Feb. 6, 1951 H. E. SCHLEICHER 2,540,294

ROTARY MAGNETIC SWITCH

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FIG. 1.

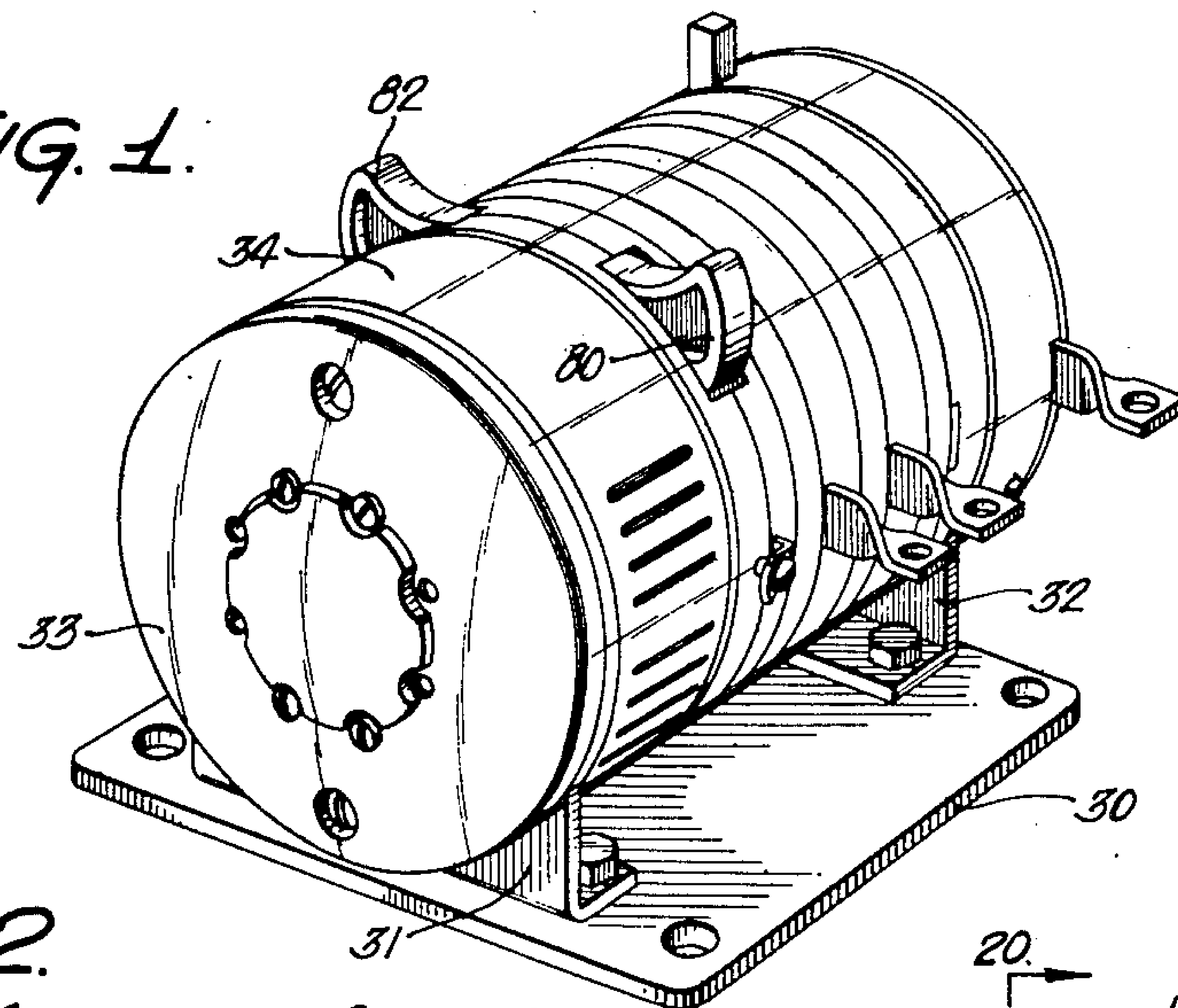
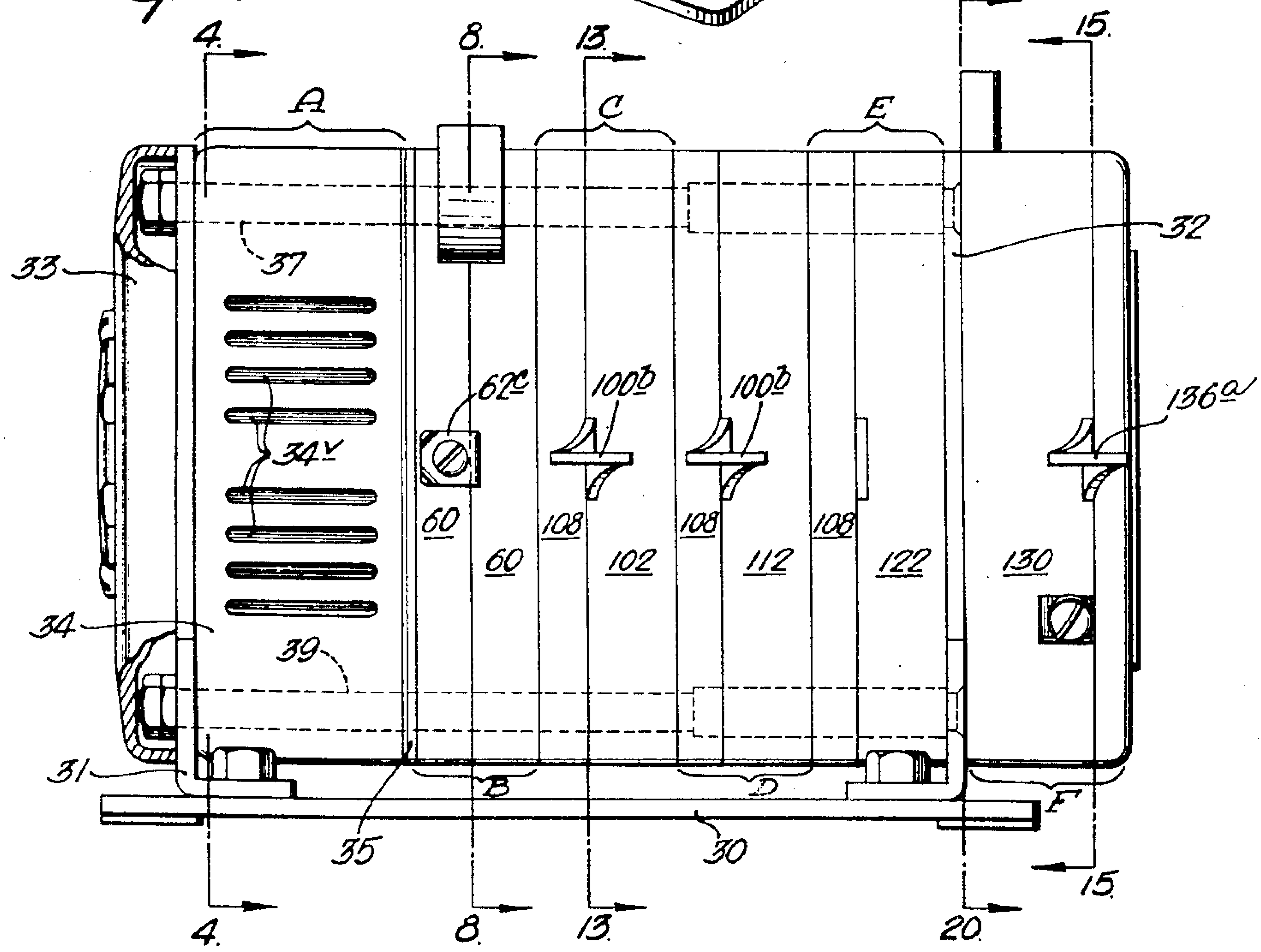


FIG. 2.



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ROTARY MAGNETIC SWITCH

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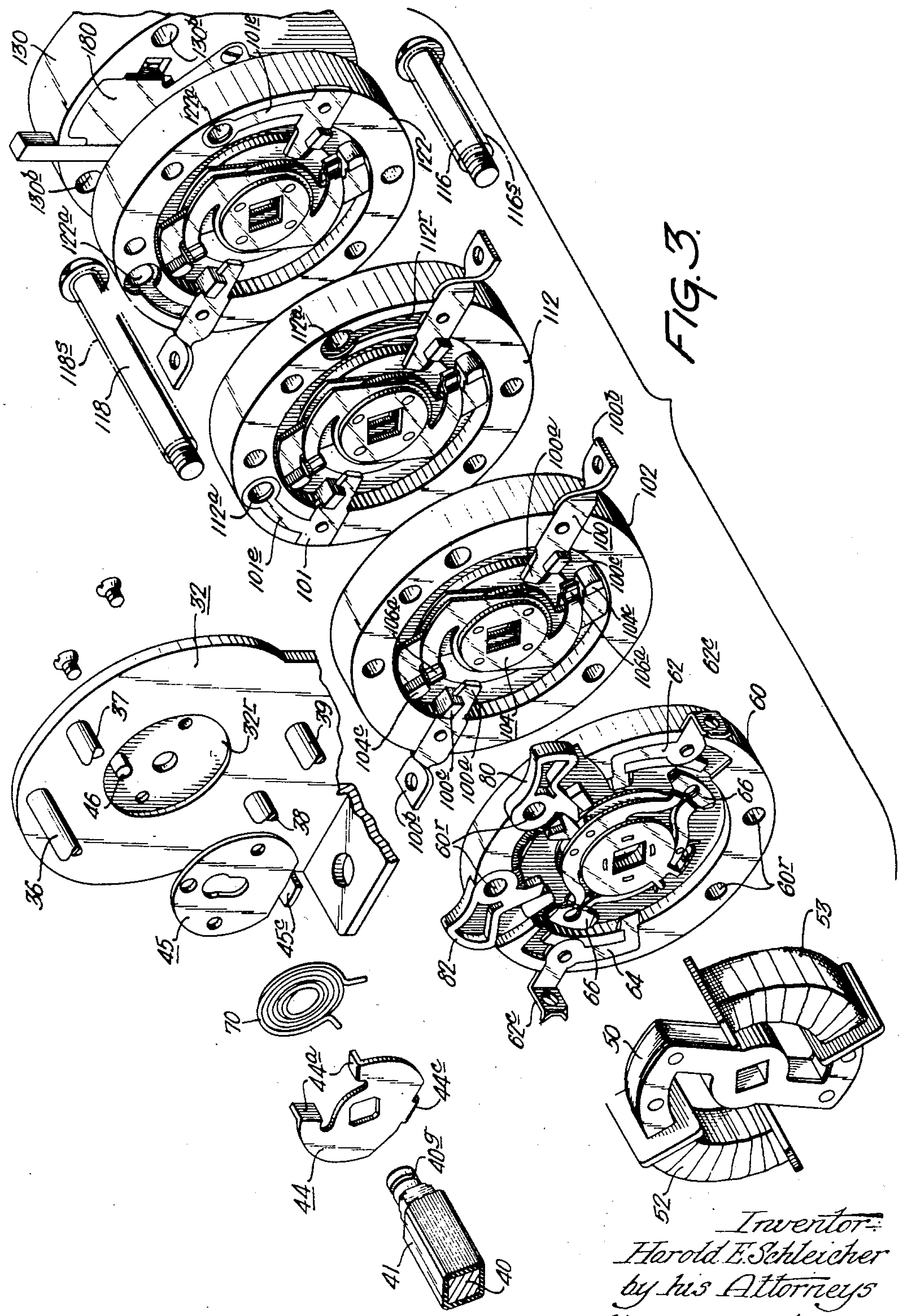

FIG. 3

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FIG. 5.

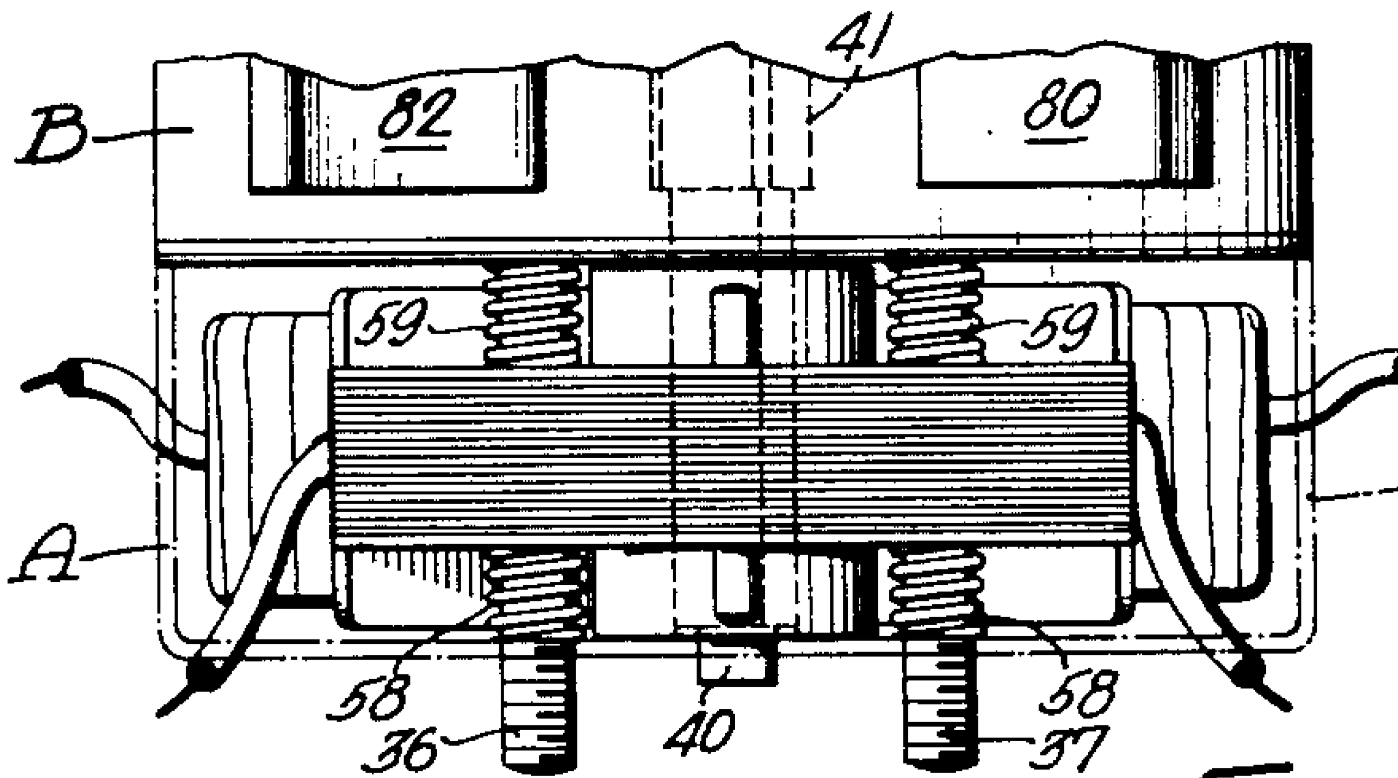

FIG. 4.

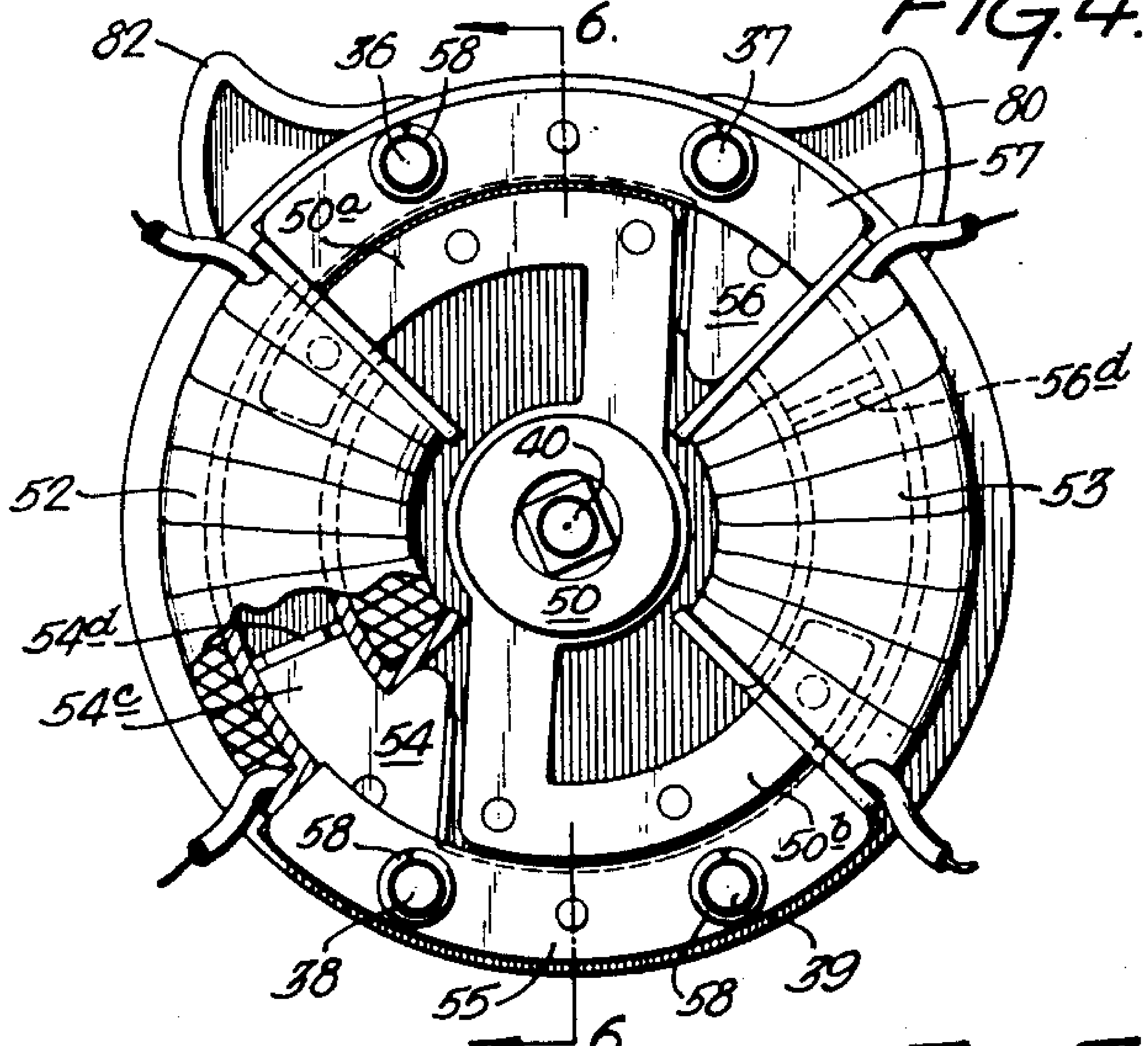

FIG. 6.

