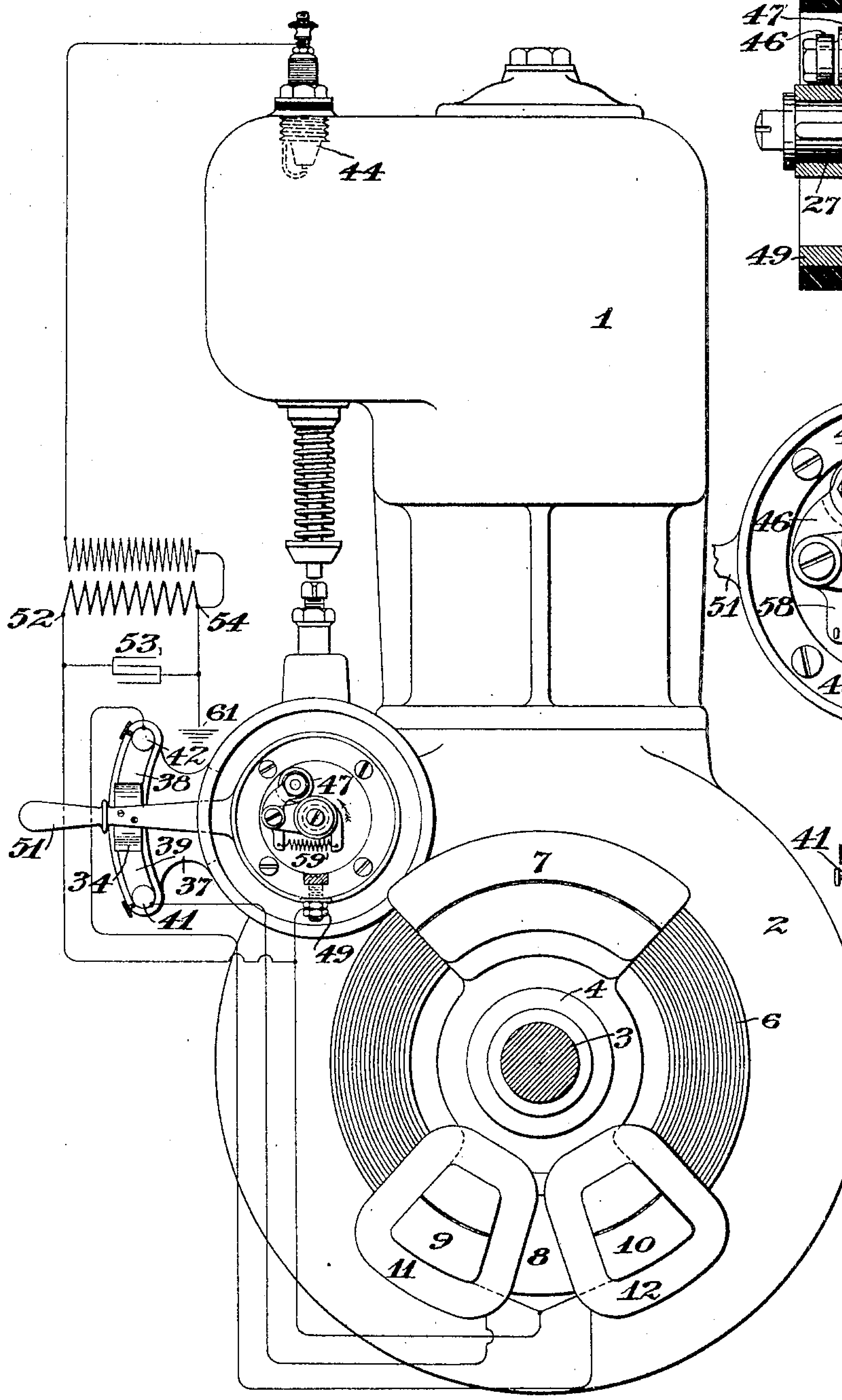

Fig. 2.

Witnesses
Milton B. Kolb.
George J. Schreiber.

