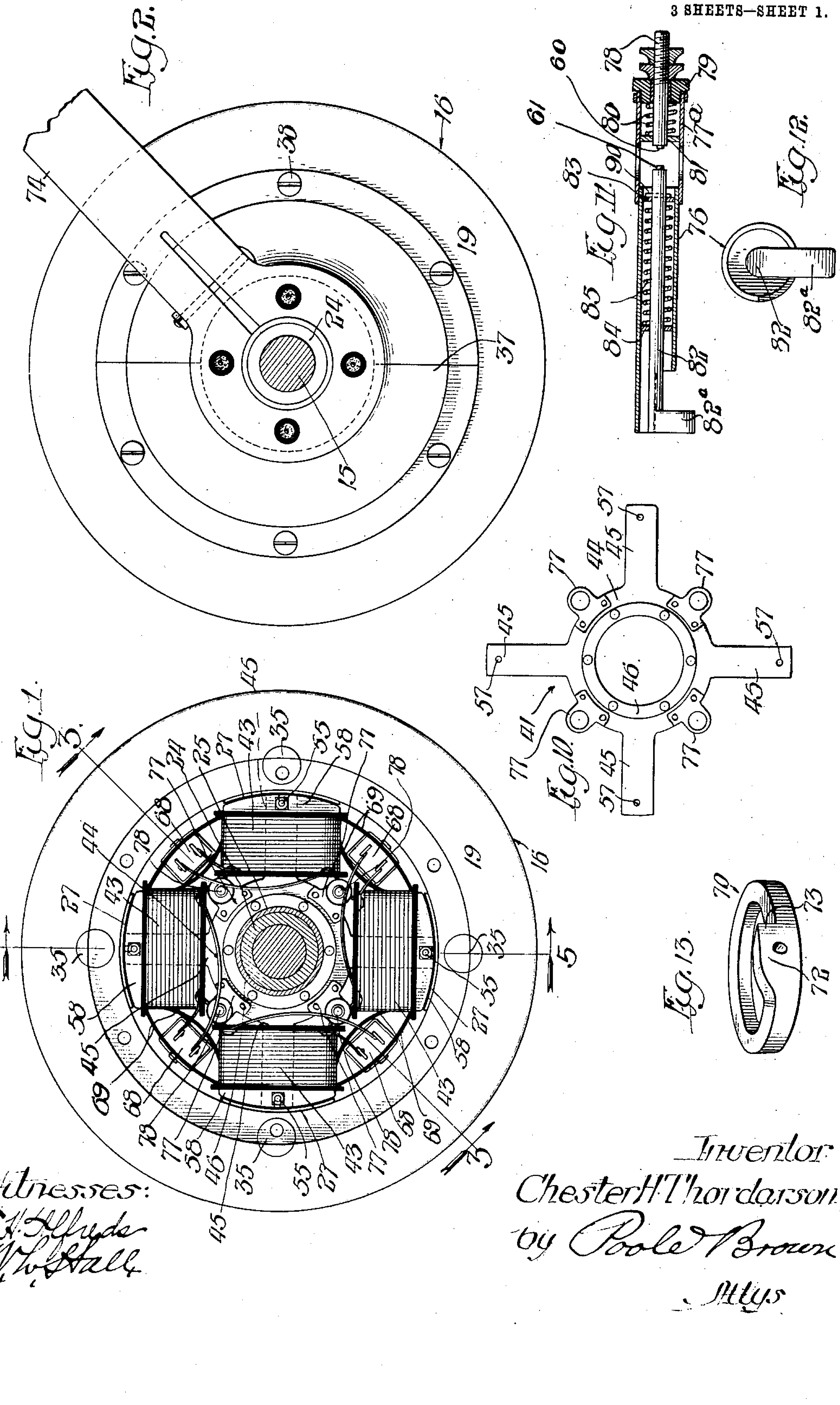
C. H. THORDARSON.

ELECTRIC IGNITION APPARATUS FOR INTERNAL COMBUSTION ENGINES.

APPLICATION FILED FEB. 15, 1907.

914,532. Patented Mar. 9, 1909.

3 SHEETS—SHEET 1.



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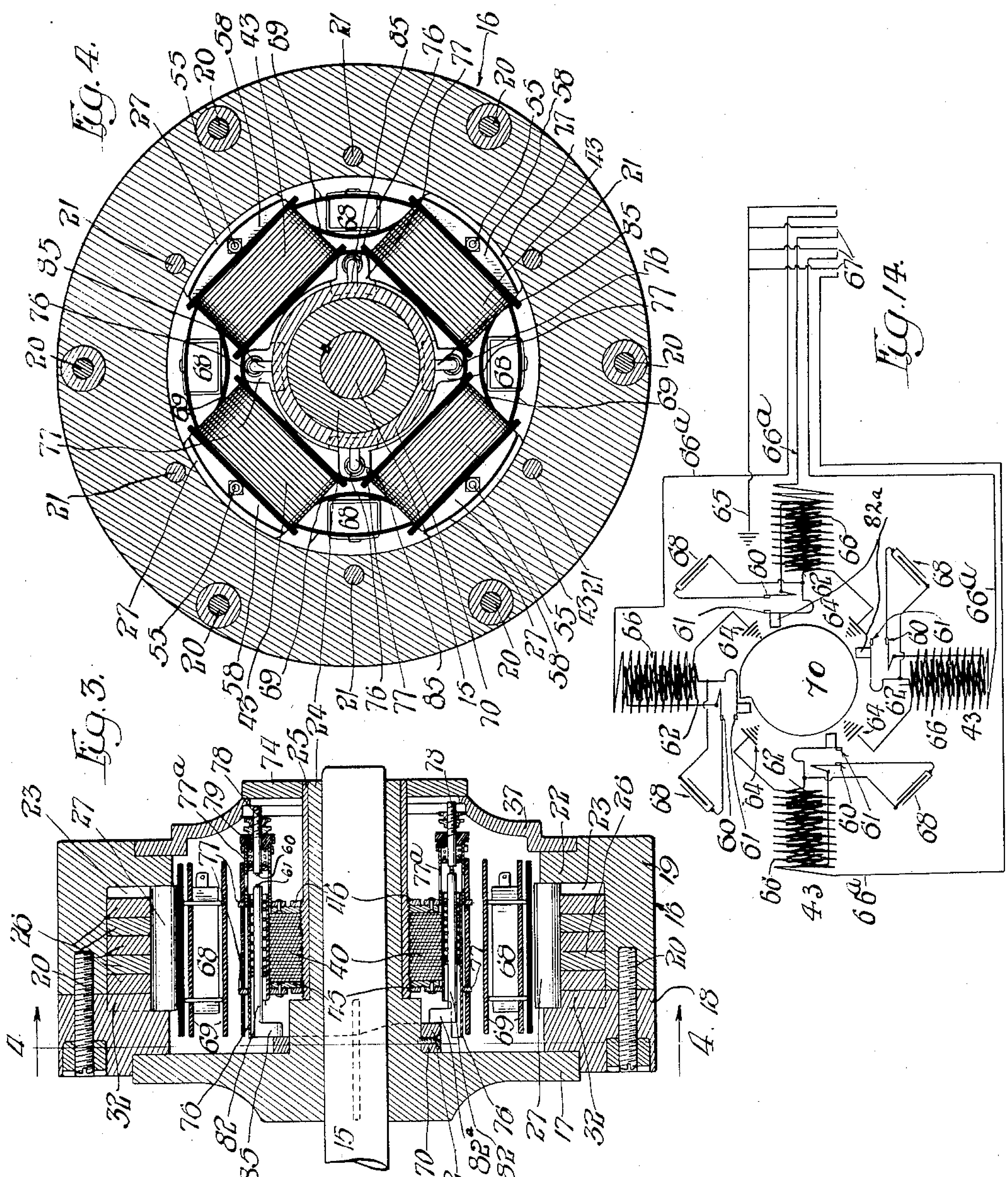