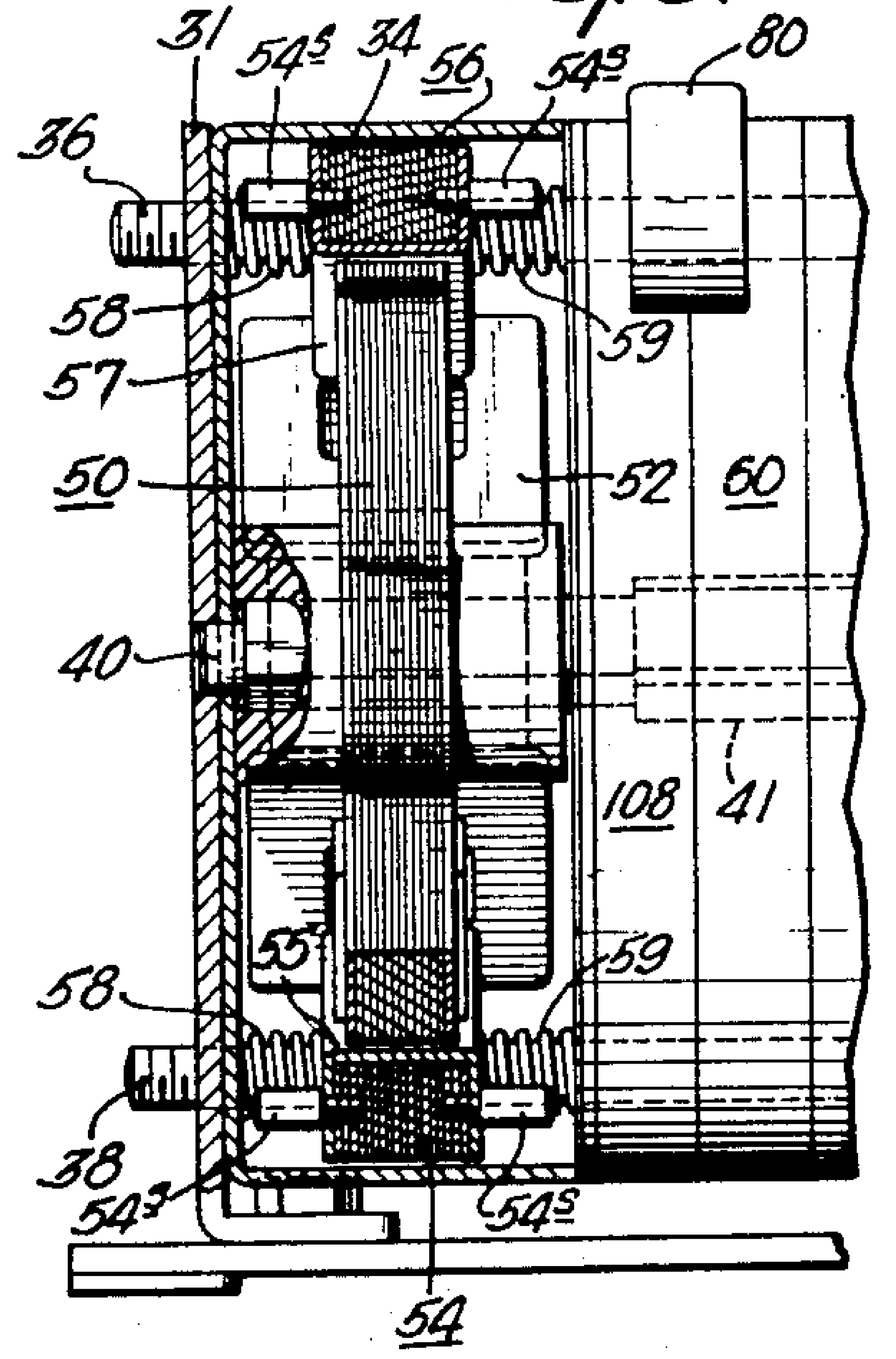

FIG. 7.

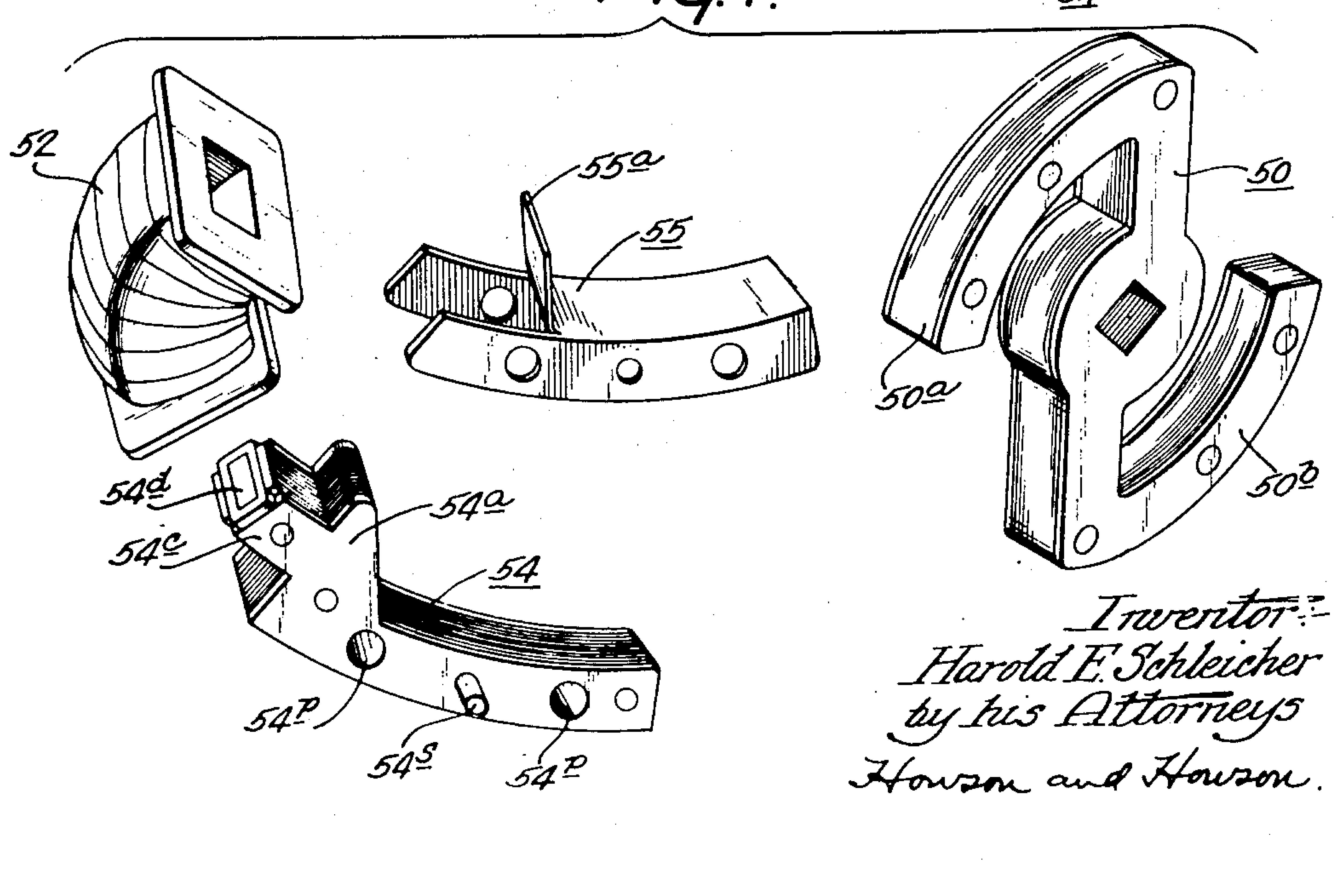

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FIG. 10.

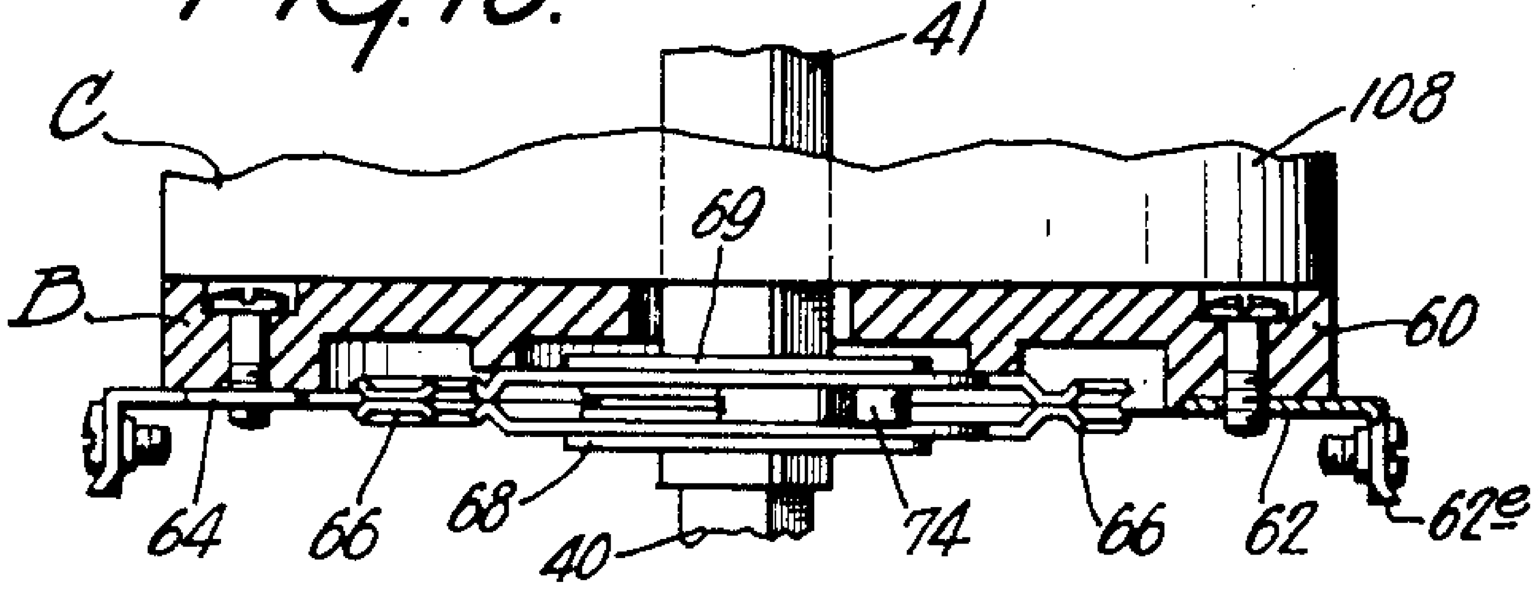


FIG. 11.

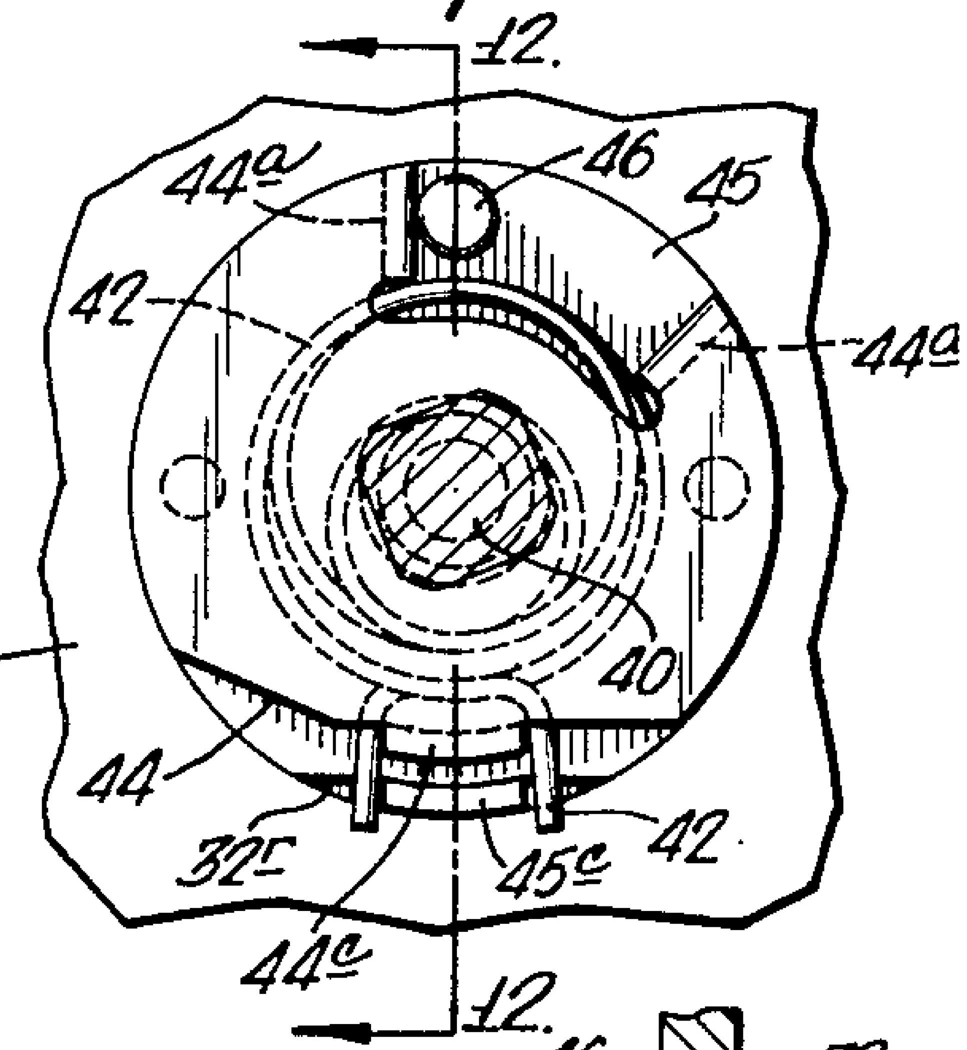


FIG. 8.