Inventor
Leon Jules Le Pontois
By his Attorney
Anthony C. Mastick

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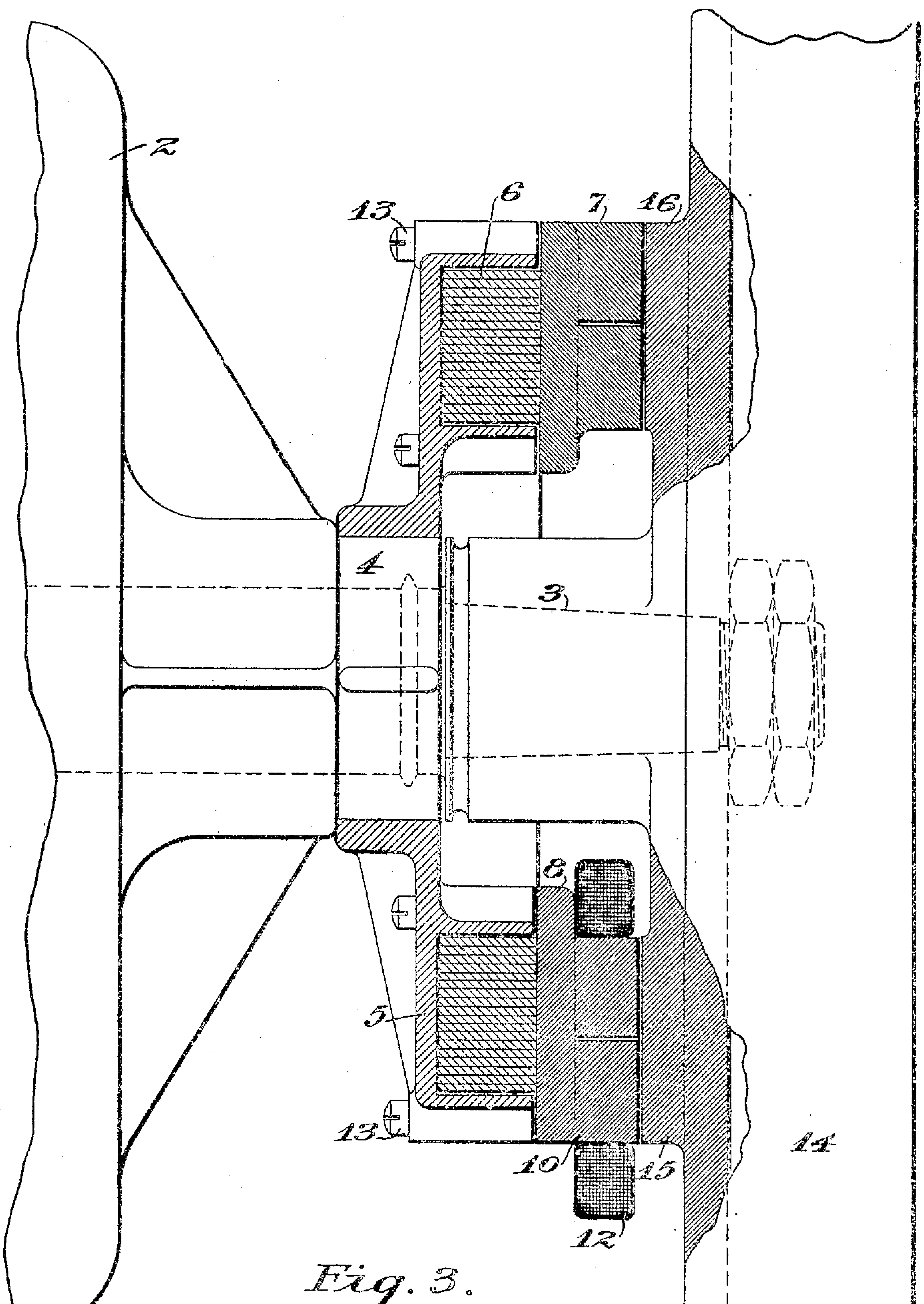

Fig. 3.

Witnesses
Milton B. Kolb.
George G. Schroeder.

Inventor
Leon Jules Le Pontois
By his Attorney
Seabury C. Mastick

No. 808,554. PATENTED DEC. 26, 1905.

L. J. LE PONTOIS.

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5 SHEETS—SHEET 4.