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3 SHEETS—SHEET 3.

Fig. 6.

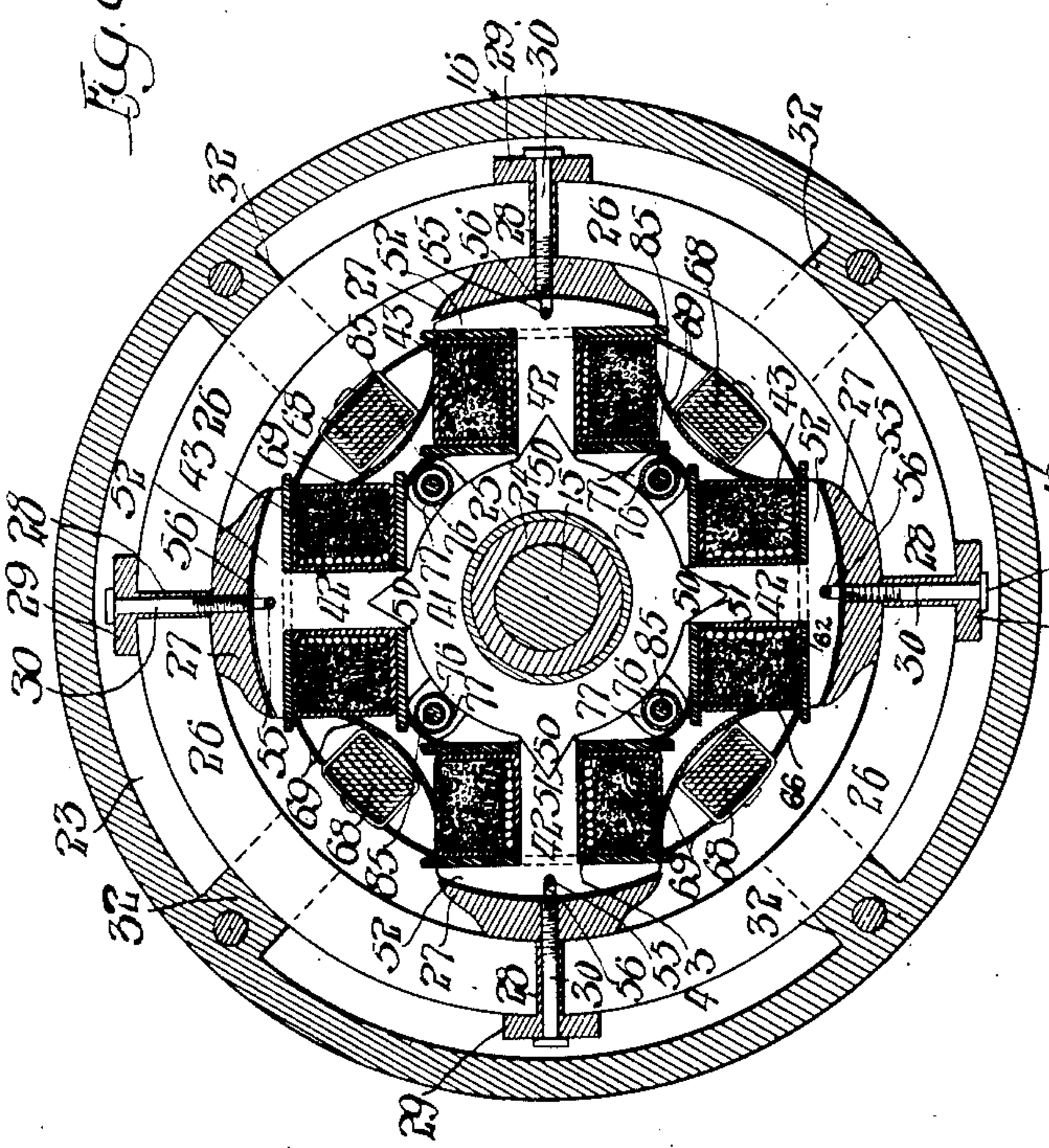


Fig. 9.