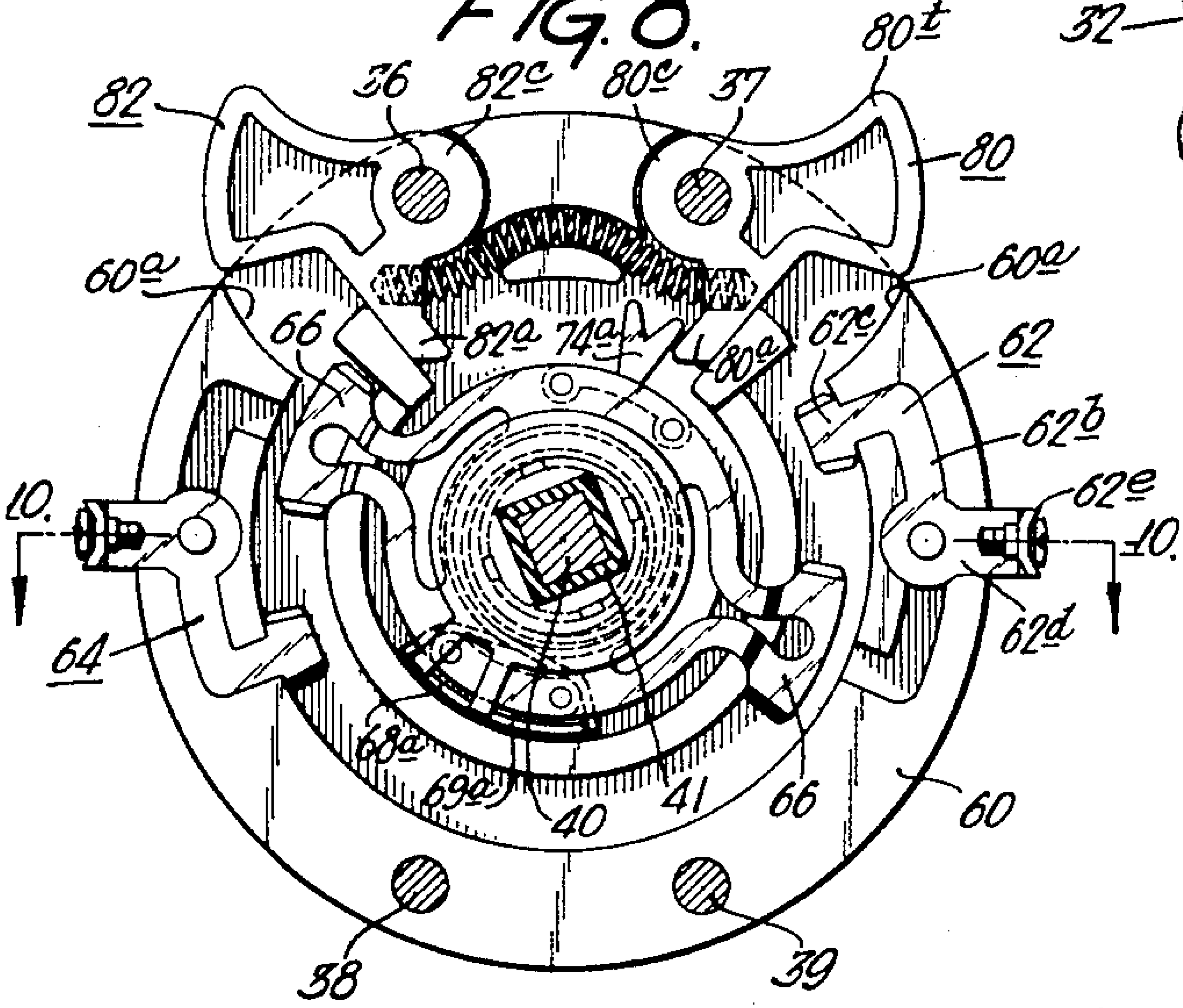
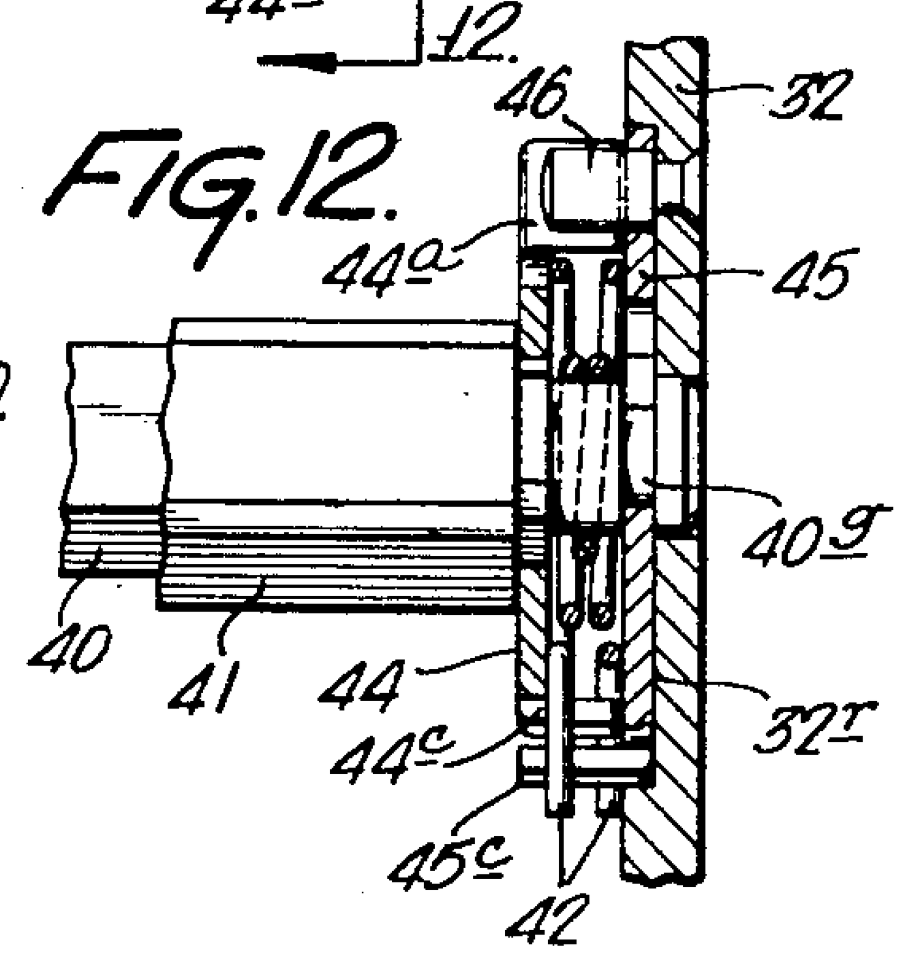


FIG. 12.



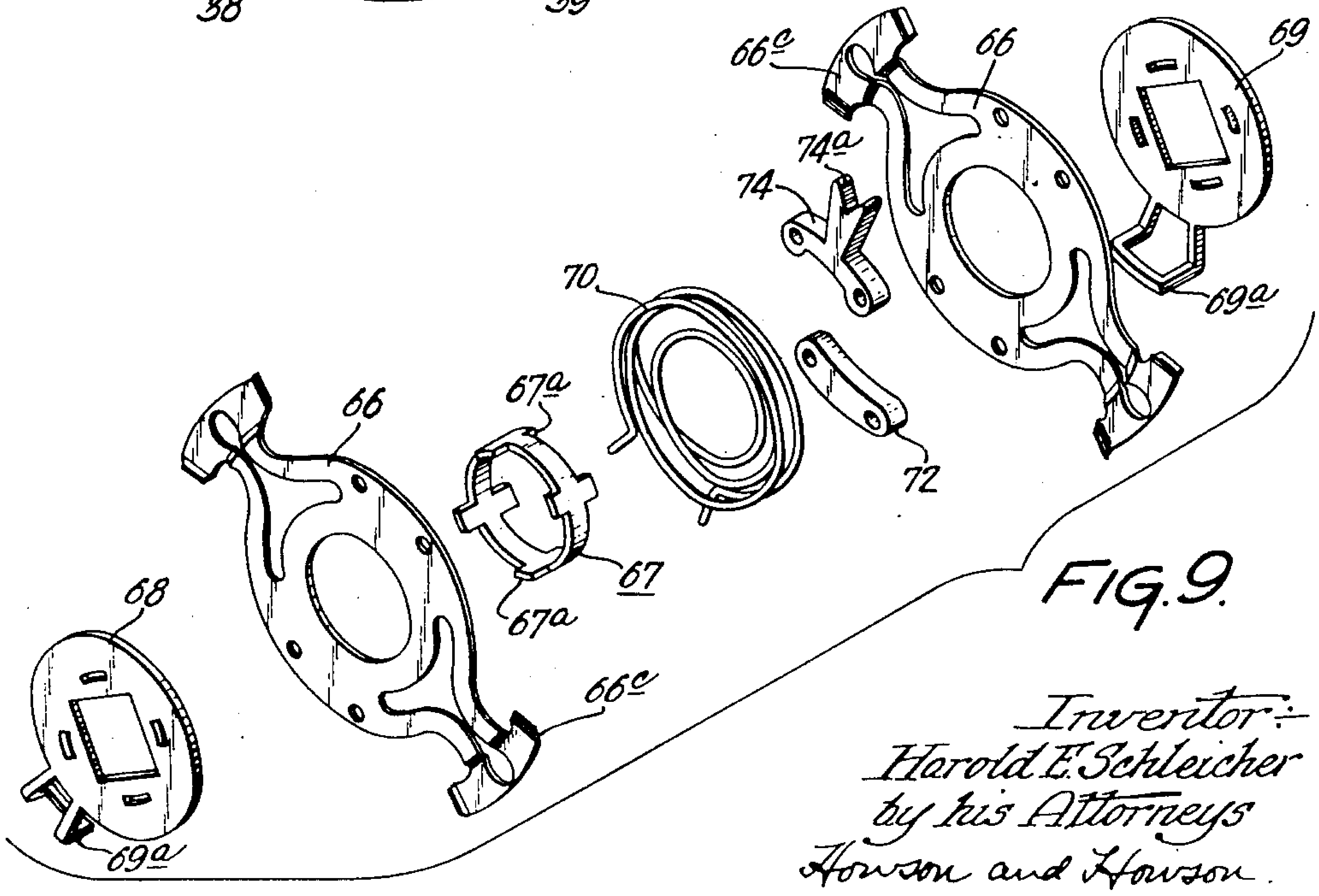


FIG. 9.

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FIG. 13.

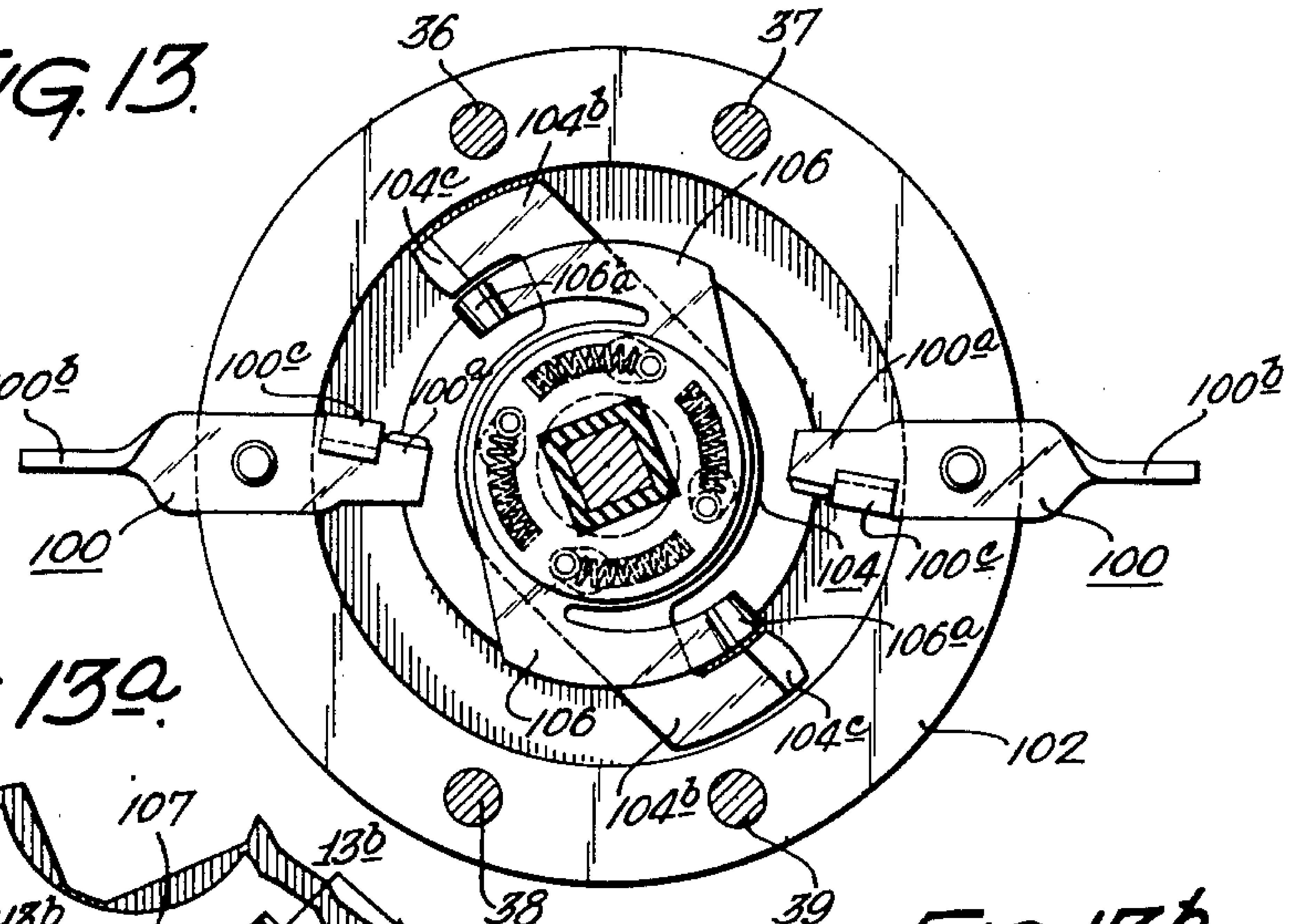


FIG. 13a.

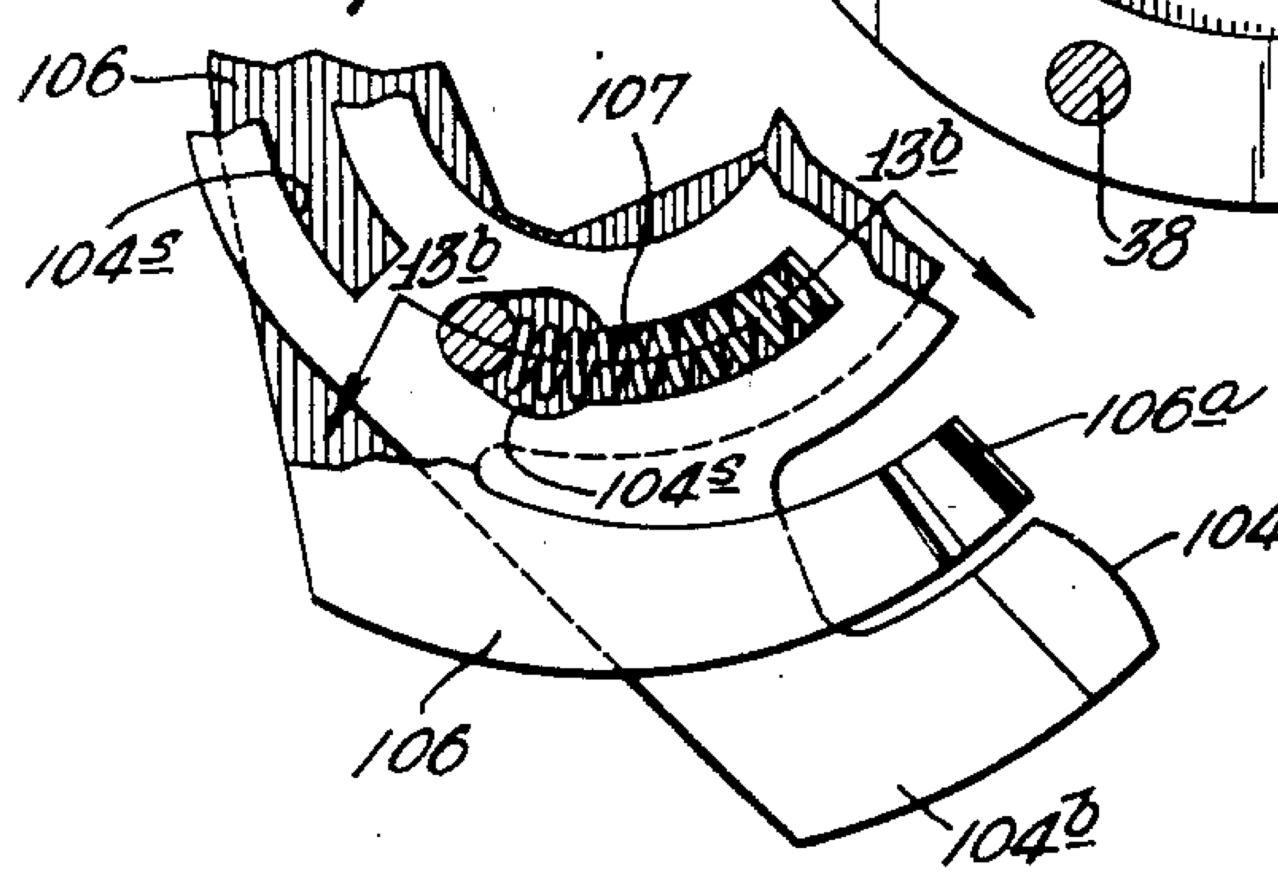


FIG. 13b.