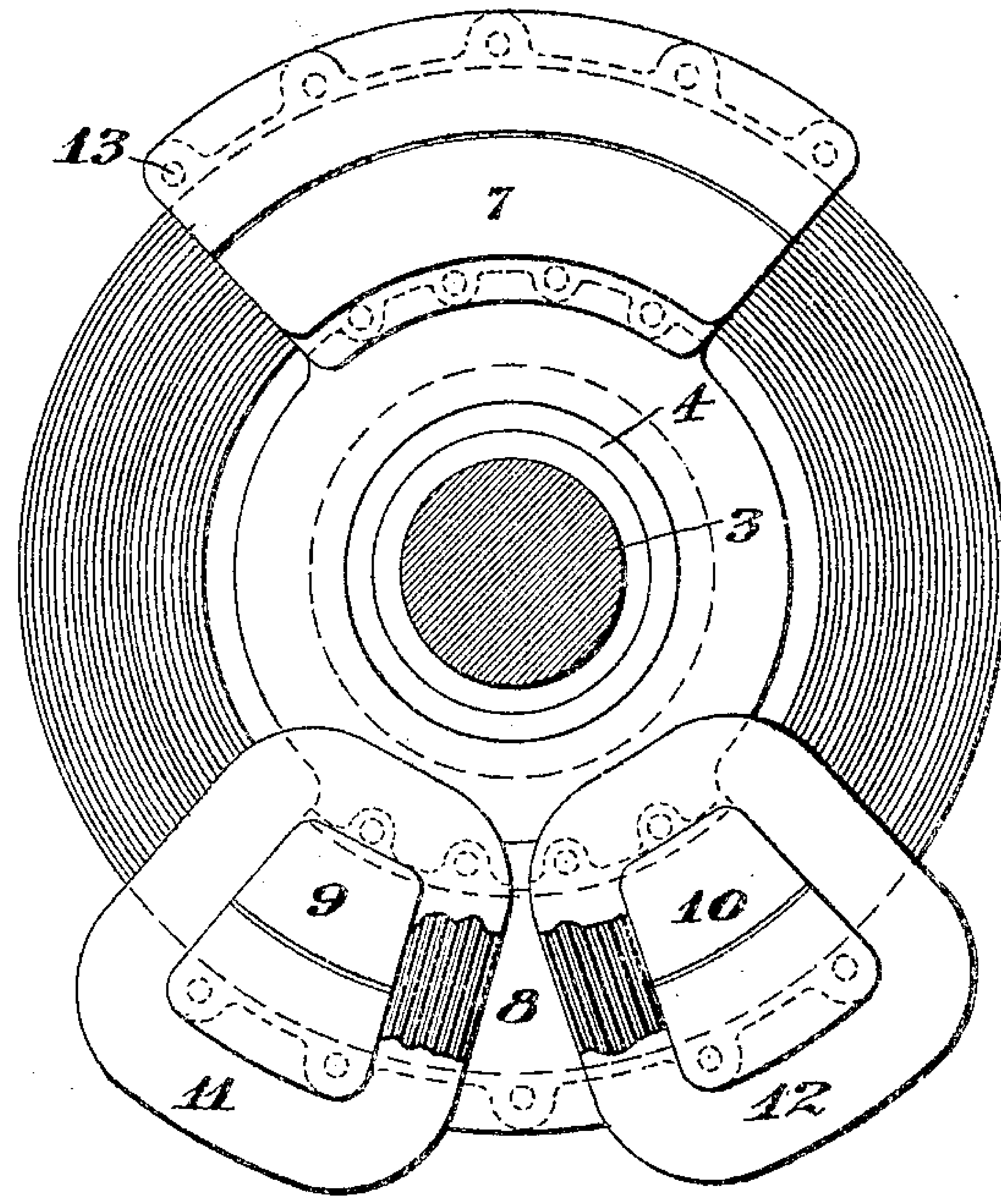

Fig. 4.

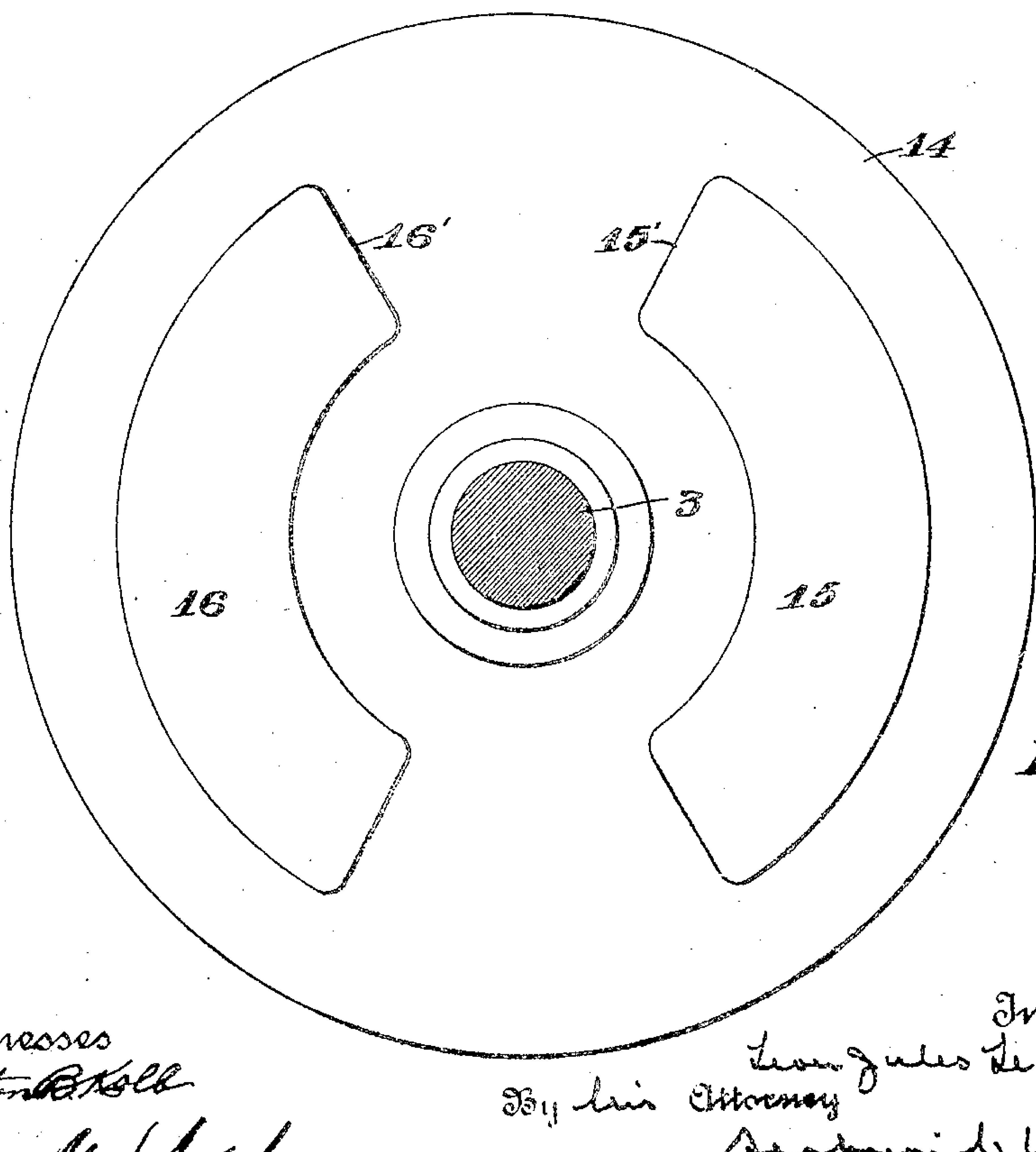

Fig. 5.