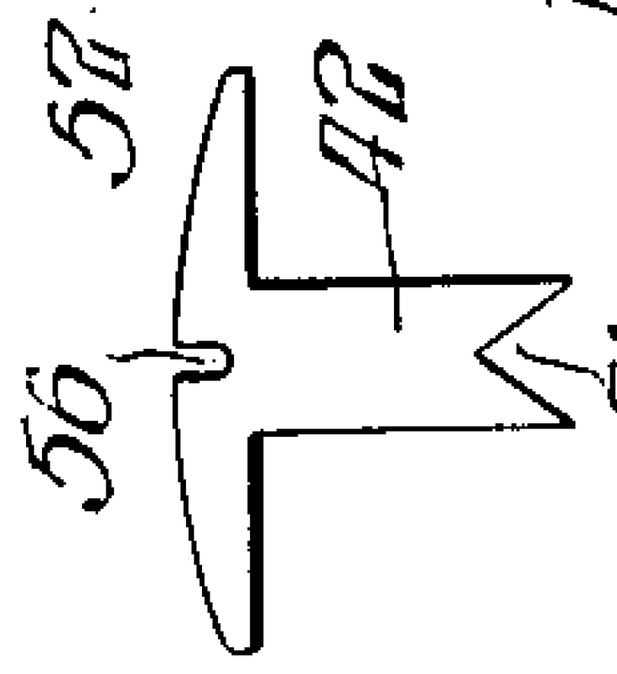


Fig. 8.

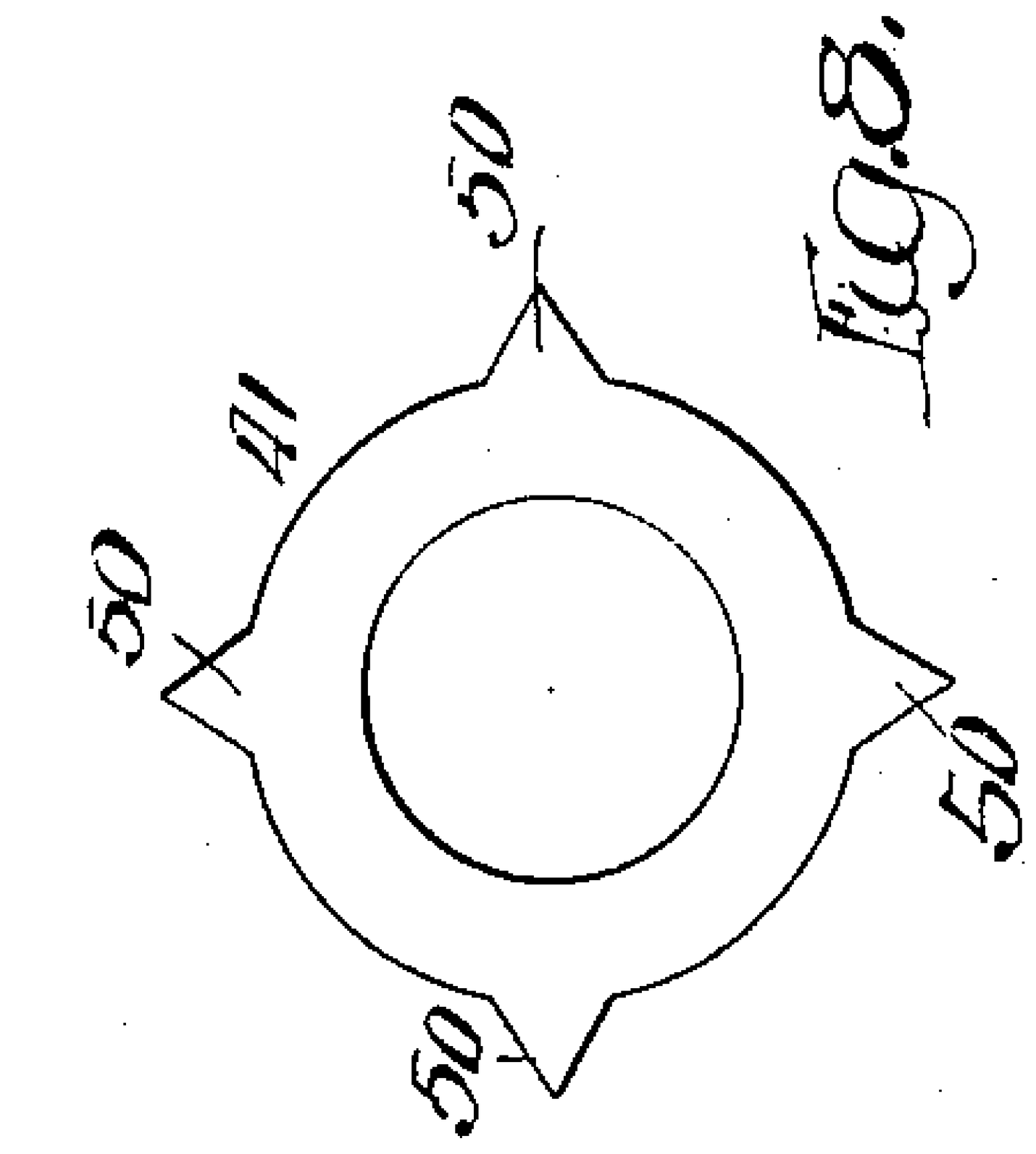


Fig. 5.