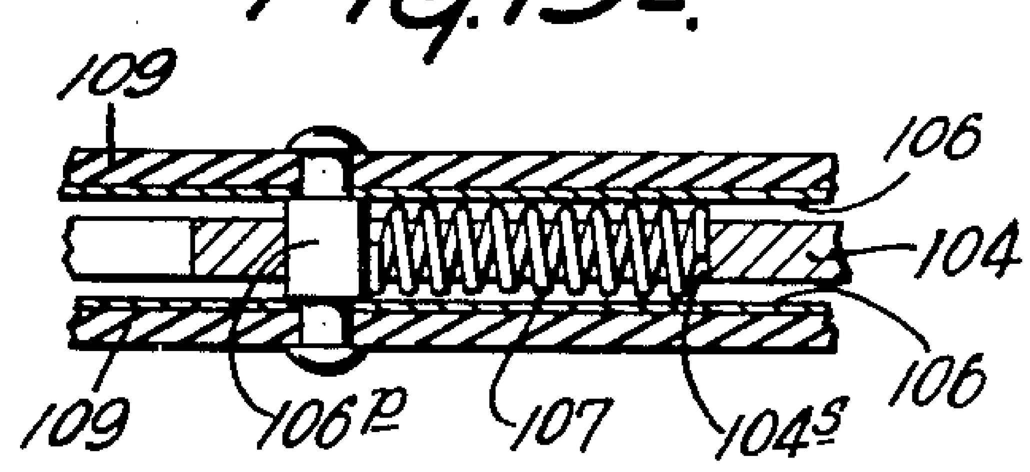
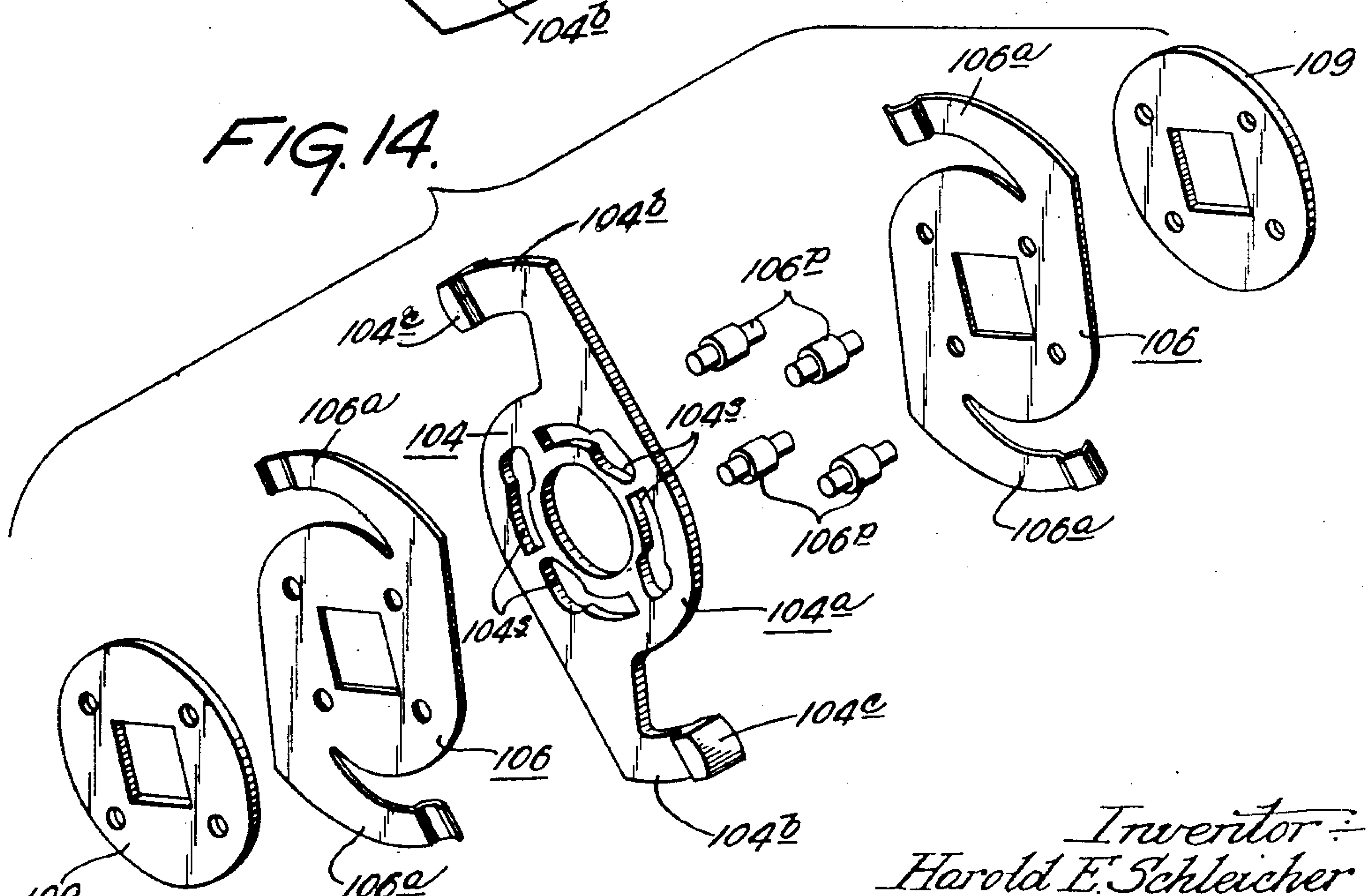


FIG. 14.



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ROTARY MAGNETIC SWITCH

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FIG. 19.

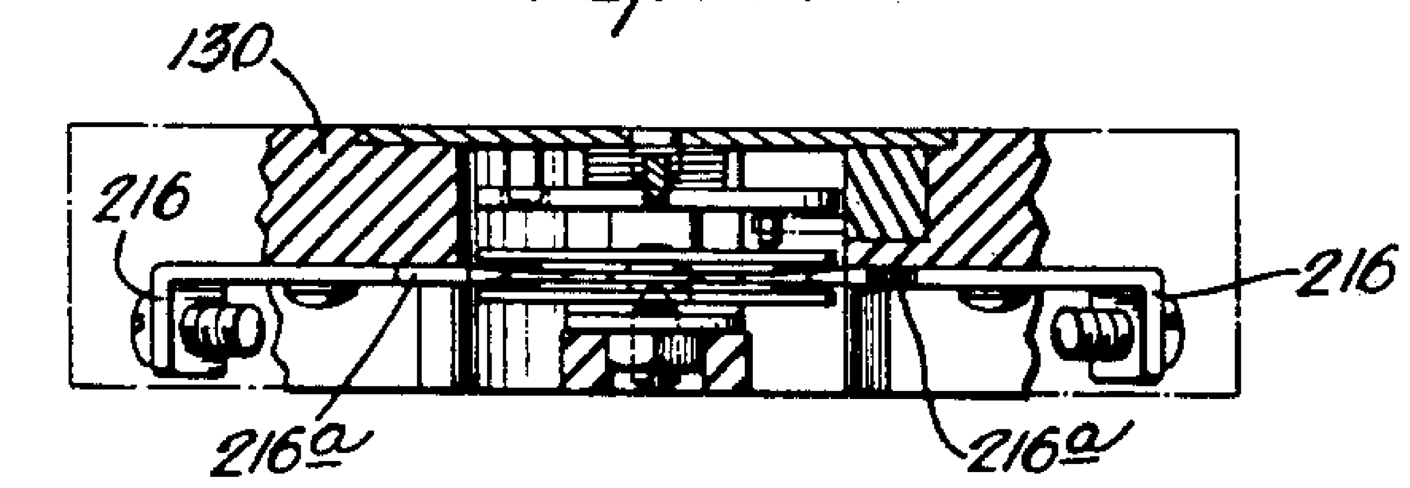


FIG. 15.

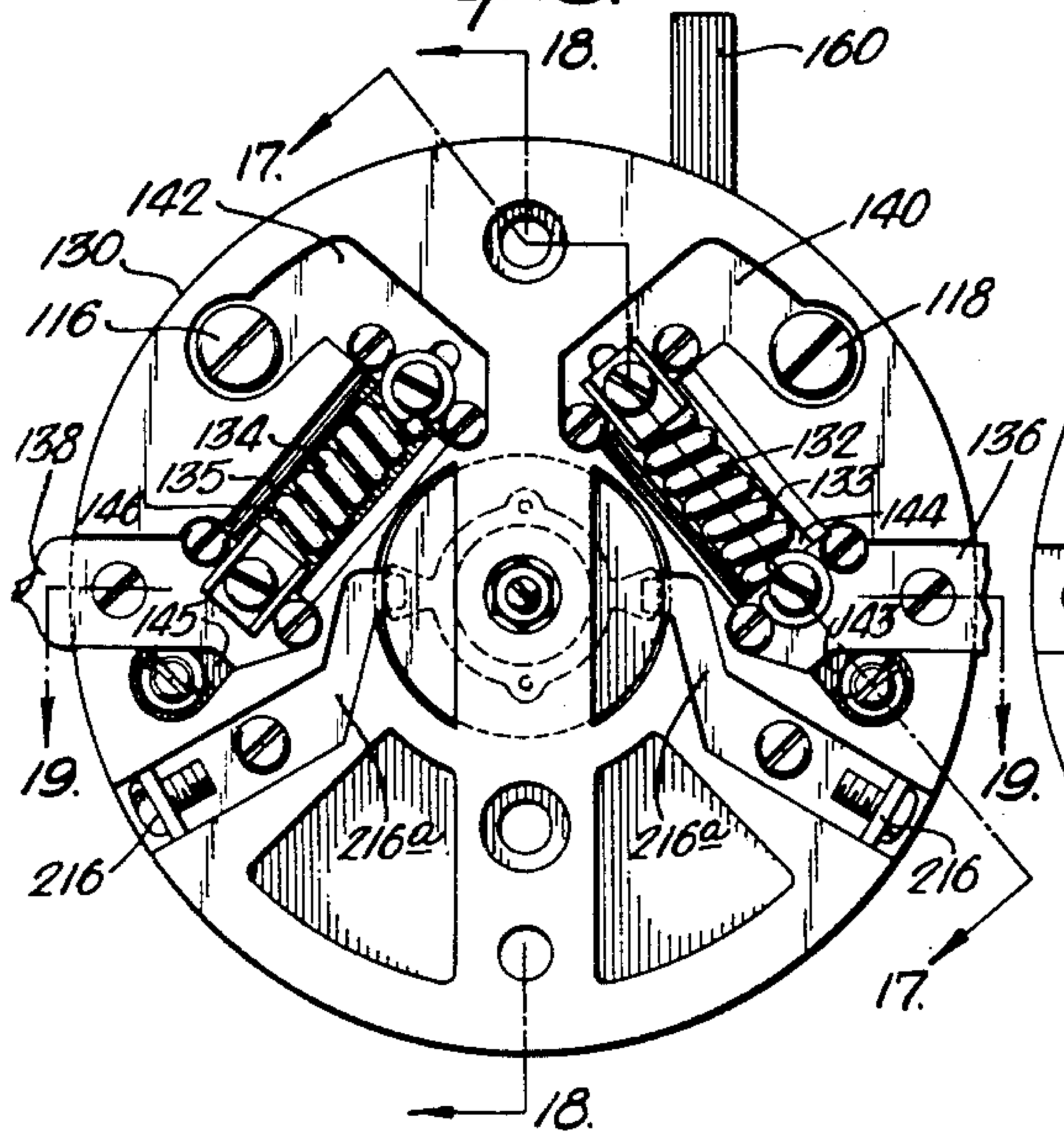


FIG. 16.

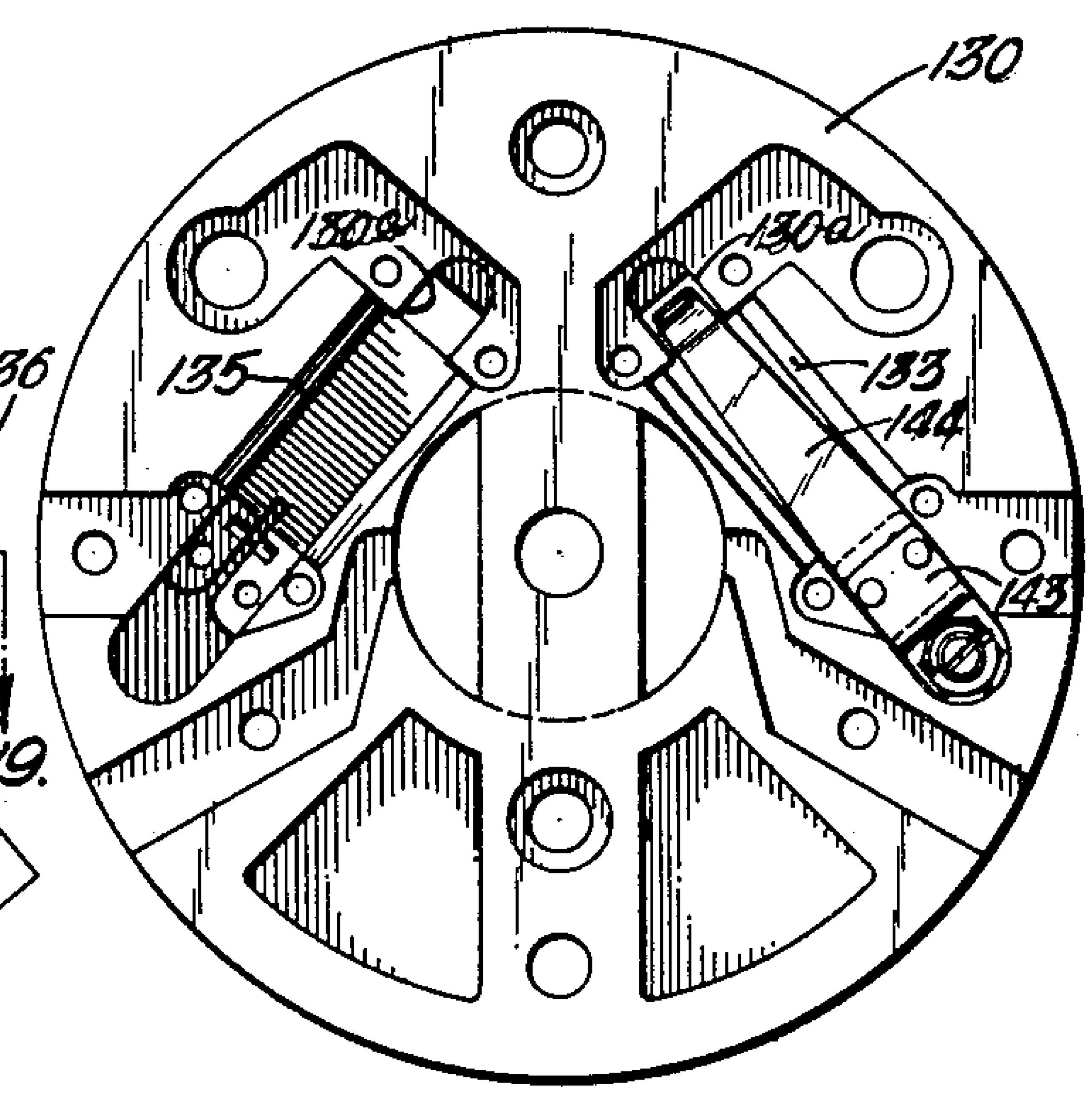


FIG. 17.

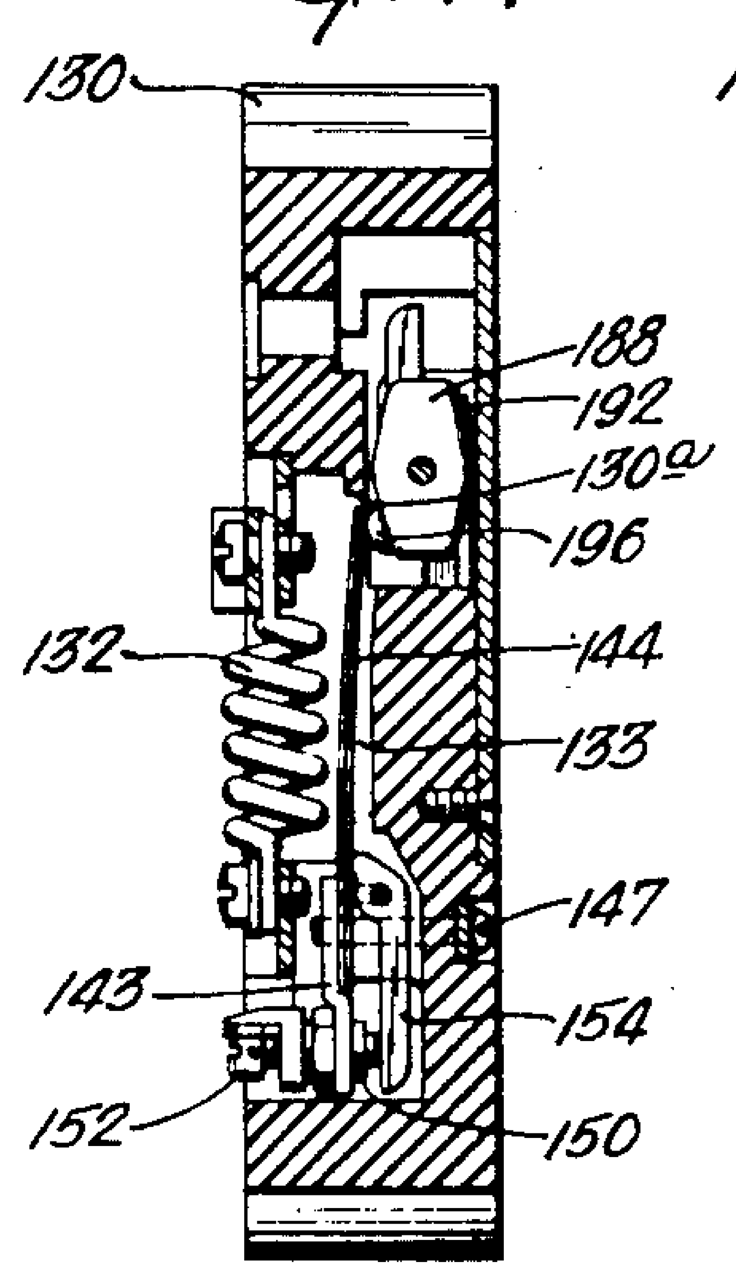


FIG. 18.