Witnesses
Milton B. Kolb
[illegible]

Inventor
Leon Jules Le Pontois
By his Attorney
Seabury C. Mastick

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L. J. LE PONTOIS.

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5 SHEETS—SHEET 5.

Fig. 6.

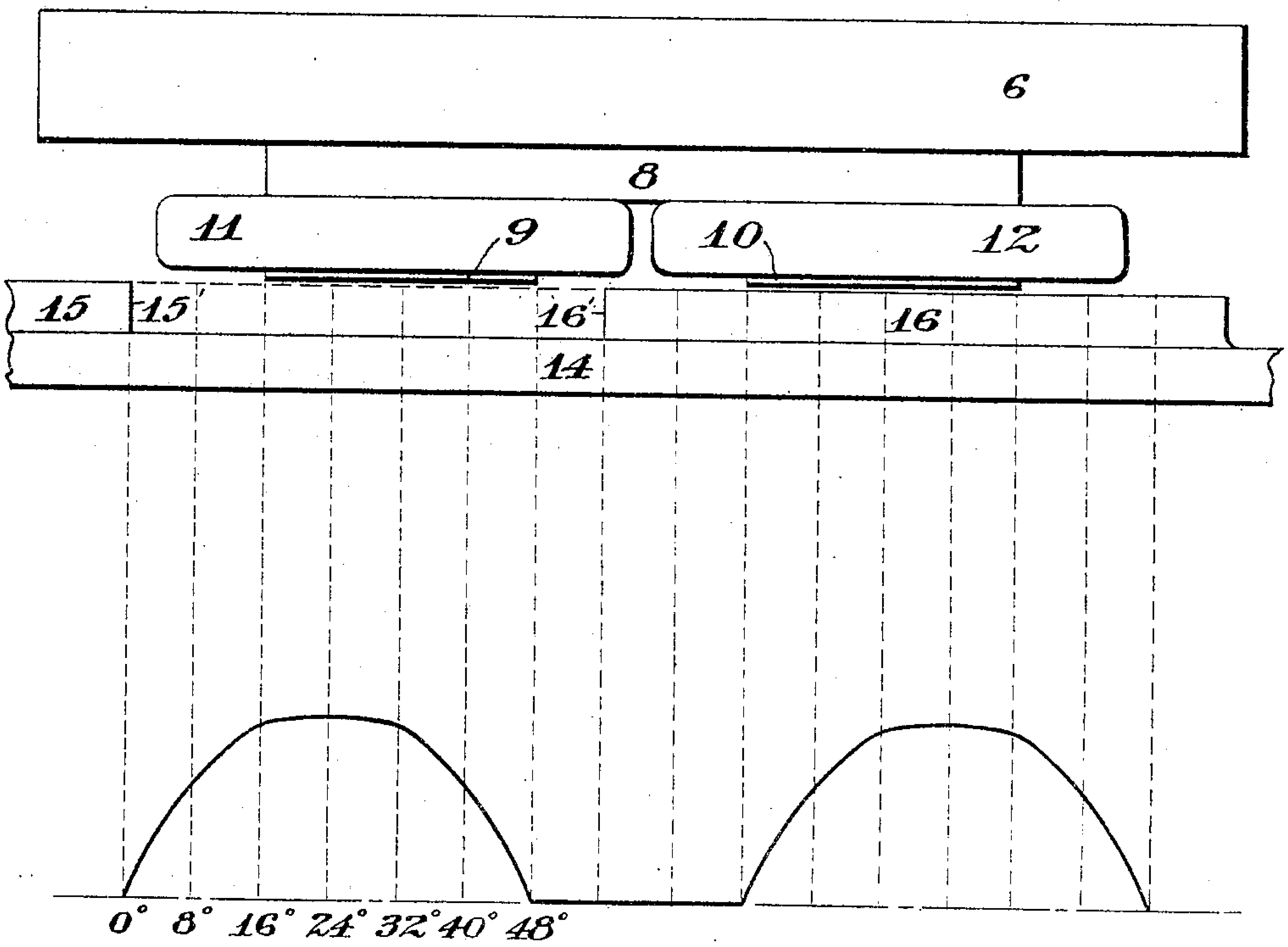

Fig. 11. Fig. 12.