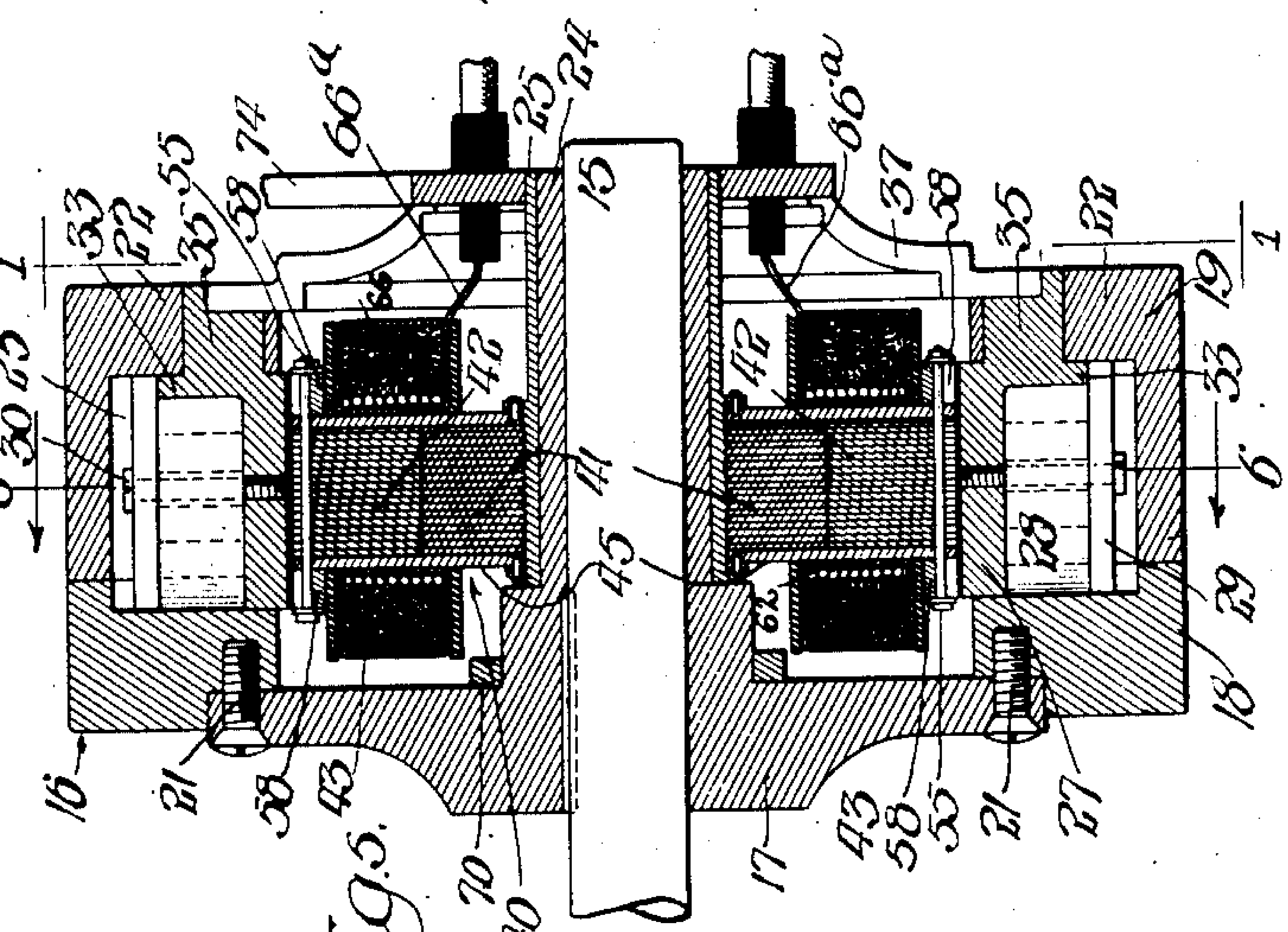
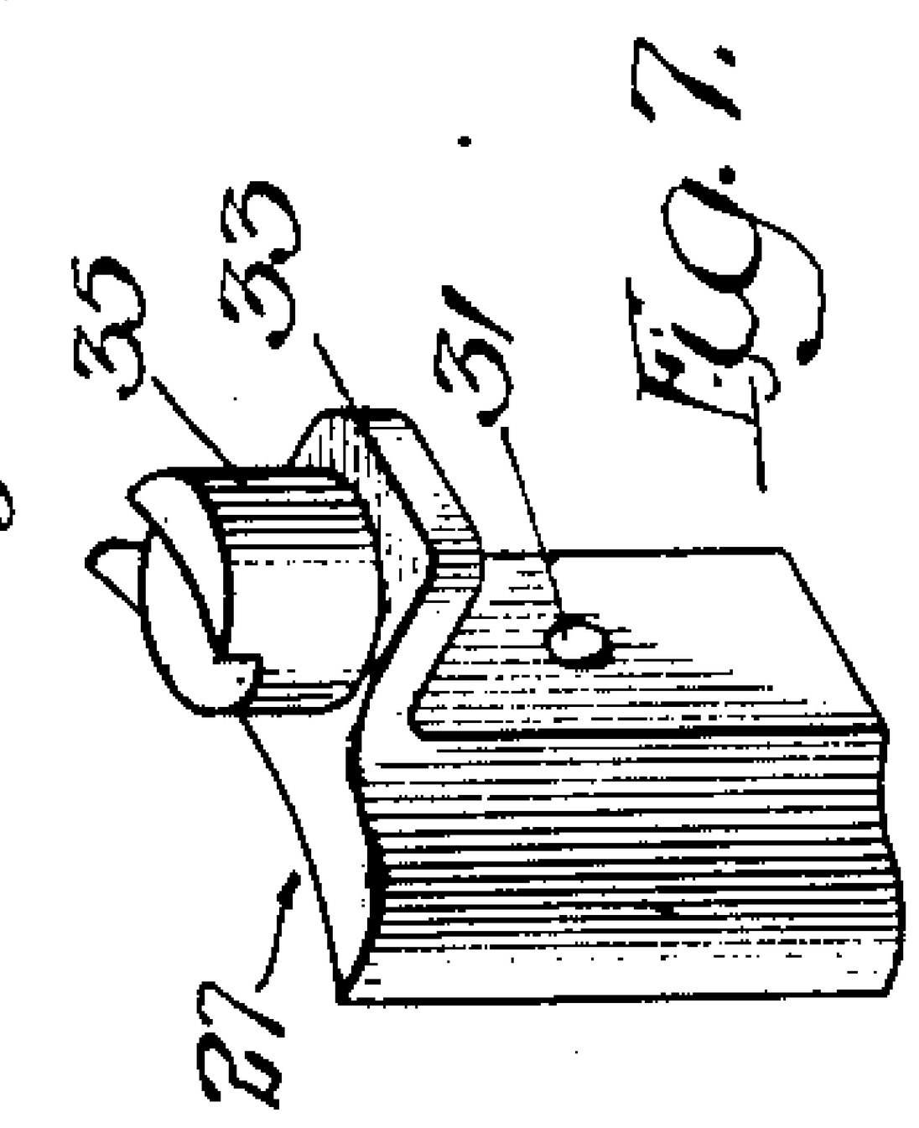


Fig. 7.