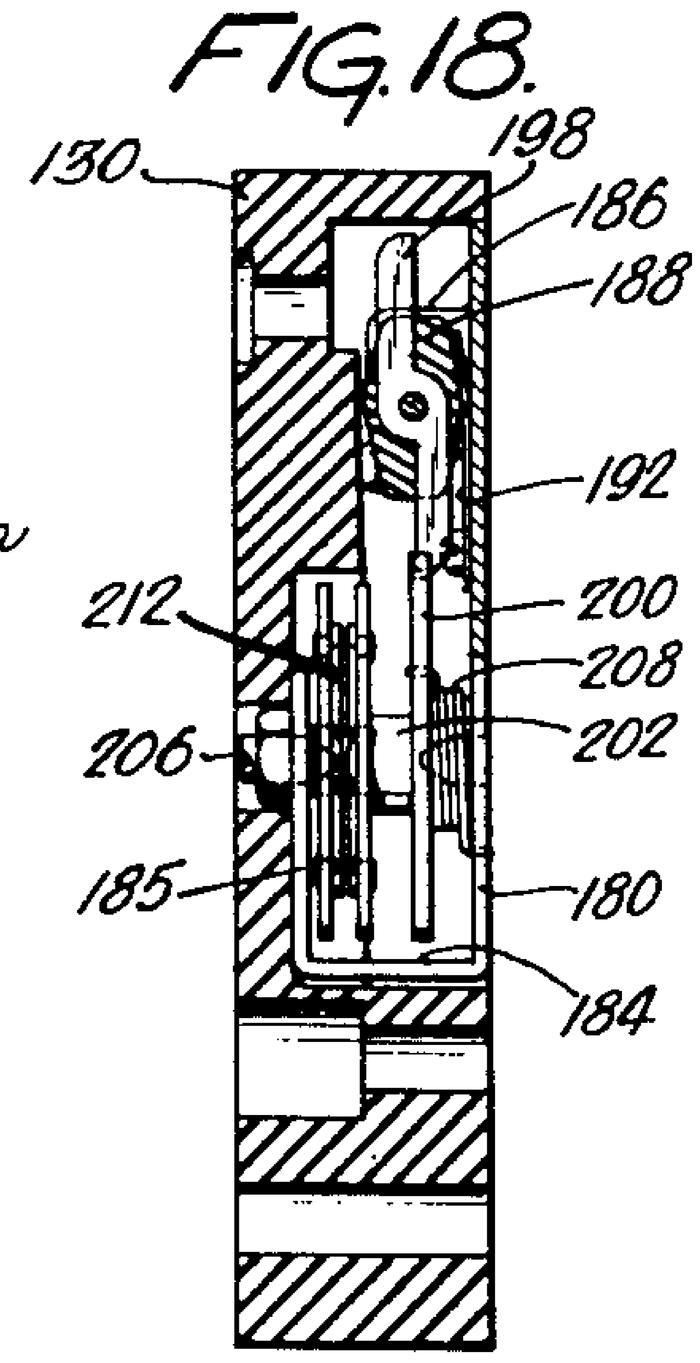
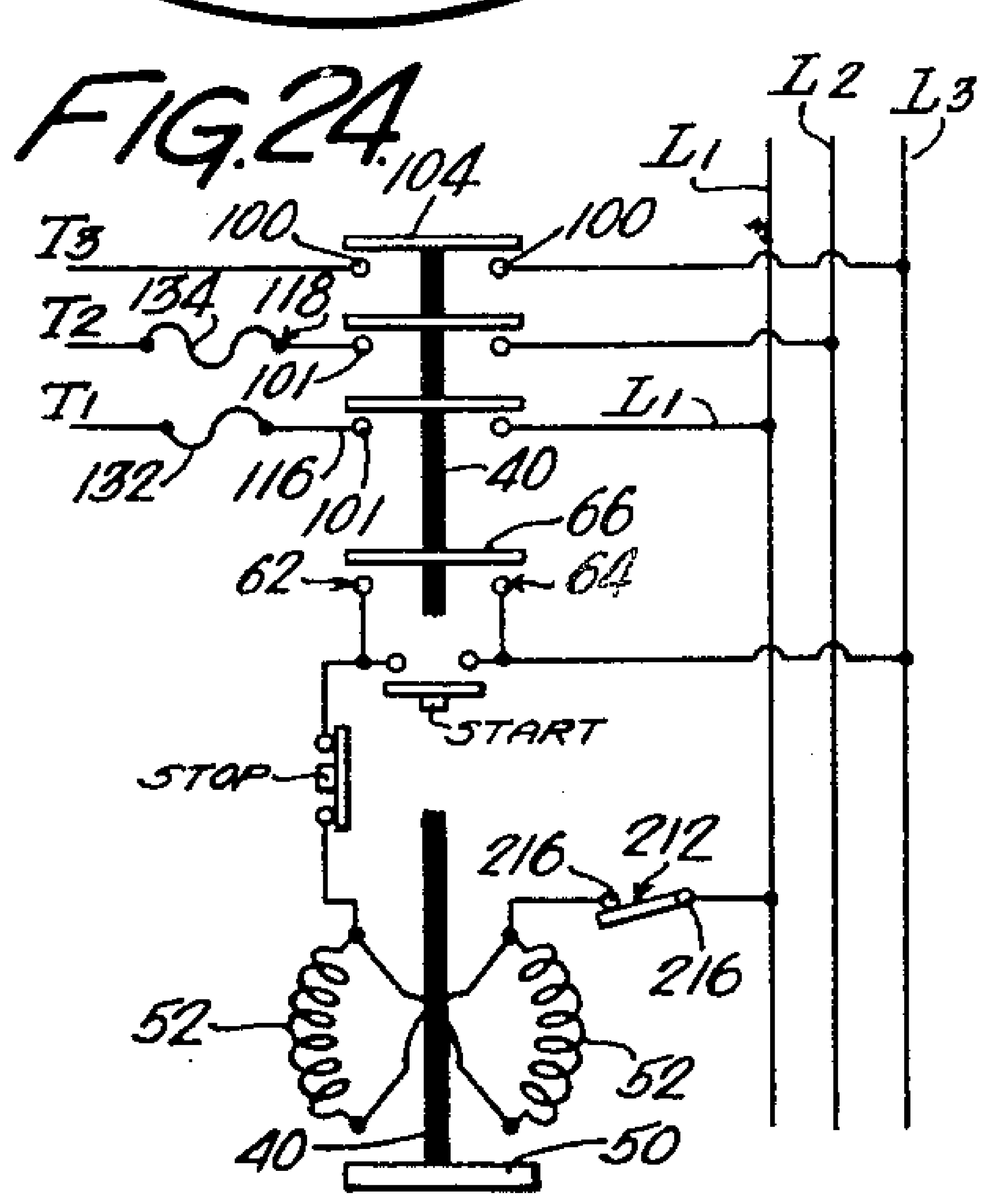


FIG. 24.



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ROTARY MAGNETIC SWITCH

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FIG. 22.

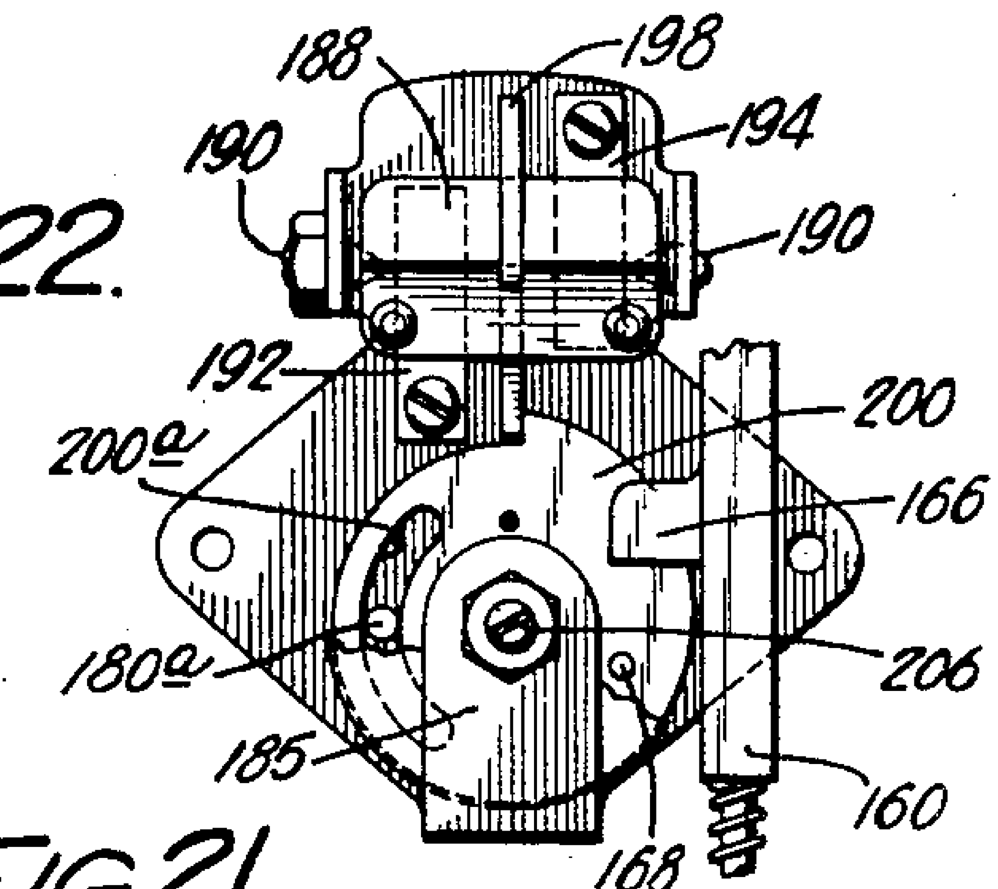


FIG. 20.

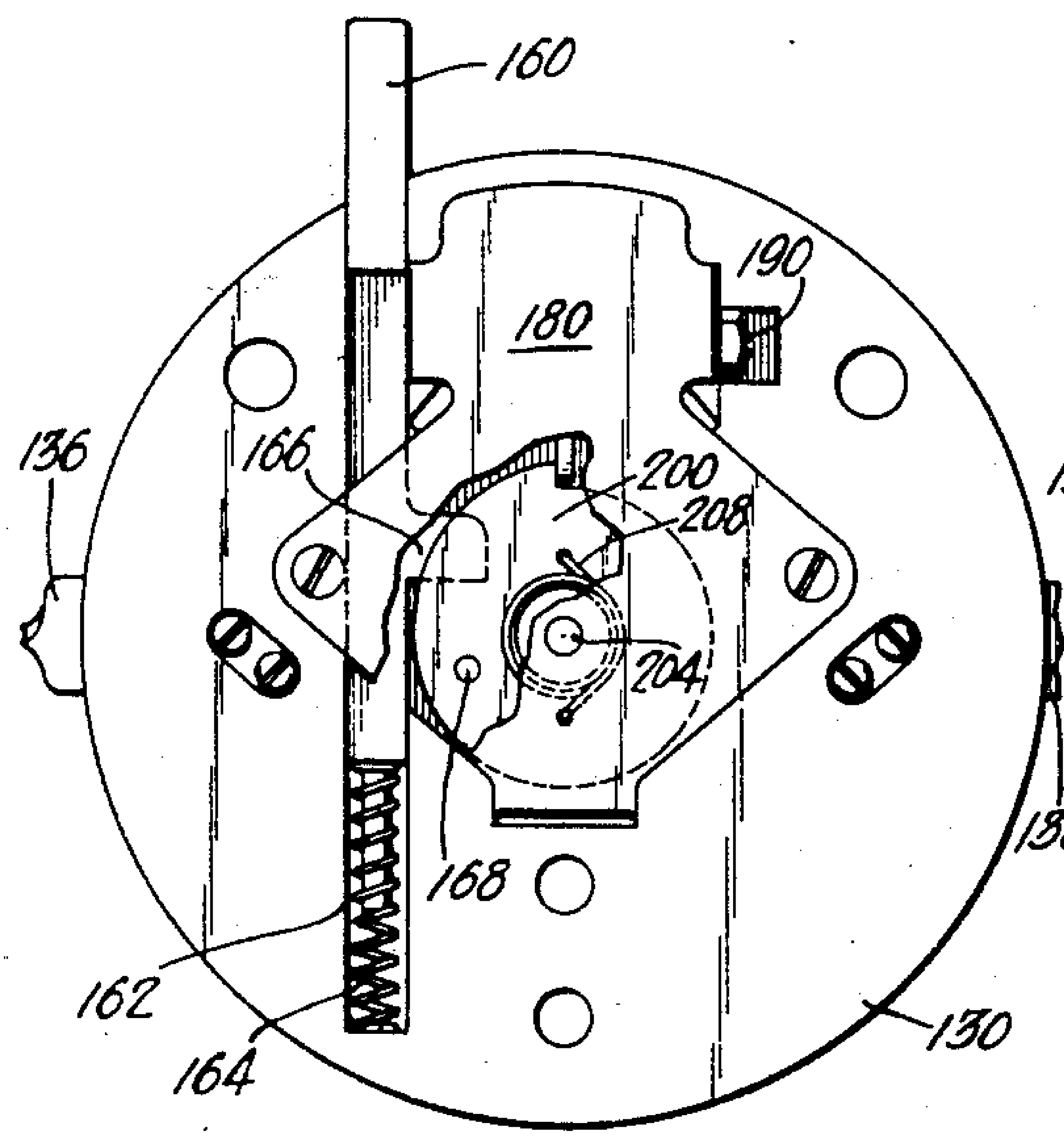


FIG. 21.