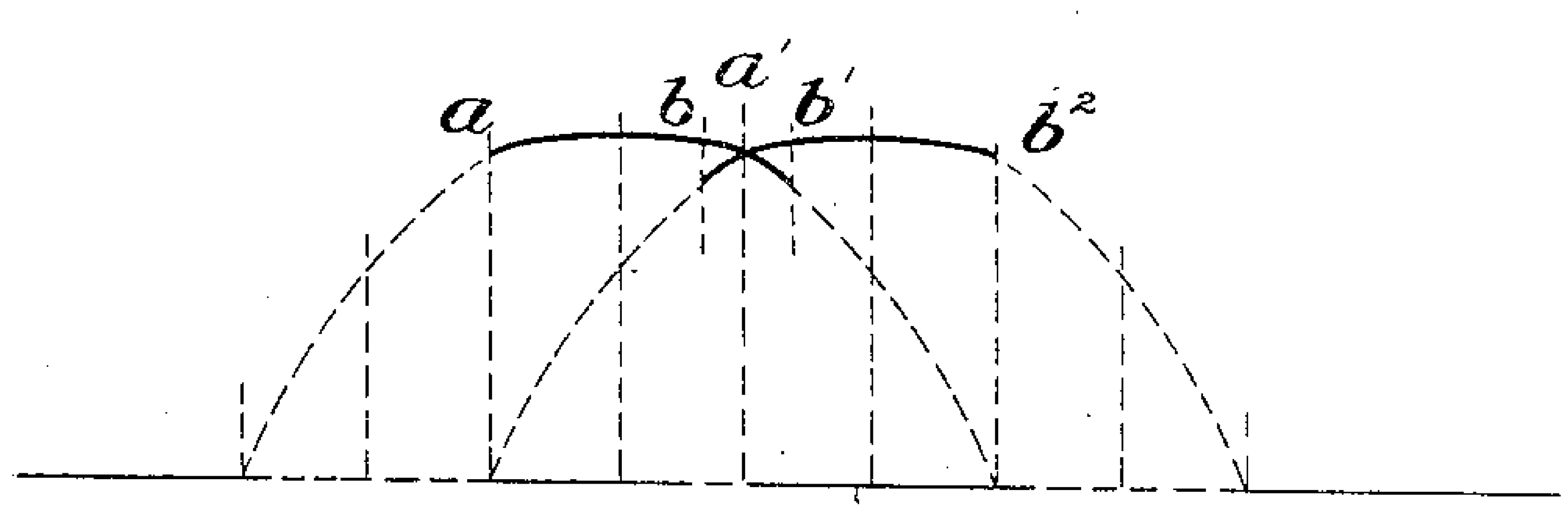

Fig. 13.

Witnesses
Milton B. Kolb.
George G. Schriver.

Inventor
Leon Jules Le Pontois
By his Attorney
Seabury C. Mastick

UNITED STATES PATENT OFFICE.

LEON JULES LE PONTOIS, OF NEW ROCHELLE, NEW YORK, ASSIGNOR TO POLY-PHASE IGNITION SYSTEM COMPANY, A CORPORATION OF NEW YORK.

APPARATUS FOR GENERATING AND UTILIZING POLYPHASE ALTERNATING CURRENTS FOR THE IGNITION OF EXPLOSIVE MIXTURES.

No. 808,554. Specification of Letters Patent. Patented Dec. 26, 1905.

Application filed October 7, 1904. Serial No. 227,548.

To all whom it may concern:

Be it known that I, LEON JULES LE PONTOIS, a citizen of the Republic of France, and a resident of New Rochelle, Westchester county, New York, have invented a certain new and useful Improvement in Apparatus for Generating and Utilizing Polyphase Alternating Currents for the Ignition of Explosive Mixtures, of which the following is a specification.

My invention relates to apparatus for generating and utilizing polyphase alternating currents for the ignition of explosive mixtures.

In order to obtain sufficient heat energy for ignition purposes from an alternating magneto, it is necessary that the alternating-current generator should be driven at such a speed in relation to the speed of the engine that the current-wave passes through its period of maximum intensity when its circuit is opened or closed by a sparking device. Such generator must, therefore, either be driven at the same angular speed as the engine or by gears or chains at such a speed that the current generated will always pass through its period of maximum intensity when a spark is desired. As the time of ignition of the explosive mixture in internal-combustion engines is determined by the piston speed of the engine or is under the control of the operator for the purpose of power regulation, it has proved very difficult to secure sufficient effective range of sparking by means of single-phase alternating-current generators.

I am aware of the fact that if a single-phase alternating-current generator is driven at the same speed or at a speed that is a constant function of the speed of the engine-shaft it is possible to extend the range of effective sparking by means of a suitable mechanism modifying the angular relations existing between the engine-shaft, the rotor, and stator of the generator. It is obvious, however, that the sparking device must in such case be shifted at the same time and in the same angular proportion. The necessity for this simultaneous control of both the generator and the sparking mechanism renders such method of extending the sparking range rather complicated and difficult of accomplishment.

The present invention has been designed to simplify the means for extending the sparking range.

In the present embodiment of my invention I employ an alternating-current generator driven at the same speed as the engine-shaft or at a speed which is a multiple of the speed of said shaft, such generator being designed so as to deliver to a sparking device singly or jointly two or more alternating currents differing in phase from each other, the circuits carrying those currents being adapted to be connected electrically, either singly or jointly, to any suitable sparking device, in such manner, however, that whatever be the time at which a spark is needed the current or currents delivered by the polyphase generator to the sparking device possesses a sufficient intensity for the effective ignition of the explosive mixture.