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UNITED STATES PATENT OFFICE.

CHESTER H. THORDARSON, OF CHICAGO, ILLINOIS.

ELECTRIC IGNITION APPARATUS FOR INTERNAL-COMBUSTION ENGINES.

No. 914,532. Specification of Letters Patent. Patented March 9, 1909.

Application filed February 15, 1907. Serial No. 357,438.

To all whom it may concern:

Be it known that I, CHESTER H. THORDARSON, a citizen of the United States, and a resident of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Electric Ignition Apparatus for Internal-Combustion Engines; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the characters of reference marked thereon, which form a part of this specification.

This invention relates to improvements in electric ignition apparatus for explosive engines and to improvements in generators adapted for use in such engines, and the invention consists in the matters hereinafter set forth and more particularly pointed out in the appended claims.

As shown in the drawings:—Figure 1 is a partial side elevation and partial cross-section of a generator made in accordance with my invention, the section being taken on line 1—1 of Fig. 5. Fig. 2 is a full side elevation thereof. Fig. 3 is an axial section, taken on line 3—3 of Fig. 1. Fig. 4 is a cross-section, taken on line 4—4 of Fig. 3. Fig. 5 is an axial section, taken on line 5—5 of Fig. 1. Fig. 6 is a cross-section, taken on line 6—6 of Fig. 5. Fig. 7 is a perspective view of one of the pole extensions of the inductor or field magnet. Figs. 8 and 9 illustrate detached parts of the armature core. Fig. 10 is a side elevation of one side of the frame for fixing the armature core in place. Fig. 11 is a detail of one of the circuit breakers. Fig. 12 is an end elevation of said circuit breaker. Fig. 13 is a perspective view of the cam for actuating the circuit breakers of the generator. Fig. 14 is a diagram illustrating the several circuits of the generator and their relation to the circuit breaker.

The generator herein shown is of the alternating current type and embraces, in general terms, a stator carrying a plurality of coils, each composed of a primary and a secondary winding, and a rotor surrounding the same carrying a plurality of permanent magnets having pole extensions which rotate in inductive relation to the coils on the stator. There are a number of coils equal to the number of sparking terminals of the explosive engine, or other device associated therewith, and the secondary circuit of each coil is connected with its own sparking terminal, each coil operating independently of the other coils to produce a spark in its own spark gap, as the spark plug of an explosive engine. The rotor conveniently comprises the rim of the balance-wheel of an explosive engine, when the generator is employed to generate current for an explosive engine igniter, while the stator is mounted concentric to the crank-shaft of the engine within the space surrounded by the rim and is fixed in any suitable manner to the frame of the engine or convenient stationary part. The terminals of the primaries of the coils are closed at predetermined periods in the rotation of the rotor to close the primary circuits and said primary circuits are sharply broken at a time of maximum magnetic flux in the core of said coils, thus inducing in the secondary circuits high potential currents that leap across the spark gaps in said secondary circuits to produce the sparks desired.

Referring now in detail to the construction of the generator thus generally indicated, 15 designates the crank-shaft of an explosive engine, and 16 designates, as a whole, the fly-wheel. For structural reasons and to facilitate the assembling of the parts, said wheel is made of three principal sections 17, 18 and 19 suitably secured together, the former comprising a central web or spider keyed to the shaft and the latter two parts rim sections. The rim members 18 and 19 are divided in a plane perpendicular to the axis of the shaft and are secured together by bolts 20 (Fig. 3). The central web or spider 17 is secured to the rim by screws 21 (Fig. 5). The rim member 19 is provided on the side remote from the central web or spider 17 with an annular radial flange 22 between which and the member 18 is formed an annular recess or chamber 23, to receive the permanent magnets or inductors of the rotor, as will hereinafter more fully appear. Said rim members 18 and 19 are made massive and of a material possessing high magnetic reluctance while the spider or web 17 may be made of steel. The said central frame of the wheel is provided with a hub extension 24 surrounding the crank-shaft. Mounted on the hub extension and capable of rotation thereon is a sleeve 25 which carries the stator element of the generator. The rotor therefore, in this embodiment of the invention, rotates at the same speed as the crank-shaft, so that the necessary operations of the

generator to produce the spark occur in perfect timing relation relatively to the travel of the pistons of the several cylinders of the engine.

The generator herein shown is adapted for use with a four cylinder, four cycle explosive engine, it being for this purpose provided with four coils and with four breakers so constructed and arranged with a snap-cam as to break the primary circuit of each coil once during each rotation of the shaft, thereby producing four distinct sparks from the several coils during one rotation of the shaft.

The rotor carries four permanent magnets 26, 26, each made of longitudinally divided curved sections or members fitted flatwise together, as shown in Fig. 3. Associated with said magnets 26 are pole extensions 27, 27 located at equidistant points about the rotor. The said pole extensions are connected with the magnets by clamping devices which serve in connection with the said extension pieces as means to fix the rotor magnets in place. Said clamping devices consist, as herein shown, of T-shaped fittings each comprising a flat shank 28 that enters the space between adjacent ends of two adjoining magnets, and a transverse head 29 that extends across the outer curved faces of said adjoining magnets. The said fittings and pole extensions are clamped upon the magnets by screw-bolts 30 that extend inwardly through the shanks of the fittings and have screw-threaded engagement with alined apertures 31 in the pole extensions. The said screw-bolts may be notched at their inner ends, as shown in Figs. 5 and 6, to admit adjustment of the bolts from the inner side of the wheel rim. The said magnets are held laterally in place between radially extending lugs 32, 32 on the member 18 of the rim and flanges 33 extending radially outwardly from the pole extensions and filling the space between the magnets and the flange 22 of the rim, as shown in Figs. 5 and 7. The magnets are supported from radial displacement by engagement with inwardly facing surfaces on the inner side of the rim, said inwardly facing surfaces being herein shown as circumferentially separated and formed on the lugs 32. This arrangement avoids the necessity of employing bolts to fasten the magnets in place and insures a firm and reliable support of the magnets in the rim by a simple arrangement. As an additional means of fastening the pole extensions 27 in place, they are provided at their flanged ends with lugs 35, extending laterally outwardly from the flanges 35 engaging suitable apertures in the radial flange 22 of the rim, as shown in Fig. 5. A two part circular, closing plate 37 is fitted to the wheel on the side opposite the central web 17 to inclose that side of the wheel, (Figs. 2, 3 and 5). The margin of said plate fits within an annular rabbet in said flange, and the plate is fixed in place by screws 38. The diameter of said plate is such that it cuts the outer ends of the lugs 35, thereby providing an additional interlocking connection between the parts which aids to hold the extensions in place and from tendency to rotate.