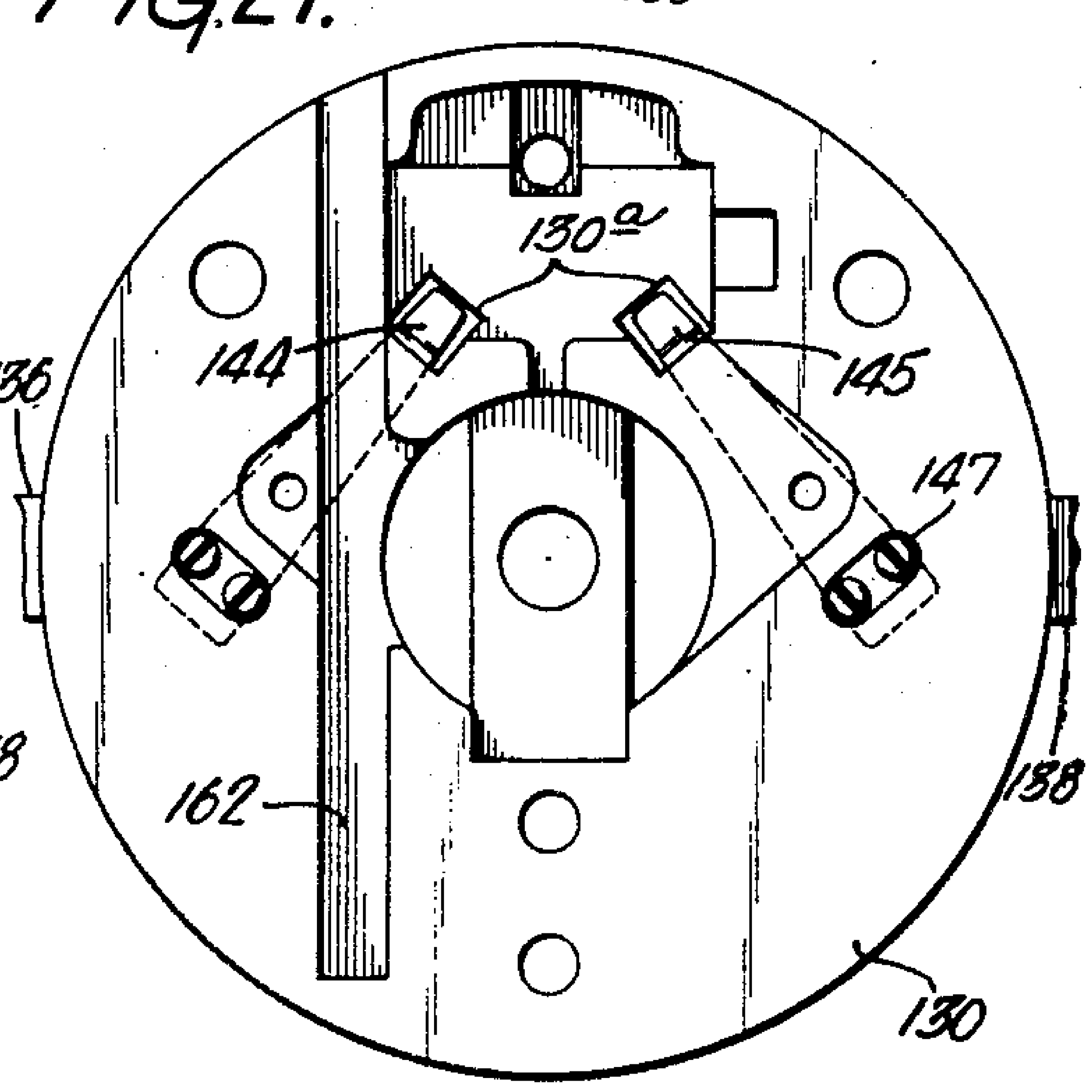
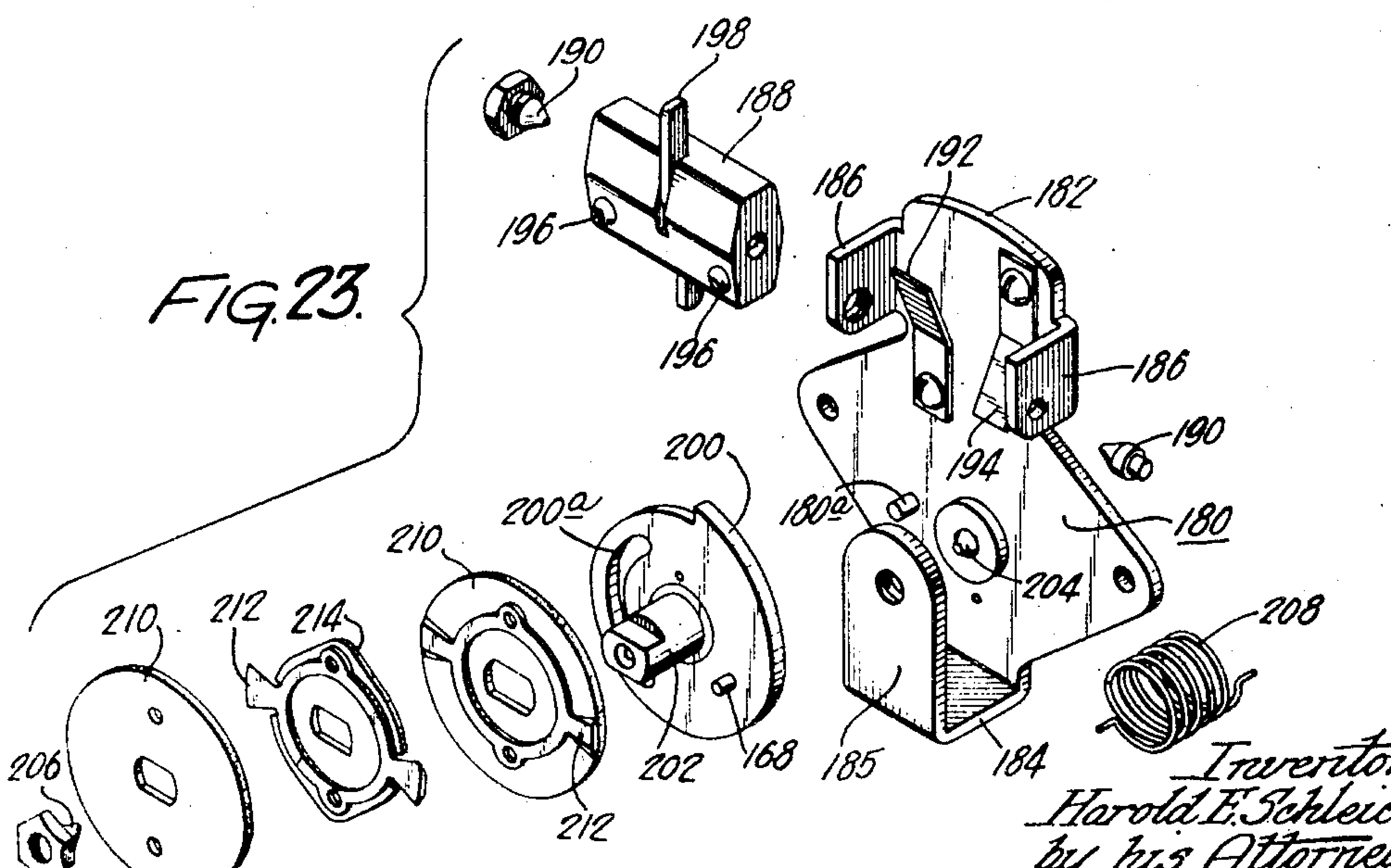


FIG. 23.



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Patented Feb. 6, 1951

2,540,294

UNITED STATES PATENT OFFICE

2,540,294

ROTARY MAGNETIC SWITCH

Harold E. Schleicher, West Hartford, Conn., assignor to The Arrow-Hart & Hegeman Electric Company, Hartford, Conn., a corporation of Connecticut

Application November 26, 1943, Serial No. 511,855

25 Claims. (Cl. 200—87)

1

This invention relates to electromagnetically-operated circuit makers and breakers capable of operation locally, or by remote control if desired, and having provision for automatic overload operation incorporated into the switch.

Modern battle conditions require electrical control apparatus to withstand high impact shocks, the shock test requirements having recently been increased more than tenfold. Attempts heretofore to meet the test requirements involved the addition of counterweights, inertia hammers, special brush-type contacts, etc., to existing conventional commercial structures. These have proved unsatisfactory under the new requirements. A new approach to the problem was needed to produce a scientifically designed device in which the movable parts would be dynamically and statically balanced.

It is an object of the present invention to provide an electromagnetically-operated circuit maker and breaker designed to withstand high impact tests by providing for dynamic and static balance of its movable parts. A related object is to provide an improved design of electromagnetic circuit maker and breaker requiring a minimum amount of energy to produce initial and succeeding movement and to maintain the mechanism in closed position.

Another object is to provide an improved electromagnetic switch structure which can be mounted in any position without entailing increased energy consumption in its operation to overcome gravity, heavy biasing springs, or the like, and which requires less energy under any conditions than prior devices for similar usage.

Another object is to provide an electromagnetic switch of the above type which will have a more uniform pull on its armature, a higher sealing pull, with quieter operation and less wattage loss in alternating current use.

Another object is to provide an electromagnetic switch of the above type for the use of dual magnet coils to enable, optionally, the use of the device on different voltages.

Another object is to provide for remote or local manual control of the device.

Another object is to provide overload protection for a device of the above type, in which the shock-proof features are embodied and in which the principles of dynamic balance are observed and incorporated, not only to preserve the effectiveness of the incorporation of the same principle in the other parts of the device, but also to insure operation accurately and only at the time and under certain predetermined conditions.

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Other objects of the invention will become apparent as the invention is described in connection with the drawings.

Although useful in military fields because of its peculiar advantages, the invention is nevertheless useful in a wide variety of domestic situations.

In the drawings—

Fig. 1 is a perspective view of a device embodying the invention;

Fig. 2 is a side elevation view of the device of Fig. 1;

Fig. 3 is an exploded perspective view of certain parts employed in the device of Figs. 1 and 2;

Fig. 4 is an elevational section view taken along line 4—4 of Fig. 2;

Fig. 5 is a plan view of the electromagnetic structure which is located within the forward end of the device in Fig. 1, the housing being removed;

Fig. 6 is a vertical section view taken along line 6—6 of Fig. 4;

Fig. 7 is an exploded perspective view of certain parts of the electromagnetic structure;

Fig. 8 is an elevational section view taken along line 8—8 of Fig. 2, showing the details of auxiliary switch for the holding-circuit and its manual operating means;

Fig. 9 is an exploded perspective view of the bridging contact of the holding circuit auxiliary switch;

Fig. 10 is a horizontal section view of the mechanism of Fig. 8, taken along line 10—10 of Fig. 8;

Fig. 11 is an elevational detail view of the spring-biasing structure associated with the main shaft;

Fig. 12 is a section view of the spring-biasing structure, taken along line 12—12 of Fig. 11;

Fig. 13 is an elevational section view taken along line 13—13 of Fig. 2 and illustrating one set of the line contacts;

Fig. 13*a* is a fragmentary detail of the line contact mounting structure;

Fig. 13*b* is a section view taken along line 13*b*—13*b* of Fig. 13*a*;

Fig. 14 is an exploded perspective view of the main-line bridging contact assembly;

Fig. 15 is an elevational section view, taken along line 15—15 of Fig. 2, of the section of the device containing the overload protective devices;

Fig. 16 is a view similar to Fig. 15 but with the heater coils and fixed control contacts removed;

Fig. 17 is a section view taken transversely along line 17—17 of Fig. 15, of the portion of the invention illustrated in Fig. 15;

Fig. 18 is a section view taken along line 18—18 of Fig. 15;

Fig. 19 is a section view taken along line 19—19 of Fig. 15;

Fig. 20 is an elevational section view taken along line 20—20 of Fig. 2 and shows the opposite side of the section of the device illustrated in Fig. 15;

Fig. 21 is a view similar to Fig. 20, with some of the tripping mechanism and its resetting means removed;

Fig. 22 is a detail view showing in elevation tripping mechanism that was removed from Fig. 20;

Fig. 23 is an exploded perspective view of the tripping mechanism of Fig. 22; and

Fig. 24 is a wiring diagram illustrating connections for a two-coil form of electromagnet and a common three wire form of contact arrangement, such as that illustrated in the preceding figures.

Referring to the drawings, the main switch contacts, certain control circuit contacts and electromagnetic operating mechanism therefor are housed within a cylindrical sectional casing, built up from molded insulating discs 60, 102, 108, 112, 122, 130 and a metal shell 34, all of which are ultimately supported from a base plate 30 by means of the mounting plates 31 and 32 bolted on said base plate and extending at right angles to the face thereof. The immediate support for the casing sections is four spaced parallel rods 36, 37, 38, 39 (Figs. 2, 3 and others), running between and supported by mounting plates 31, 32. Holes are formed in each of the parts that make up the casing so they may be slid on the rods.

The device may be conveniently considered as comprising a number of sections or units. Referring to Fig. 2, in the section A at the left end is the electromagnetic operating means, the electric terminal connections for which extend through the left end cover or cap plate 33, which may conveniently be made of molded insulating material and secured against the face of the mounting plate 31 by screw bolts.

In the section B are a switch and its manual operating means for local control of operation of the device.

In the sections C, D and E are the main circuit making and breaking contacts for the three lines of a three-wire power system. However, the invention is applicable equally to the making and breaking of any number of lines, the three line form having been chosen for illustration as a preferred embodiment because of its common usage. Each section includes a pair of fixed contacts and a movable bridging contact structure, hereinafter more fully described.

In section F are located the overload protective devices which, in the form illustrated, are for a three-wire line.

The movable bridging contact structure and the movable portion of the electromagnetic operating mechanism are mounted upon a main shaft 40 (Figs. 3, 4, 6 and others) whose axis is the main axis of the device. The main shaft 40 has its end journalled in and supported by the mounting plates 31 and 32.

The electromagnetic operating means

The parts of the electromagnetic operating means are protected by and located within a two-part magnetic sheet metal housing (Figs. 1, 2, 6). One part 34 has a cylindrical wall and an integral end wall. The other part 35 is a sheet metal disc completely covering the open end of the part 34. The end wall of part 34 lies against the mounting plate 31 and both end wall and cover plate 35 are apertured centrally for passage of the main shaft. Louvers 34v for ventilation may be formed in the cylindrical wall of part 34. As will presently appear, the housing 34, 35 completely surrounds the electromagnetic parts and is in close proximity thereto, providing a flux path around the coil sides.

Referring particularly to Figs. 3, 4 and 7, it will be observed that the laminated armature 50 of the electromagnet is substantially of Z-shape, with the oppositely directed ends of its arms 50*a*, 50*b* made arcuate. A square passageway is formed through the central portion of the armature to enable it to be slid upon and to turn with the main shaft 40, which, also, is square in section. The nature of the armature structure is such that the armature is dynamically balanced upon the main shaft, so that it possesses dynamic and static equilibrium at all times, eliminating, for all practical considerations, tendency for the armature and shaft to turn, unless acted on by an outside force.

The curved end portions 50*a*, 50*b* of the armature are adapted to move in and out of hollow toroidal solenoid coils 52, 53 positioned diametrically opposite each other about the main shaft 40. These coils may be connected electrically either in series or in parallel. In case of use, for example, on a 220-volt 3-wire line, if the coils are each 110-volt coils they may be connected in series across the 220-volt lines; or they may be connected in parallel between the neutral and one outside line, supplying 110 volts. Alternatively, the coils may have dual windings, each winding comprising a 110-volt coil which may be connected in series or in parallel with its neighbor, in a manner similar to that just described, and in series or parallel with the opposite dual coil. In any case, the electromagnetic effect of the coils will be cumulative, creating a greater force and a more uniform pull on the armature than a single coil.

Cooperating with the coils 52 and 53 are pole pieces (designated as a whole by 54 and 56) made up of laminated magnetic material. These pole pieces are identical and are generally arcuate in form, being enlarged near one end as at 54*a* and having an arcuate extension such as 54*c* concentric with, but of less radius than, the main portion of the pole piece. The extensions 54*c* and 56*c* extend into one end of each of the coils 52 and 53, while the main portions of the pole pieces bridge the air gap between the ends of the coils 52 and 53, said portions lying just beyond but closely adjacent the paths of movement of the arcuate portions 50*a* and 50*b* of the armature. Lying against the inner face of the pole pieces are non-magnetic shield or liner members 55 and 57. These shield members are channelled in shape and arcuate in form to fit around the inner and side faces of the pole piece which they shield. They may be affixed to the pole pieces by riveting. A tongue, such as 55*a*, is bent inwardly toward the axis of the armature adjacent one end of each shield member, so as to lie along the inclined surface of the enlargement 54*a* of the pole piece. When the armature is returned to inactive position by a spring, as hereinafter described, upon deenergization of the coil of the magnet the back side of its radial arms will abut the tongue 55*a*, preventing the armature from sticking to the pole piece. The liners also provide a momentary time delay, while the flux field is building up to strength needed for moving the armature. This and the non-sticking feature insure that the initial pull on the armature will be unopposed by the armature itself.

To fix the pole pieces and the coil in position resiliently, circular apertures, such as **54**p, are provided in the arcuate portions of the pole pieces to enable the pole pieces to be mounted on the mounting rods **36**—**39**, inclusive. As illustrated, the pole piece **56** is mounted upon the rods **36** and **37**. To position or space the pole pieces, small coiled compression springs **58** are mounted on the rods, between the pole pieces and the inner surface of that portion of the housing which lies against the plate **31**; and on the opposite side of the pole piece, similar small compression springs **59** (also mounted upon the mounting rods) lie between the pole pieces and the next adjacent section B.

To allow limited, but to prevent excessive, side thrust of the pole pieces, stud pins such as **54**s, are attached to the opposite side faces thereof and are engageable with the side walls of the enclosure in which the magnet is housed.

From the foregoing, it may be observed that as the coils are energized, a magnetic field will be set up and will be concentrated at the ends of the coils in the pole pieces and concentrated in the oscillatory path of the armature, reducing losses to a minimum. The force of the magnetic field will draw the arcuate portion of the armature into the coil and against the faces **54**d, **56**d of the extensions **54**c, **56**c. (These faces may conveniently be provided with shading coils in the conventional manner.) Upon deenergization of the coils, the armature will be retracted to its original position by spring means hereinafter to be described. The oscillatory movement of the armature is communicated to the main shaft of the device because the shaft is of the square section. An insulating sleeve **41** is provided to insulate the shaft from all the parts it carries.

To return the shaft **40** to the position normally occupied when the electromagnet is deenergized, a flat coil spring **42** (Fig. 3) is placed around the end of the shaft near mounting plate **32**, between a spring-tension and stop member **44** and an anchor member **45**. The stop and spring tensioning member is a small sheet metal stamping of irregular shape (see Fig. 3) with a square aperture for the square main shaft **40** and spaced, laterally-bent, radially-extending stop lugs **44**a which are adapted to butt against a circular stud or pin **46** extending from the mounting plate **32** as the shaft **40** oscillates. On the opposite side of the member at its periphery is a spring tensioning lug **44**c bent normal to the member and embraced by the ends of the coil spring **42**. Also embraced by these coil spring ends is a similar lug **45**c on the stationary anchor member **45**. The anchor member **45** is a small sheet metal disc-shaped stamping with a keyhole aperture which interengages with a circumferential groove **40**g in the end of the shaft **40** to hold the shaft against axial movement but permit its rotation when the anchor member is fixedly secured within a countersunk recess **32**r in the mounting plate **32**.

The stop plate or member **44** has its travel limited in both open and closed contact positions. The stoppage in the closed position enables the armature and magnets to align themselves freely; otherwise the magnets would be forced against the mounting rods and prevented from assuming natural adjustment.

The foregoing electromagnet structure is also described and is claimed in my divisional application Serial No. 185,422 filed September 18, 1950.

The local control contacts and their operating mechanism

In customary practice, the control of the electromagnet is usually accomplished by a push button station that often is remote from the magnet itself. However, in some fields of use, it is desirable that the device be manually operable locally. To meet such a demand, a local control is provided for in the present invention in the section B of the device.

My invention, without preventing the use of conventional remote control buttons, provides for local control manually by utilizing, as control contacts and in a reconstructed and novelly-improved and manually operable arrangement, the contacts in the conventional sealing-in circuit. In normal manual local operation, these control contacts not only seal-in the main contacts, but these control contacts form the primary circuit-closing means for bringing about energization of the electromagnet coil.

If, however, it is desired to use the invention in a remote control circuit arrangement, the dual functioning sealing-in and control contacts can be utilized for their sealing-in function after the energization of the solenoid; and the provision of the supplementary remote control can be made without affecting the operability of the local control arrangements.

The current carrying parts, except the terminals, are housed wholly within insulating discs **60**, which are recessed for the stationary and movable contacts and for the mechanism by which the contacts are or may be manually manipulated. The discs **60** and the similar purpose discs for the remaining sections hereinafter described are all mounted on the rods **36**—**39** by sliding the rods through suitable apertures **60**r in the discs.