By "sparking device" used in this specification I mean to include all apparatus adapted to produce high or low tension sparks when a current of sufficient intensity is delivered to their terminals.

In the accompanying drawings I have shown for the purpose of explanation an engine equipped with either the so-called "make-and-break" system of ignition or the so-called "jump-spark" system of ignition, these being the two principal systems in present use.

In the drawings, Figure 1 is an end view of a single-cylinder engine embodying the make-and-break type of ignition, certain parts being in section. Fig. 2 is a similar view utilizing a jump-spark system of ignition. Fig. 3 is a view, partly in section and partly in elevation, of a two-phase generator, certain of the parts being broken away. Fig. 4 is a front view of the stationary element of a two-phase generator. Fig. 5 is a similar view of the moving element of said generator hereinafter designated as the inductor. Fig. 6 is an outline view of certain parts of the generator in connection with the diagrammatic views of Figs. 11, 12, and 13. Figs. 7 and 8 are detail sectional views of certain of the parts, Fig. 9 an enlarged view of a part of Fig. 2, and Fig. 10 is a section on the plane of the line 10 10 of Fig. 9.

Similar reference-numerals indicate similar parts in the several views.

Referring to the drawings, the numeral 1 designates the engine-cylinder in which the explosive mixture is ignited.

2 designates the crank-casing, having a bearing for the motor-shaft 3, the end of said casing, as shown in Fig. 3, having a hub 4 constituting a support for a spider 5, the latter preferably made of non-magnetic material, said spider being rigidly secured to said hub. An annular permanent magnet 6 is rigidly supported by the spider, said magnet being formed of a steel ribbon continuously wound in the form of a helix after it has been hardened, as described in a companion application. After the steel ring has been securely fastened to the spider 5 it is accurately ground at two opposite zones of the same diameter and placed in a powerful magnetic circuit closing itself by the two zones and by each side of the annular magnet. Two opposite magnetic poles are thus developed in the zones. An annular segment 7, of annealed wrought-iron, constituting a polar projection, is securely fastened to one of the zones by bolts 13, special care being taken that said segment fits perfectly over the whole surface of the zone in order to reduce the reluctance of the magnetic joint to a minimum. An annular segment 8, also made of annealed wrought-iron, is securely fastened by similar means to the lower or other zone, the zone-surface covered by the segment 8 being equal to the surface covered by the upper segment 7. The segment 8 has integral therewith two polar projections 9 and 10, set radially with reference to the center, the angle between the two sides of each of said projections being in the case illustrated thirty-two degrees. It can thus be readily seen that the magnetic field concentrated about the magnetic poles 7, 9, and 10 closes itself throughout space from poles 9 and 10 to pole 7. Two coils 11 and 12 are wound on the polar projections 9 and 10, respectively.

Referring to Fig. 3, 14 designates the fly-wheel of the motor, mounted on shaft 3. For convenience in the present case I have selected said fly-wheel to serve as an inductor, although, as its function consists mainly in permitting the magnetic field concentrated, respectively, about poles 7, 9, and 10 to close its circuit through the polar projections 15 and 16 (see Fig. 5) on the inductor and the central mass of the inductor, it is obvious that any disk of suitable material would answer the same purpose, the object of the construction shown being to design the generator in a more compact form and to make it an integral part of the motor itself. The inductor 14 is so mounted on the shaft 3 as to rotate in close proximity to the polar projections of the magnet, suitable means being provided to prevent any possible side motion of the inductor, which rotates within about one sixty-fourth of an inch of said polar projections. As the inductor is rotated it will cause variations in the intensity of the magnetic flux threading through the coils 11 and 12, and these coils will therefore become the seats of alternating currents differing in phase from each other.