The armature core, designated as a whole by 40, (Figs. 3 and 5), is of laminated construction and is supported non-rotatively on the sleeve 25 surrounding the extension of the hub 24 of the fly-wheel. The said core consists of a central ring 41 and radial core arms 42 surrounded by and supporting the coils 43. As herein shown, said core is supported between two side frames (Figs. 5 and 10) removably fitted to said sleeve 25. Said side frames each comprise a central ring 44 and four radial arms 45 between which latter the laminæ of such core arms 42 are confined. As herein shown, the said rings 44 are thickened at their inner margins by the addition of supplemental rings 46 fixed thereto and the rings and the part of the sleeve 25 surrounded by the armature are screw-threaded to constitute the proper interlocking connection between the parts. In order to facilitate the assembling of the coils on the armature core, the said core arms 42 are made separate from and are interlocked to the central ring member 41 thereof. The said interlocking connections consist of inner and outer V-shaped lugs and notches 50 and 51 on the ring and radial arms, respectively, of the armature. This construction admits of the coils being placed over the projections 50 of the ring member of the armature core or the radial members 42 in assembling the parts, after which the outer radial members 42 are inserted in place. The outer ends of the arms 45 of the side frames for the armature core are narrow so that they do not interfere with the assembling of the coils in this manner. The ends of said radial members of the armature core are formed to provide transverse heads 52 giving to said outer members a general T-form; said heads being located radially outside of the coils and constituting the poles of the armature core. The said radial members of the armature core are fastened to the frame by means of bolts 55, extending transversely through notches 56 in the outer pole ends of said radial members and through registering apertures 57 in the outer ends of the arms of the core attaching plates. The said bolts also extend through clamping blocks 58 located one outside of each of said frames, whereby the clamping effect of the bolts is exerted uniformly on all parts of the transverse head portions of said outer members of said core. The said clamping blocks are provided with radially extending notches (Fig. 5) to receive said clamping bolts.

Referring now to the circuits of the generator, it will be noted that the terminals 60, 61 (Fig. 14) of each primary coil 62 are normally separated but are adapted to be brought together to close the primary for a limited time in the rotation of the rotor through the medium of a suitable breaker hereinafter to be described in detail, and designated as a whole by 70 in said Fig. 14. In practice one of the terminals of each primary may be grounded to the engine frame. The terminals 64, 65 of the secondary 66 of each coil are grounded to the engine frame, and the secondary windings are arranged to provide loops or exterior circuits 66ª in which are formed spark gaps or terminals, indicated diagrammatically at 67 in Fig. 14; it being understood that when applied to an explosive engine said spark terminals or gaps occur in the sparking plug of the engine cylinders. Between the terminals of each of the primary coils is connected a condenser 68, the purpose of which is to accumulate a potential in the primary during the time the primary circuit is closed and to discharge upon the opening of the circuit for the purpose of avoiding sparking between the separating terminals when the circuit is broken, and also for demagnetizing the core of the coil and strengthening the current in the secondary at this time. The said condensers are conveniently located between adjacent coils, as shown in Figs. 4 and 6, and secured between insulated strips or plates 69, 69, which span the spaces between adjacent coils and are attached to the coil structures. It may be stated here that the pole extensions of the rotor are so related to the breakers for the primary circuits that the breaking of the primary circuit of each coil occurs at the approximate moment of reversal of the magnetic circuit through the core of that coil. Thus it will be seen that the value of the high potential current induced in the secondary to produce the spark at the gap 67 represents the sum of the effects of the reversal of the magnetic circuit and the reversal of the primary circuit, due to the sudden breaking of said circuit and the discharge of the condenser.

Four breakers are herein shown as employed, one associated with each of said coils. Each breaker, as a whole, is of elongated proportions, as shown in Figs. 3 and 11. They are located in the spaces between adjacent arms 42 of the core and are disposed parallel with the axis of rotation of the rotor. They are each adapted to be operated by a snapping cam 70 once during each rotation of the shaft. Said snapping cam comprises a ring that encircles the hub of the balance-wheel (Figs. 3 and 5) and is rigidly attached thereto. Said cam is provided on its inner face with a single raised portion at 72 at the rear end of which (relative to its direction of rotation) is an abrupt cam shoulder 73 (Fig. 13). The cam is adjusted in a predetermined angular relation with respect to the pole extensions of the magnets 26, and said adjustment is made in such manner as to close each primary circuit for a limited time during each rotation of the rotor and to admit of the opening of each primary circuit at the time of approximately greatest magnetic flux through the core of the coil and also closely coincident with the reversal of the magnetic circuit through said core. The effect of suddenly breaking the primary circuit at this time is to greatly strengthen the high potential current in the secondary, thus producing an efficient and reliable spark. The stator is capable of angular adjustment about its axis relative to the rotor in order to retard or advance the sparking period. This is effected in the present instance by the rotative engagement of the sleeve 25 with the hub extension 24 of the balance wheel, and a desired angular adjustment is maintained by means of an arm 74 fixed to the sleeve and extending radially therefrom for adjustable attachment at its outer end to a stationary part of the engine or other adjacent fixed part.

The circuit breakers for the primary windings of the coils 43 are arranged symmetrically about the shaft, one between two adjacent coils. The construction herein illustrated is made as follows, reference being made immediately hereinafter to but a single breaker and its associated coil.