Two identical stationary contacts, designated generally by the numerals **62**, **64**, are irregular, stamped, sheet metal parts. From a circular, central portion having a screw-threaded aperture, there extends an arcuate arm, such as **62**b, whose end turns at right angles inwardly toward the axis of the device, as **62**c, to form a contact blade. From the circular central portion of the contact member, in a position substantially 90-degrees from the position of extension of the arm **62**b, there extends another arm **62**d whose end portion **62**e is bent at right angles to arm **62**d to form a wire terminal. The portions **62**b and d, lying in one plane, are countersunk within a recess molded within the base of the insulating mounting disc **60**. A contact and terminal member **64**, identical to contact **62**, lies in a diametrically opposite position on the disc **60**.

The contacts **62** and **64** are adapted to be engaged and disengaged by movable bridging contact structure made up of the parts clearly shown in the exploded view of Fig. 9. This movable contact structure comprises a pair of identical stamped sheet metal, highly-conductive members **66** of a form illustrated in Fig. 9, namely having a large central circular section with a large circular central aperture and with a pair of diametrically oppositely-extending resilient arms forming contact blades **66**c. Within the circular apertures of the members 66 lies a cylindrical collar 67 having four lugs 67a extending from the edges thereof on each side of the collar and adapted to be received within apertures provided in a pair of disc-shaped spring-tensioning driving members 68, 69, which lie against the opposite outside faces of the conductive members 66. The ends of the lugs 67a are peened over to permanently hold the spring tensioning members and the conductive members 66 together as a unit. Coiled around the collar 67 and located between the conductive members 66 is a coil spring 70, whose ends are radially outturned to engage the end portions of arms 68a, 69a radially extending from the spring tensioning members 68 and 69. The arms are so located on the spring tensioning members 68 and 69 that when these members are secured together by the peening over of the end of the collar 67, the radially-extending arms will lie side by side, covering an arc equivalent to the sum of the widths of the ends of the arms. For the dual purpose of spacing the conductive members 66 apart and for establishing a resilient or lost-motion connection between the conductive member 66 and the spring tensioning members 68, 69, an arcuate member 72 is placed between the inner face of the conductive member adjacent the edges of said members. This arcuate member 72 is riveted fixedly in position by means of rivets passing through the conductive members and the arcuate member. In a diametrically opposite position, a member 74 is placed between the conductive members 66. In thickness, this operating member 74 is the same as member 72 and in shape it is somewhat similar to the member 72 with the exception that a radial extension protrudes outwardly from beyond the edges of the conductive member 66 in position to be engaged by portions of manual actuating members, hereinafter to be described.

When the movable contact structure is assembled, it will comprise a unit capable of mounting upon the square section of the main operating shaft 40 of the device, so that the spring tension members 68 and 69 will turn as a unit with the shaft. Since the outturned ends of the spring 70 embrace the arms 68a, 69a of the spring tensioning members and the spacing member 72, and since the latter is permanently connected with the conductive members 66, the whole movable contact structure will normally turn as a unit with the shaft. As the shaft turns counterclockwise from the position shown in Fig. 8 under the influence of the electromagnetic operating means, the contacts 62 and 64 will be bridged; in like manner, when the electromagnetic means is deenergized and the shaft rotates clockwise, the contacts 62 and 64 will be disengaged by the bridging contacts.

In order to cause engagement or disengagement of the bridging contact with the fixed contacts 62 and 64 by manual operation when conditions so require, regardless of the condition of the electromagnetic operating means, there are provided circuit making and circuit breaking thumb members 80 and 82 pivotally mounted upon the mounting rods 36 and 37. These thumb-operated members 80 and 82 may conveniently be molded from insulating material in the form illustrated in Figs. 3 and 8. Preferably they will be formed with a generally curved or circular formation, such as 80c, at one end, through which is bored a circular hole for the reception of the mounting rods 36 and 37. From this portion extends a winged or thumb-engaging portion 80t which protrudes through and beyond the edge of the insulating disc 60, so that at the exterior of the device it will be engageable for manipulation by one's thumb or forefinger. For engaging and moving the movable contact structure, extensions 80a, 82a, from portions 80c, 82c, are directed inwardly of the device into the path of movement of the radial extensions 74a of the contact structure and are so placed as to be engageable with opposite sides of that radial extension. To permit depression of the thumb pieces 80 and 82, the mounting disc 60 is provided with recesses, such as 60a.

Referring to Fig. 8, with the parts in the position there shown, if the thumb piece 80 be depressed, the extension 80a will engage the radial extension 74a to rotate it counterclockwise, thereby causing the movable contact member 66, which is fixed to part 74, to rotate counterclockwise and to engage the fixed contact. During such movement, the main shaft of the device, and thus the spring tensioning members 68 and 69 affixed thereto, would normally remain stationary. Thus, one end of the coil spring 70 will be held stationary by reason of its engagement with the arm of the spring tensioning members 68 and 69. The other end of the spring, however, would be moved by reason of the engagement therewith of the arcuate member 72 moving with the conductive member 66. Because the spring is relatively weak as compared with the friction and inertia of the shaft 40 and the parts it carries, the tension of the spring does not cause the shaft to move.

If the auxiliary switch (comprised of contacts 62, 64, 66) be connected in the holding circuit of the electromagnetic operating means in shunt with the usual "start" switch (not shown), it will be obvious that as soon as the contacts 62, 64 are bridged, the electromagnet will be energized, thus causing the main shaft of the device to rotate counterclockwise following the partially-completed counterclockwise rotation of the bridging member 66 and completing that counterclockwise motion to hold the bridging contact in engagement with the stationary contact and thereby maintaining the device in closed circuit position.

An opposite result may be obtained by pressing the thumb piece 82 when the device is in closed circuit position. In that position, the radial extension 74a will lie adjacent the upward extension 82a of the thumb piece; and depressing the thumb piece 82 will rotate the movable contact 66 in clockwise direction, disengaging it from the stationary contacts. This rotation of the movable contact member will take place without the necessity of any movement of the main shaft. As soon as the holding circuit is broken, the device will be free to resume open circuit position under the force of the return spring 70, as hereinbefore described. Thus, the auxiliary switch 62, 64, 66 performs the functions of the usual holding or sealing in contacts but in addition it can function as a local control switch for both opening and closing electromagnetically-operated main contacts.

The line contactors and their operation

There are three sets of power line contactors, each set including a pair of fixed contacts and a bridging contact member for engaging the fixed contacts. When used in a three-line power system, one set of contacts will be employed for each of the power lines. Each contactor is housed in a separate section (C, D or E), the housing for each section comprising a spacing disc **108** and a mounting disc **102**, **112** or **122**. On the latter are mounted the fixed current carrying parts. The discs may be of molded insulation suitably recessed and apertured for the fixed contacts, the movable contact structure and the mounting and terminal rods.

In the section C is the contactor for the neutral line. This section is made up of molded insulation discs **108**, **102**. The fixed contact members for this set are identical in structure and comprise stamped sheet metal pieces **100** of irregular shape, as indicated in Fig. 3. mounted upon the mounting disc **102** by means of screw bolts. The members **100** have a flat central portion lying in a radial recess adjacent the periphery of the disc **102**. A portion **100a** of the members **100** extends radially inward into a circular recess molded into the face of the disc, within which recess the movable contact member **104** may oscillate. Welded transversely onto the edge of the inwardly-extending portions of the members **100** are rectangular contact blocks **100c** of good contact material, such as silver, positioned so as to be engaged and disengaged by similar contact blocks **104c** on the end of the arms **104b** of the movable contact. The fixed contact members **100** may have an outwardly-extending terminal portion **100b** which may be twisted at right angles to the central portion of the members **100**.

The rotatable contact member **104** comprises a stamped sheet metal member **104a** having a large central portion with a pair of counterbalancing arms **104b** extending in diametrically opposite directions. To the ends of the arms **104b** the contact tips **104c** are permanently affixed.

For the purpose of maintaining the circuit in case of momentary disengagement of contact blocks **104c** and **100c**, dual supplementary contact members **106** stamped from sheet metal and lying against opposite faces of the central member may be provided. Arcuate fingers **106a** conforming substantially to the curvaure of a radius about the axis of the movable contact may be provided on opposite sides of the main central portion in diametrically opposite positions so as to engage and disengage the inwardly-extending end **100a** of the fixed contact members **100**.

In order that these circuit maintaining supplementary contacts **106** shall engage their stationary counterparts after the butt-contact tips **104c** engage the stationary contact blocks **100c** and disengage before the contacts **104c** separate from the contacts **100c**, the center **104a** of the contact member **104** is provided with four equally-spaced, concentrically-placed, arcuate key hole slots **104s**, through each of which passes one of four pins **106p** that join the pair of supplementary contacts **106** by means of peened-over ends of said pins. The enlargement of the ends of the slots **104s** around the pins **106p** provides limited relative motion between the pins and the contact **104** to take care of manufacturing inaccuracies and to insure proper contact engagement. Lying in said slots **104s** and pressing at one end against one end of the slot and at the other end against the pins **106p** are small coiled compression springs **107**, the springs being held in said slots by the adjacently-lying surfaces of the mid-portion of the contact members **106**. The supplementary contacts **106** and the main contacts **104** are so dimensioned that, in the disengaged or open-circuit condition, the angular distance between supplementary contacts **100a** and **106** is greater than the angular distance between the butt contacts **100c** and **104c**. Thus the butt contacts will engage first.

Since the supplementary contacts **106** turn with the shaft **40** by reason of the non-circular connection with the shaft **40**, the supplementary contacts will be positively moved to disengage the fixed contact members and will do so while the butt contacts **104c** are still maintained in engagement with contacts **100c** by the action of the springs **107**. Since the butt contacts **104c** will engage first and disengage last, the supplementary contacts will normally only be called on to maintain the circuit in case of any tendency of the butt contacts to separate. The described structure, thus, maintains continuously the closed-circuit relation of the fixed and movable contact structures, considered as a whole, by reason of the engagement of contacts **106a** and **100a**, so long as the shaft **40** remains unmoved, even though vibration or other causes might tend momentarily to separate the butt contacts **104c**, **100c**.

Against the outside surfaces of the supplementary contact members **106** metal driving discs **109** are placed; and all of these parts are then secured together to form a permanent dynamically and statically balanced unit. A square aperture is formed in each of the parts, except the member **104a** which has a large circular aperture, for the reception of the main shaft of the device, so that the movable contact unit will move with the main shaft as it oscillates.

When the spacing disc **108** and the mounting disc **102** are placed face to face with their recesses adjacent, the movable current carrying parts are enclosed and are insulated from the parts within the sections B and D.

The movable contacts within the sections D and E are or may be identical with that within the section C.

The stationary contacts in sections D and E may be identical with those in section B. However, when it is desired to use overload protection in connection with these devices, one of the contacts **101** in each of these sections D and E need not have an outside terminal portion. Such contacts may be connected to the overload heater coil in the section F by bolts **116**, **118** which perform the functions of a securing means and a connector. These bolts may pass through registering apertures, such as **112a**, **122a**, near the periphery of the mounting discs **112**, **122** and the spacing discs **108**. For connection with the bolt ends, an arcuate extension or arm **101e** may be formed upon the contact members **101** to lie within recesses of similar shape (such as **112r**, for example) molded in the discs **112**, **122** adjacent their peripheries. The end of such arcuate extension **101e** is enlarged and apertured with the aperture in register with the apertures **112a**, **122a** in the discs **112**, **122**. By having the extension **101e** embedded within and flush with the surface of the discs **112**, **122**, it is possible to have the spacing discs lie flat against the surface of the discs **112**, **122**, and at the same time to substantially enclose the current carrying parts.

The overload protective devices

These devices are contained compactly within the section F of the device, which cooperates with the remainder of the device to present a pleasing overall appearance. Equally important in the protective end of the device is the need to prevent actuation, when shocks occur, for unless the overload or protective devices be shockproof, they may operate under shock conditions to trip the breaker open in spite of all precautions taken in making the breaker itself shockproof.

The overload protective devices themselves are mounted upon a molded insulation mounting disc 130 which is suitably and symmetrically recessed at various points and places on each side of a vertical axis of symmetry for the individual elements which make up the dual protective devices.

On one side of the mounting disc 130 are mounted the heater coils and bimetallic strips (see Figs. 15 and 16); on the other side (see Figs. 20 and 21) is mounted the balanced tripping mechanism which controls a rotary switch connectible in the electromagnetic circuit so as to accomplish deenergization of the magnet and resultant circuit opening movement of the whole device on overload. The tripping mechanism is a removable unit (see Fig. 22 wherein it is removed) which can be tripped by the action of bimetallic strips 144 and 145 responsive to heat developed on overload in resistance wire coils 132, 134 carrying main line current and placed next to the bimetallic strips.

Outside connections to the heater coils are made through identical stamped sheet metal terminal members 136, 138 mounted in diametrically opposite radially directed recesses at the periphery of the mounting disc 130 having their terminal portions, such as 136*a*, extending beyond. To accommodate the heater coils and bimetal members. oblique channels 133, 135 convergent from the inner ends of the terminal members 136, 138 are formed in the mounting disc. At the inner ends of these channels, L-shaped stamped sheet metal connectors 140, 142 form a mounting to which one end of the heater coils is secured, their opposite ends being screwed to the terminals 136, 138, whereby the coils are positioned in the upper part of the channels.

Electric connection of the heaters 132, 134 to the main contact extensions 101*e* of the sections D and E respectively is by the connecting bolts 118, 116 respectively, insulating sleeves 116*s* and 118*s* being placed around the shanks of the bolts to insure insulation of the bolts from other parts of sections through which they may pass. Bolt-receiving apertures 130*b* are formed in the disc 130 in register with apertures 112*a*. 122*a* in sections D and E for the bolts 118 and 116.

Located beneath. and substantially parallel to the axis of the heaters 132, 134 are bimetal strips 144, 146 mounted at one end of small brackets 143, 145. The brackets are each secured at one end to the mounting disc 130 by through bolts 147.

To adjust the bimetal strips one end of the bimetal supporting brackets 143 receives a screw bolt 150, which is bored through and internally threaded to receive a calibration-compensating screw 152 that engages one end of a lever 154 pivotally mounted near one end in the disc 130. The other end of the lever engages the under surface of the bimetal so that on turning the adjustment bolt and screw the lever is rocked to vary the position of the bimetal with resultant variation in the amount of flexure thereof that will cause the latch 188 to trip free of the latch disc 200. Suitable locking means, as shown, are provided to maintain the position of adjustment of the screw 152 and bolt 150.

In order that the bimetal strips may act on the tripping mechanism on the opposite side of the mounting disc 130, the disc is pierced with openings 130*a* (Figs. 21 and 16) beneath the free ends of the bimetal strips at the end of the channels 133, 135, where the connectors 140, 142 are. As the bimetal strips flex on overload, their ends (one or both) enter the openings 130*a* to engage buttons 196 on the trigger member of the tripping mechanism now to be described.

The tripping mechanism is carried by a frame that may be stamped from sheet metal in the form best indicated in Fig. 23. The central portion of this frame 180 is in the form of a parallelogram, from the opposite corners of which there are extensions 182, 184. The extension 182 has lateral arms or lugs 186 bent up at right angles thereto, between which is located the dynamically and statically balanced pivoted trigger member 188 which is preferably formed from molded insulating material into hexagonal prismatic form. In order to resiliently maintain the trigger member in a neutral position, obliquely-angled leaf spring members 192, 194 each have one arm lying upon and screwed to the face of the frame 180, while the other arm extends obliquely upward to engage converging adjacent faces of the trigger member 188. On the opposite side of the trigger member from said converging faces semispherical buttons or nubs 196 are located near the ends of the trigger in position to be engaged by the ends of the one or the other of the bimetallic members. Thus, when either of the bimetallic members bend and press against either of the nubs or heads 196, the trigger member 188 will be caused to pivot. In the central portion of the trigger member is molded a balanced tripping member which is balanced by having similar fingers such as 198 extending in opposite directions. The finger 198 extends radially of the pivotal axis beyond the surface of the tripping member in position to be engaged by the radial shoulder on a dynamically balanced rotary latch disc 200 which is driven onto, keyed to. or otherwise secured to, a stud shaft 202. To afford support for bearings for the stud shaft 202, the frame 180 has its extension 184 turned up at right angles to the central section of the frame 180 and its end again turned at right angles so as to lie parallel to the central section 180. Conical bearing holes are formed in the end of the stud shaft 202 to receive the conical bearing member 204 located in the central portion of the frame 180 and to receive the conical end of a journal pin 206 which is screw-threaded into an aperture in the arm 185 co-axial with the conical bearing member 204. The pin 306 may be adjusted to remove all excess play and prevent movement under impact.

In order to bias the latch disc 200 in one direction normally, a coil spring 208 is placed around the end of the stud shaft 202 with one end of the spring 208 anchored in the frame 180, and the other anchored in the latch disc. In order to limit the rotation of the latch disc, an arcuate recess 200*a* is formed adjacent the periphery thereof and extending through an angle of approximately 60 degrees. A pin 180*a* affixed in the central portion of the frame 180 extends up into the aperture 200*a* and acts as a stop to limit the rotation of the latch disc 200.