Figs. 11, 12, and 13 graphically illustrate the variations taking place simultaneously in the coils 11 and 12 when the edges 15′ and 16′ move toward and away from the poles 9 and 10, respectively, through an angular distance of forty-eight degrees, and for convenience of illustration I have shown in Fig. 6 the permanent magnet 6, the poles 9 and 10, coils 11 and 12, and inductor 14. In these figures the curve of Fig. 11 theoretically expresses the different values of current generated in the coil 11 as polar projection 15 traverses an angle of forty-eight degrees. The curve of Fig. 12 theoretically expresses the different values of the current generated in the coil 12 as the polar projection 16 of the inductor traverses an angle of forty-eight degrees, and the curve shown in Fig. 13 theoretically expresses the simultaneous variation of both alternating currents while the inductor traverses an angle of thirty-two degrees. It has been found by experiment with the apparatus illustrated that from the point a of the curve in Fig. 13 to the point a' on the same curve the current generated in coil 11 has sufficient intensity to produce effective sparking, that being in the present instance equivalent to an angular distance of about sixteen degrees, while at the same time the current generated in coil 12 does not have a sufficient intensity for that purpose. If now the inductor is moved through an angle of sixteen degrees, the current generated in the coil 12 will possess sufficient intensity for the required purpose, while the current generated in coil 11 does not. It will be seen, therefore, that during an angular movement of the inductor of thirty-two degrees the currents generated in coils 11 and 12 successively possess the required energy. Referring to Fig. 13, it will be noted that the curves intersect each other at the point a', at which point both currents have the same intensity. From the point a to the point b coil 11 alone is cut into the circuit comprising the sparking device. From the point b to the point a' the circuits of the coils 11 and 12 are placed in parallel and jointly supply energy to the sparking-device circuit in order that one current-circuit shall not be cut out before the other is cut in and so that at all times current will be delivered to the sparking device. This condition is maintained from the point b to point b'. From point b' to point b^2 the coil 12 alone supplies energy to the circuit comprising the sparking device. It is to be noted that at only one point a' both of the currents have an equal intensity, but the slight difference of potential existing between them when they are in parallel is not sufficient to cause one circuit to pump energy into the other circuit, because of the great reactance of coils 11 and 12. The effective range of sparking from the point *a* to the point b^2, as above described, corresponds to an angular displacement of the inductor of thirty-two degrees. If, however, a greater range of sparking is desired, the angle of the polar projections 9 and 10, as well as the length of the polar projections 15 and 16 of the inductor, may be modified accordingly. In the present case the sparking range of thirty-two degrees is sufficient to produce efficient ignition at variable speeds of the engine. It is unnecessary, therefore, that the generator should deliver energy to the sparking device at other periods, and for that reason the polar projections 15 and 16 have been made as long as possible for the purpose of maintaining the magnetic field in closed circuit most of the time..

In Fig. 1 I have shown a form of the so-called "make-and-break" system of ignition. In the combustion-chamber of the engine is located an insulated plug or terminal 17, and adapted to contact therewith is a lever 18, mounted on a rock-shaft 19, the latter passing through a suitable stuffing-box in the wall of the combustion-chamber. The end of the plug or terminal 17 and the contact end of lever 18 will preferably be made of case-hardened nickel-steel. The contact-lever 18 is held in the position shown in Fig. 1 by the action of a spring 28, surrounding a reciprocating rod 21, supported in suitable guides, said spring bearing between one of said guides 29, integral with the engine-cylinder, and a collar 30 on said rod. The rod 21 rests upon and is moved in one direction by the action of a lever 22, loosely pivoted at 23 to a hand-controlled lever 24, pivoted on a bracket 25 of the casing. Assuming that the present motor is of the four-cycle type, a cam 26 is mounted on the cam-shaft 27, which rotates at one-half the speed of the crank-shaft. The lever 22 is provided with a toe 55, which engages the cam 26, so that upon rotation of shaft 27 in the direction of the arrow the cam will raise said lever 22, and consequently the rod 21, against the action of spring 28. The rod 21 has at its upper end a collar 31, which rests upon the end 32 of a lever 33, which lever is secured to the rock-shaft 19. A spring 20 is secured to the other or free end of lever 33 and to a fixed bracket or to the end of an arm 56, pivoted at 60 and resting at its inner end on the guide-bracket 29. When the rod 21 is raised by the action of the cam 26 and lever 22, the collar 31 will be raised from contact with the end 32 of lever 33, thus permitting the outer end of said lever to be drawn down by the spring 20 to rock the shaft 19, and thereby bring the end of lever 18 into contact with the terminal 17. The face of the cam 26 is provided with a step 57, so as to suddenly release rod 21 as the cam wipes from under the toe of lever 22, permitting the collar 31 on said rod to strike forcibly against the end 32 of the lever 33, resulting in a sudden break between the contacts 17 and 18. The lever 24 has secured thereto a bent spring 34, (see Fig. 8,) which spring at its inner ends carries two small contact-shoes 35 and 36, adapted to slide over a sector 37, secured to the casing. Said sector carries two segments 38 and 39, which are insulated from the sector by insulation 40, as shown. Two binding-posts 41 and 42 are provided to place segments 38 and 39 in electrical connection with one terminal of the coils 11 and 12, respectively, the other terminals of said coils being connected together to the insulated terminal 17. A non-inductive resistance 43 connects the two binding-posts for the purpose of lessening to a considerable extent the arc which would occur between the sectors and the shoes 35 and 36 when either current is open-circuited. In the construction shown in Fig. 1 the position of lever 24 determines the time of break in the explosion-chamber. If said lever is moved to the left, it is evident that the center of oscillation of lever 22 will be displaced to the left, and therefore the cam 26 will act later on the rod 21, and consequently the spark will occur at a later period. If, on the contrary, the lever 24 is moved to the right, the cam will act at an earlier period, and consequently the spark will occur at an earlier period of the piston-stroke. When the lever 24 is moved to the right, both contact-shoes 35 and 36 rest on the segment 39, thereby grounding the coil 12, in which at that time and during the entire time that the lever 24 is being moved to the right there will be sufficient electrical energy to produce a spark having the necessary heat value to explode the mixture. If the lever 24 is moved toward the left, it follows that the current from coil 11 will supply the breaker-circuit with sufficient energy to attain the same result. When the lever 24 is in such position that the circuits 11 and 12 are connected in parallel by both of their terminals 41 and 42 being grounded, said coils possess sufficient energy to supply jointly the sparking device for the desired purpose. As the inductor rotates at the same speed as the motor-shaft, it follows that there exists a constant relation between that period of the piston-stroke during which sparking must occur at some definite time, according to the piston speed, and the period of current generation, during which sufficient current for sparking purposes is generated at all times. It will also be seen that while the lever 24 is being moved directly or indirectly across the sector 37 a spark will occur at variable times in the explosion-chamber; but at whatever time it occurs there is always sufficient energy delivered by either one of the coils singly or by both of them jointly to the sparking device for the purpose desired.