76 designates a tube that extends between and is supported at its ends in oppositely disposed, apertured brackets or lugs 77 attached to the ring members 44 of the armature core fastening frames. The tube is open at its end adjacent to the snap cam 70. A second short tube 77ª fits telescopically over and constitutes an extension of the other end of the first tube. Both tubes are hereinafter termed the shell of the breaker.

78 designates an insulated terminal of one side of the primary to which the circuit wire 60 is adapted to be attached. Said terminal consists of a short rod that is mounted to slide endwise in a plug 79 which fits within and closes the adjacent end of the tube, and is made of insulating material. The said terminal is normally pressed inwardly toward the snap cam by a spiral, expansively acting spring 80 located within the shell, said spring surrounding the terminal rod and being interposed between the inner face of said plug 79 and a shoulder 81 at the inner end of said stem or rod. 82 designates the other terminal of the primary. It consists of a longer endwise reciprocating rod that engages at one end the snap cam 70 and is adapted to contact at its other end 61 with the inner end 60 of the spring controlled or yielding terminal pin 78 to close the primary circuit. The inner end of said longer terminal pin 82

engages an apertured, fixed guide disk 83, within the shell, and is provided at its outer end with a fixed, circular flange or disk 84 that has guiding engagement in the shell. The said terminal pin 82 is held yieldingly against the cam 70 by means of a spiral, expansively acting spring 85 interposed between the fixed disk 83 and the shoulder or disk 84 on said terminal pin. It will be noted that the longer terminal pin has metal to metal engagement with the shell and cam and constitutes, therefore, a grounded terminal that contacts with an insulated terminal. If desired, of course, said terminal may be insulated also.

In the operation of this part of the device the terminal pin of each of the breakers is thrust endwise inwardly during each rotation of the cam 70, at the time the outer end of said terminal pin engages the raised face of the cam, and contacts with the shorter terminal pin 78 to close the primary circuit. The travel of the terminal pin 82 is greater than the distance between the same and the insulated terminal pin 78, so that during the final endwise movement of the longer terminal pin the insulated terminal pin 78 is moved endwise outwardly against the action of its spring. During the subsequent retraction of the terminal pin 82, after it has dropped off the raised face of the cam, the insulated terminal pin 78 follows it during the first part of its return movement. The terminal pin 78 reaches the inner limit of its movement while the pin 82 is still moving outwardly, thereby producing a separation of said terminals much more abruptly than if the terminal pin 82 were retracted from an opposing stationary terminal. The abruptness of the breaking of the circuit results in a high potential of induced current in the secondary or sparking circuit, as before stated.

The longer terminal pin 82 of each breaker is capable of rotation and is provided at its end which engages the cam with an angular turned part or crank 82^a, with which the cam directly engages. The purpose of thus rotatively mounting said pin and providing it with a crank portion to engage the cam is to permit the fly-wheel to be rotated rearwardly when desired without its rotation being interrupted by engagement of the longer terminal pin with the abrupt shoulder of the cam. It will be observed that the axes of the pins 82 are radially outside the periphery of the cam ring, and that the inner ends of the cranks are radially inside said periphery of the ring. It will be furthermore observed that the adjacent outer ends of the breaker shells are slotted to permit the cranks of said pins to project inwardly from the shells. Thus the cranks are prevented from rotating so far as to become entirely disengaged from the cams. In order to prevent the crank-arms of said pins from being forced entirely across the periphery of the cam when they swing over the shoulder portions of the cam, as stated, stops 90 are provided to limit the endwise movement of said pins 82. As herein shown said stops are formed upon the inner ends of the pins 82. Obviously, however, the stops may be formed in the face of the cam if desired. Thus when the wheel and cam are rotated rearwardly and the shoulder of the cam strikes the crank portion of the terminal pin, the pin rotates to permit the crank to ride over the shoulder on the higher face of the cam. By thus turning the fly-wheel backwardly and forwardly a potential is built up such as will produce a current in the secondary associated with the breaker to produce a spark at a time when the engine is not running.

The mounting of the coils on the stator is advantageous inasmuch as this construction avoids the use of collector rings which would be necessary if the coils were carried by the rotor. In the present instance, the wires of the secondary, suitably insulated, lead outwardly through suitable openings in the closing plate 37 and the hub of the adjusting arm 74 (Figs. 2 and 5).

A general advantage of the construction herein shown is the great compactness with which the mechanism is assembled. The generator occupies but little space beyond that occupied by a balance-wheel of usual size and construction. Furthermore, the parts of the generator are effectively protected from dust and dirt. A further advantage of the construction shown is that the diameter of the stator admits of a high speed of the pole extensions of the inductor past the pole-pieces of the coils, thereby giving high current efficiency to the generator.

I claim as my invention:—

1. In an igniting apparatus for explosive engines, the combination with a plurality of sparking terminals, of an electric generator of the alternating type embracing a stator provided with a plurality of radially arranged cores, coils surrounding said cores, each composed of a primary and a secondary winding, the sparking terminals being included in the secondary circuits, a rotor carrying a plurality of inductors having pole extensions rotating in inductive relation to the cores of said coils, circuit breakers for the primaries of said coils supported on said stator and located one between each two adjacent coils, and a cam carried by the rotor for separately and successively operating said breakers.

2. In an igniting apparatus for explosive engines, the combination with a plurality of sparking terminals, of an electric generator of the alternating type embracing a stator provided with a plurality of cores, coils surrounding said cores, each composed of a primary and a secondary winding, the sparking

terminals being included in the secondary circuits, a rotor carrying a plurality of inductors having pole extensions rotating in inductive relation to the cores of said coils, means for successively breaking the primary circuits of said coils, including circuit breakers located one between each two adjacent coils, and condensers connected between the terminals of the primary coils and located one between each two adjacent coils radially outside of the circuit breakers.

3. In an igniting apparatus for explosive engines, the combination with a plurality of sparking terminals, of an electric generator of the alternating type embracing a stator provided with a plurality of cores, coils surrounding said cores, each composed of a primary and a secondary winding, the sparking terminals being included in the secondary circuits, a rotor carrying a plurality of inductors having pole extensions rotating in inductive relation to the cores of said coils, means for successively breaking the primary circuits of said coils, and condensers connected between the terminals of the primary coils, said condensers being located one between each two adjacent coils and supported on the coil structures.