In Fig. 2 I have shown a motor equipped with a jump-spark system, 44 designating any suitable form of jump-spark plug located in the combustion-chamber. Again assuming a four-cycle motor, I secure to the end of the shaft 27 (see Figs. 9 and 10) an arm 45, to which at one end is pivoted a lever 46, having at its free end a roller-contact 47. The lever 46 has a depending portion 58, between which and a depending portion of arm 45 is a spring 59, which tends to maintain the roller 47 in close rolling contact with a fiber ring 48, said ring being securely fastened inside a circular socket 50, which latter is free to rock on the end of the shaft 27. An oil-cup 60 on the socket feeds oil to the bearing on the shaft. A contact-plate 49 is inserted at a suitable point in the fiber ring 48, said ring being capable of rotary adjustment through the medium of a hand-lever 51, secured to the supporting-socket 50. The lever 51 has attached thereto a spring 34, Fig. 7, which spring carries contact-shoes 35 and 36 adapted to be moved over segments 38 and 39 in all respects similar to that shown in Fig. 8 and as above described in connection with the make-and-break system of Fig. 1, except that no shunt is provided. The position of lever 51 determines the time of sparking in the jump-spark system in a manner similar to the position of lever 24 described in connection with Fig. 1—that is, by moving lever 51 downward or to the left the ring 48, with contact-block 49, will be moved to the left, and assuming that the shaft 27 is rotated in the direction of the arrow the contact of roller 47 with plate 49 will occur at a period later than that when the lever 51 is in the position shown in Fig. 2. Therefore the make-and-break of the current will occur at a later period, thereby delaying the time of sparking. On the contrary, when the lever 51 is moved upward or to the right the contact-plate will be moved to the left, so that the contact of the roller 47 with said plate will occur at a period earlier than in the position shown in Fig. 2, resulting in an advance of the time of sparking. One terminal of the coils 11 and 12 is connected to the contact-plate 49, the other two terminals being connected, respectively, to the binding-posts 41 and 42. One end of the primary induction-coil is connected to the contact-plate 49, the other terminal 54 being grounded in the casing at 61. A condenser 53, having a condensance equal to the reactance of the primary, is connected to the terminal 52 and to ground. The secondary of the induction-coil is grounded in 54, and the other terminal is connected to the jump-spark plug 44. The same constant relation existing between the period of current generation and the time during which sparking must occur at some definite time, according to the piston stroke, as before described in connection with the make-and-break system of ignition, exists in the jump-spark system of ignition.

The drawings show the polar projections 7, 9, and 10 as slotted in order to prevent closed-circuited currents around the edges of said projections.

What I claim, and desire to secure by Letters Patent, is—

1. A system for igniting combustible mixtures in internal-combustion engines comprising a polyphase alternating-current generator having its rotor driven at a speed proportional to that of the engine-shaft, and means for varying the time of operation of the sparking device constructed to connect electrically said device to the generator at the time of generation of either of the alternating currents or of both of them jointly according to their respective intensities.

2. The combination with an internal-combustion engine having a spark-producing device, of a polyphase alternating-current generator, means for driving said generator at a speed proportional to that of the engine-shaft, means for connecting to the spark-producing device first that one of the polyphase circuits the current of which is passing through its period of maximum intensity; then for connecting both circuits to the spark-producing device while their respective current intensities are equal or nearly equal; then for disconnecting the first-named circuit while its current is passing through its period of minimum intensity and leaving connected to the spark-producing device the second-named circuit while its current is passing through its period of maximum intensity.

3. The combination with an internal-combustion engine having a sparking device, of a polyphase alternating-current generator having its field-magnet supported in an adjustable frame or spider, and an inductor connected to the engine-shaft so as to be driven at a speed proportional to that of the engine-shaft.

4. The combination with an internal-combustion engine having a sparking device, of means to vary the time of sparking comprising a cam, a lever actuated by said cam, shifting means to vary the positions of said cam and lever relatively to each other, and contact-segments included in the current-circuits over which said shifting means may be moved.

5. The combination with an internal-combustion engine having a sparking device, of a polyphase alternating-current generator for delivering the current or currents to said sparking device, contact-segments included in the current-circuits, means for varying the

time of sparking comprising a cam, a lever actuated by said cam, and means for shifting the position of said lever and cam-surfaces relative to each other, said shifting means being adapted to move over said contact-segments.

In testimony whereof I have hereunto signed my name in the presence of two subscribing witnesses.

LEON JULES LE PONTOIS.

Witnesses:
E. F. PORTER,
CHARLES S. JONES.