4. In an igniting apparatus for explosive engines, the combination with a plurality of sparking terminals, of an electric generator of the alternating type embracing a stator having a plurality of radial cores, coils surrounding said cores, each embracing a primary and a secondary winding, the secondary windings being connected severally with the sparking terminals, a rotor carrying a plurality of inductors having pole extensions rotating in inductive relation to the cores of the coils, circuit-breakers located between said cores, each embracing an endwise movable terminal pin disposed parallel to the axis of rotation of the rotor and a cam fixed to the rotor and having a laterally facing cam surface for actuating said terminal pins.

5. In a sparking apparatus for explosive engines, an electric generator comprising a rotor and a stator, an inductor carried by the rotor and provided with a plurality of pole extensions, said stator comprising a central ring and radial core pieces and coils surrounding said core pieces, said ring having parts extending into the coils and said core pieces being separably joined to said parts of the central ring within and between the ends of the coils.

6. In a sparking apparatus for explosive engines, an electric generator comprising a rotor and a stator, an inductor carried by the rotor and provided with a plurality of pole extensions, said stator comprising a central laminated ring and radially arranged laminated core pieces with means for confining the laminæ of the core pieces flatwise together, and coils surrounding said core pieces, the central laminated ring having projections which extend into the inner ends of the coils and the laminated core pieces being separably joined to such extensions within and between the ends of the coils.

7. In a sparking apparatus for explosive engines, an electric generator comprising a rotor and a stator, the stator comprising a central laminated ring and radial laminated core pieces, said core pieces being made separable from the central ring, coils surrounding the said core pieces, side frame-members, and means for clamping said side frame members upon the radial core pieces to hold the laminated structure together.

8. In a sparking apparatus for explosive engines, an electric generator comprising a rotor and a stator, the stator comprising a central laminated ring and radial laminated core pieces, coils surrounding said core pieces, side frames members mounted on the part which carries said stator, and rods extending through the outer ends of said frame members and laminated core pieces for clamping the laminæ of the core pieces together, said side frame members being made narrower than the laminæ of the core pieces, and the core pieces being made separable from the central ring.

9. The combination with a balance wheel of an explosive engine provided in its rim with an annular chamber, of an inductor in said chamber comprising a plurality of curved magnets sections arranged end to end the inner side of the rim being provided with supporting projections against which the outer sides of the sections bear and are supported, pole extensions fitted to the inner side of the inductor at the junctions of said magnet sections, core pieces disposed concentrically about the axis of the said wheel within the space surrounded by said inductor and coils surrounding said core pieces and supported thereon.

10. In a sparking apparatus for explosive engines, an electric generator comprising a rotor and a stator, the stator comprising a central laminated ring and radial laminated core pieces, coils surrounding said core pieces, side frame-members mounted on the part which carries said stator, and rods extending through the outer ends of said frame members and laminated core pieces for clamping the laminæ of the core together, said side frame members being made narrower than the laminæ of the core pieces, and the core pieces being made separable from the central ring and joined thereto by notches on one of the parts engaging corresponding projections on the other part.

11. The combination with a balance wheel of an explosive engine, provided in its rim with an annular chamber, of an inductor in said chamber comprising a plurality of curved sections arranged end to end, the in-

ner side of said rim being provided with a plurality of lugs against which the outer sides of the sections bear and by which the sections are supported, pole extensions fitted to the inner side of said inductor at the junctions of said sections, said pole extensions having parts between which and the lateral faces of said rim lugs the inductor sections are confined, core pieces disposed concentrically about the axis of said wheel within the space surrounded by said inductor and coils surrounding and supported by said core pieces.

12. The combination with a balance wheel of an explosive engine provided in its rim with an annular chamber, of an inductor in said chamber comprising a plurality of curved sections arranged end to end, the radially outer sides of which bear against and are supported by inwardly facing projections of said rim, pole extensions fitted to the inner side of said inductor at the junctions of said sections, clamping devices for fixing said pole extensions in place and for rigidly connecting said inductor sections, core pieces disposed concentrically about the axis of said wheel within the space surrounded by said inductor and coils surrounding said core pieces.

13. The combination with a balance wheel of an explosive engine provided in its rim with an annular chamber, of an inductor in said chamber comprising a plurality of curved sections arranged end to end, the rim being provided with inwardly facing surfaces against which the radially outer sides of said inductor sections bear, pole extensions fitted to the inner side of said inductor at the junctions of said sections, T-shaped fittings, the shanks of which extend between the ends of said inductor sections and the heads of which overlap the radially outer sides of the adjacent ends thereof, clamping bolts extending inwardly through said fittings and having screw threaded engagement with said pole extensions, core pieces disposed concentrically about the axis of said wheel and coils surrounding said core pieces.

14. The combination with a balance wheel of an explosive engine provided in its rim with an annular chamber, of an inductor in said chamber comprising a plurality of curved magnets, each consisting of a number of sections placed flatwise together arranged end to end, pole extensions fitted to the inner side of the inductor at the junctions of said magnets, said pole extensions being provided with flanges which fit between one side wall of said chamber and the inductor and between which and the other side wall of the chamber the sections of the inductor magnets are confined, core pieces disposed concentrically about the axis of said wheel within the space surrounded by said inductor and coils surrounding said core pieces.

15. The combination with a balance wheel of an explosive engine provided in its rim with an annular chamber, of an inductor in said chamber comprising a plurality of curved magnets arranged end to end, each consisting of a number of sections placed flatwise together pole extensions fitted to the inner side of the inductor at the junctions of said magnets and clamped thereto, lugs extending laterally from said pole extensions and engaging sockets in the adjacent side wall of said chamber by means preventing rotation of said pole extensions, core pieces disposed concentrically about the axis of the wheel, and coils surrounding said core pieces.

In testimony, that I claim the foregoing as my invention I affix my signature in the presence of two witnesses, this 6th day of February A. D. 1907.

CHESTER H. THORDARSON.

Witnesses:

WILLIAM L. HALL,

GEORGE R. WILKINS.