Carried by the stud shaft 202 at its end, is a movable self-aligning contact member made up of a pair of insulating discs **210**, between which and to which are riveted a pair of bridging contact members **212** having the form illustrated in Fig. 23, namely a ring-shaped portion with diametrically opposite apertures for the rivets and with contact blades diametrically opposite each other but spaced 90 degrees from the rivet holes. An insulating spacer disc **214** is placed between the two bridging contact members, so that the blades of the members may engage opposite sides of fixed contact fingers **216a** (see Figs. 18 and 19). These fingers **216a** extend radially inward as extensions from contact and terminal members **216** that may conveniently be stamped from highly conductive sheet metal into the oblique form shown in Fig. 15. The members **216** are bolted to the mounting disc **130** in symmetrical positions of the axis of symmetry on opposite sides. Recesses having the same form and shape as the members **216** are provided for embedding said members in the base of the mounting disc **130**. The outer ends of the members **216** are bent to provide terminal lugs, which are provided with terminal screws in conventional fashion.

In order to reset the thermal-overload opened contacts **212** into position to bridge the contacts **216a**, there is provided a resetting button in the form of a depressible insulating bar **160** sliding in a rectilinear tangential passage **162** in the disc **130**. A spring **164** in the bottom of passage **162** urges the button outwardly of the passage; and a laterally extending arm **166** near the inner end of the button is positioned to engage a pin **168** extending up from the surface of the latch disc **200**. When the button is depressed, the engagement of arm and pin cause rotation of the latch disc **200** against the urge of spring **208** until the tongue **198** falls back of the shoulder on the latch disc to hold said disc latched. In that position the contacts **212** and **216** are engaged.

From the foregoing description of the parts, it may be observed that when either one or the other of the heater coils becomes overheated by excess current, it will cause one or the other of the bimetallic members to bend, so that its end engages and turns the trigger member **188**, causing its tongue or extension **198** to disengage the shoulder on the latch disc **200** (the positioning springs **192** and **194** for maintaining the latching member **188** in neutral position are not of sufficient strength to interfere with the overload operation of the bimetallic member). As soon as the latch disc **200** is free, the spring **208** will cause it to rotate. Since the stud shaft **202** turns with the latch disc, the movable contact structure will also turn with it and the bridging contact member **212** thereof will thereupon disengage the fixed contact members to break the control circuit. In conventional practice, the contacts controlled by this tripping mechanism will be in the holding circuit of the electromagnet and their disengagement will cause the energization of the electromagnet coil, whereupon under the influence of the biasing spring the electromagnet contacts and the shaft on which they are mounted will rotate into open circuit position, causing the switch to open.

The dynamic balance of movable parts is carried out in the overload devices by the structure of the trigger **188** with its oppositely-extending mutually balancing fingers **198** and the springs **192, 194** which balance it in latching position, and in the balanced rotary contact structure **210, 212, 214** in which, also, the stationary contacts are engaged on both sides so as to prevent momentary disengagement due to shock occurring in an axial direction.

In Fig. 24 there is shown diagrammatically one possible method of connecting the form of invention illustrated in the preceding figures. In this diagram like reference characters indicate equivalent physical parts of the device illustrated in the preceding figures. Although the diagram illustrates one form of connections, the invention in no sense is limited thereto.

In considering the functions, advantages and novel features, the following should be noted:

Long angular rotation of the armature is one of the factors desirable for securing a high interrupting gap of the contacts for direct current ratings, without resorting to condensers or blow out coils. In the present invention, the air gap of the armature can be regulated to any intermediate position, to suit various interrupting characteristics, by governing the location of the stop-plate lugs **44a**. On maximum stroke, the armature moves within that portion of the solenoid that produces the maximum constant magnetic force value, with a minimum of inrush current.

Due to the high starting torque resulting from the novel magnet construction, the armature return spring may be of sufficient strength to arrange the same contacts in normally closed position if required, such as by reversing the fixed and bridging contacts and placing the bridging contact 90 degrees from its present position on the main shaft. The contacts will then face oppositely from the present showing and will be normally engaged. This reversal will not interfere with the dynamic and static balance or condition of equilibrium of the device, since all the movable parts are individually balanced.

Being totally enclosed, the movable parts are protected against tampering, atmospheric conditions, and the like.

From the foregoing it will be observed that all movable parts are in balanced condition, in both open and closed positions. Since the return spring **42** which normally would move the parts to open position, is overcome by the electromagnet while the latter is energized there is no tendency by weight, bias, or location of the movable parts to move when the whole device is suddenly subjected to shock or violent motion. The balance of the parts and condition of equilibrium avoids such tendency. At the same time it provides a more easily operable device, requiring less power with better holding qualifications.

Many modifications within the scope of the invention will occur to those skilled in the art. Therefore I do not limit the invention to the embodiment disclosed.

I claim:

1. In an electromagnetic switch, a rotary armature having counterbalancing oppositely extending arms, a shaft actuated by said armature, opposite electromagnet coils acting on said armature solid inflexible movable contact means mounted on said shaft, rigid fixed contact means engageable by said movable contact means, said movable contact means having counterbalancing portions to maintain static and dynamic equilibrium and to avoid tendency to move from a given position when the switch is subjected to shock or motion, and a plurality of coiled springs between said shaft and said movable contact means to permit limited motion of said shaft

after engagement of said fixed and movable contact means.

2. In an electromagnetic switch, a rotary armature having counterbalancing oppositely extending arms, a shaft actuated by said armature, opposite electromagnet coils acting on said armature, a solid inflexible movable contact member mounted on said shaft, solid inflexible fixed contact means engageable by said movable contact means, said movable contact member having counterbalancing portions to maintain static and dynamic equilibrium and to avoid tendency to move from a given position when the switch is subjected to shock or motion, and means including a plurality of independent spring members to resiliently mount said solid inflexible movable contact means on said shaft permitting limited motion of said shaft after engagement of said contact means.

3. In an electromagnetic switch, a rotary armature having counterbalancing oppositely extending arms, a shaft actuated by said armature, opposite electromagnet coils acting on said armature, rigid movable contact means mounted on said shaft, rigid fixed contact means engageable by said movable contact means, said movable contact means having counterbalancing portions to maintain static and dynamic equilibrium and to avoid tendency to move from a given position when the switch is subjected to shock or motion, said fixed contact means halting said rigid movable contact means on engagement thereof, and means to resiliently mount said movable contact means on said shaft permitting limited motion of said shaft after engagement of said contact means.

4. In an electromagnetic switch, a rotary armature, a shaft actuated by said armature, electromagnet coils to actuate said armature, contact means moved by said shaft, fixed contact means engageable by said movable contact means, a non-rigid connection between said shaft and movable contact means permitting movement of said contact means relative to said shaft, manually operable means to move said movable contact means into or out of engagement with said fixed contact means regardless of the condition of energization or deenergization of the electromagnet.

5. In an electromagnetic switch, a rotary armature, a shaft actuated by said armature, electromagnet coils to actuate said armature, fixed contact means, movable contact means on said shaft engageable with said fixed contact means, means resiliently connecting said shaft and movable contact means and permitting movement of said movable contact means independently of said shaft. manually actuated means for moving said movable contact means independently of said shaft.

6. In an electromagnetic switch, a rotary armature, electromagnet coils to actuate said armature, a shaft actuated by said armature, control contact means moved by said shaft and non-rigidly mounted thereon, fixed contact means engageable by said movable contact means, main contact means movable by said shaft, main fixed contact means engageable by said main movable contacts, manually actuated means for moving said movable control contact means without moving said shaft.

7. In an electromagnetic switch, a rotary armature, electromagnet coils to actuate said armature, a shaft actuated by said armature, control contact means moved by said shaft and non-rigidly mounted thereon, fixed contact means engageable by said movable contact means, connecting means between said fixed and movable contact means and said coils for controlling the energization of said coils, main contact means movable by said shaft, main fixed contact means engageable by said main movable contacts, manually actuated means for moving said movable control contact means without moving said shaft to cause energization or deenergization of said coils.

8. In an electromagnetic switch, a rotary armature, electromagnet coils to actuate said armature, a shaft actuated by said armature, control contact means moved by said shaft and non-rigidly mounted thereon, fixed contact means engageable by said movable contact means, connecting means between said fixed and movable contact means and said coils for controlling said coils, main contact means movable by said shaft, main fixed contact means engageable by said main movable contacts, manually actuated means for causing engagement or disengagement of said control contact means to cause deenergization or energization of said coils and to actuate said main contact means.

9. In an electromagnetic switch, a rotary armature, electromagnet coils to actuate said armature, a shaft actuated by said armature, control contact means moved by said shaft and non-rigidly mounted thereon, fixed contact means engageable by said movable contact means, main contact means movable by said shaft, main fixed contact means engageable by said main movable contacts, manually actuated means for moving said movable control contact means without moving said shaft, each of said movable contact means and said armature being constructed, arranged and mounted on said shaft in dynamically and statically balanced condition to avoid tendency to move from a given position when the switch is subjected to shock or motion.

10. In an electromagnetic switch, a rotary armature, electromagnet coils to actuate said armature, a shaft actuated by said armature, control contact means moved by said shaft and non-rigidly mounted thereon, fixed contact means engageable by said movable contact means, main contact means movable by said shaft, main fixed contact means engageable by said main movable contacts, manually actuated means for moving said movable control contact means without moving said shaft, each of said movable contact means and said armature being separately mounted on said shaft and being removable therefrom and being constructed and arranged in dynamically and statically balanced condition, said condition of balance being undisturbed by removal of any of said contact means.

11. An electromagnetic switch comprising plural separate sections, cooperating insulating discs forming certain of said sections and housing separate sets of contact means, a shaft passing through said sections, rotary contact means within said contact housing sections connected and moved by said shaft, and fixed contact means engaged by said rotary contact means, rotary electromagnetic operating mechanism in one of said plural sections for moving said shaft comprising an armature on said shaft, and plural toroidal coils for actuating said armature.

12. An electromagnetic switch comprising plural separate sections, cooperating insulating discs forming certain of said sections and hous-

ing separate sets of contact means, a shaft passing through said sections, rotary contact means within said contact housing sections connected and moved by said shaft, and fixed contact means engaged by said rotary contact means, rotary electromagnetic operating mechanism in one of said plural sections for moving said shaft comprising an armature on said shaft, and plural toroidal coils for actuating said armature, said movable contact means and said armature being constructed and mounted on said shaft in individual and combined dynamic and static balance to avoid tendency to move from a given position when said switch is subjected to shock or motion.

13. In an electromagnetic switch, a rotary armature, electromagnet coils to actuate said armature, a shaft actuated by said armature, control contact means moved by said shaft and non-rigidly mounted thereon, fixed contact means engageable by said movable contact means, main contact means movable by said shaft, main fixed contact means engageable by said main movable contacts, means normally urging said shaft into a certain position, said urging means being overcome by energization of said coils and manually actuated means for moving said movable control contact means without moving said shaft to cause energization of said coils for moving said shaft electromagnetically, or deenergization of said coils for permitting said urging means to return said shaft to normal position.

14. A rotary electromagnetically operated switch comprising a shaft, an armature mounted to turn said shaft, electromagnet coils to actuate said armature, movable control contact means operable by said shaft, fixed contact means engageable by said movable control contact means, movable main contact means operable by said shaft, fixed main contact means engageable by said movable main contact means, means normally urging said shaft into one position when said coils are deenergized, means connecting said movable control contact means to said shaft permitting relative motion by the control contact means while the shaft remains stationary, manual actuating means for moving said movable control contact means to deenergize the coils to permit return of said shaft to normal position by said urging means, or to energize the coils to overcome the urging means and move said shaft to energized position, said connecting means and shaft and electromagnet cooperating to cause said control contact means to remain in engaged or disengaged position after manual movement thereto, until subsequent opposite movement of said shaft or actuation of said manual means.

15. In an electromagnetic switch, electromagnetic operating means comprising coils, a rotary shaft and a balanced armature on said shaft, in combination with local operating means for controlling said magnet, and main contact means operated by said shaft, said local control means comprising movable contact means operated by said shaft and fixed contact means engaged thereby, manual actuating means for said local movable contact means for causing energization or deenergization of said magnet, means mounting said movable local control contact means on said shaft and causing movement of said local movable contact means with said shaft but permitting independent movement thereof by said manual actuating means.

16. In an electromagnetic switch, electromagnetic operating means comprising coils, a rotary shaft and a balanced armature on said shaft, in combination with local operating means for controlling said magnet, and main contact means operated by said shaft, said local control means comprising movable contact means operated by said shaft and fixed contact means engaged thereby, manual actuating means for said local movable contact means for causing energization or deenergization of said magnet, means mounting said movable local control contact means on said shaft and causing movement of said local movable contact means with said shaft but permitting independent movement thereof by said manual actuating means, said main contact means and said movable local contact means having balanced moving parts for the purpose of avoiding tendency of said shaft to move from a given position when the switch is subjected to shock or movement.

17. An electromagnetic switch comprising a rotary armature, oppositely located arcuate arms on said armature, arcuate magnetic pole pieces lying outside the arc of movement of said arms but adjacent thereto, arcuate electromagnet coils oppositely located, said pole pieces lying between the ends of opposite coils to form a flux path, each pole piece having an extension entering the end of a coil, a shaft actuated by said armature, a solid inflexible movable contact means mounted on said shaft, rigid fixed contact means engageable by said movable contact means, said movable contact means having counterbalancing portions to maintain static and dynamic equilibrium and to avoid tendency to move from a given position when the switch is subjected to shock or motion, and a plurality of coiled springs between said shaft and said movable contact means to permit limited motion of said shaft after engagement of said fixed and movable contact means.

18. An electromagnetic switch comprising a rotary armature, oppositely located arcuate arms on said armature, arcuate magnetic pole pieces lying outside the arc of movement of said arms but adjacent thereto, arcuate electromagnet coils oppositely located, said pole pieces lying between the ends of opposite coils to form a flux path, each pole piece having an extension entering the end of a coil, a shaft actuated by said armature, contact means moved by said shaft, fixed contact means engageable by said movable contact means, a non-rigid connection between said shaft and movable contact means permitting movement of said contact means relative to said shaft, manually operable means to move said movable contact means into or out of engagement with said fixed contact means regardless of the condition of energization or deenergization of the electromagnet.

19. An electromagnetic switch comprising a rotary armature, oppositely located arcuate arms on said armature, arcuate magnetic pole pieces lying outside the arc of movement of said arms but adjacent thereto, arcuate electromagnet coils oppositely located, said pole pieces lying between the ends of opposite coils to form a flux path, each pole piece having an extension entering the end of a coil, a shaft actuated by said armature, control contact means moved by said shaft and non-rigidly mounted thereon, fixed contact means engageable by said movable contact means, main contact means movable by said shaft, main fixed contact means engageable by

said main movable contacts, manually actuated means for moving said movable control contact means without moving said shaft.

20. An electromagnetic switch comprising plural separate sections, cooperating insulating discs forming certain of said sections and housing separate sets of contact means, a shaft passing through said sections, rotary contact means within said contact housing sections moved by said shaft, and fixed contact means engaged by said rotary contact means, rotary electromagnetic operating mechanism comprising a rotary armature, oppositely located arcuate arms on said armature, arcuate magnetic pole pieces lying outside the arc of movement of said arms but adjacent thereto, arcuate electromagnet coils oppositely located, said pole pieces lying between the ends of opposite coils to form a flux path, each pole piece having an extension entering the end of a coil.

21. An electromagnetic switch comprising a rotary armature dynamically and statically balanced for the purpose of avoiding a tendency to move from a given position when the electromagnet is subjected to shock or motion, said armature having oppositely extending counterbalancing arms with circumferentially curved end portions, electromagnet coils having arcuate open-end cores to receive said arms, magnetic pole pieces adjacent the arcs of travel of said arms and positioned between the ends of opposite coils, a shaft actuated by said armature, a solid inflexible movable contact member mounted on said shaft, fixed contact means engageable by said movable contact means, said movable contact member having counterbalancing portions to maintain static and dynamic equilibrium and to avoid tendency to move from a given position when the switch is subjected to shock or motion, and means including a plurality of independent spring members to resiliently mount said solid inflexible movable contact means on said shaft permitting limited motion of said shaft after engagement of said contact means.

22. An electromagnetic switch comprising a rotary armature dynamically and statically balanced for the purpose of avoiding a tendency to move from a given position when the electromagnet is subjected to shock or motion, said armature having oppositely extending counterbalancing arms with circumferentially curved end portions, electromagnet coils having arcuate open-end cores to receive said arms, magnetic pole pieces adjacent the arcs of travel of said arms and positioned between the ends of opposite coils, a shaft actuated by said armature, rigid movable contact means mounted on said shaft, rigid fixed contact means engageable by said movable contact means, said movable contact means having counterbalancing portions to maintain static and dynamic equilibrium and to avoid tendency to move from a given position when the switch is subjected to shock or motion, said fixed contact means halting said rigid movable contact means on engagement thereof, and means to resiliently mount said movable contact means on said shaft permitting limited motion of said shaft after engagement of said contact means.

23. An electromagnetic switch comprising a rotary armature dynamically and statically balanced for the purpose of avoiding a tendency to move from a given position when the electromagnet is subjected to shock or motion, said armature having oppositely extending counterbalancing arms with circumferentially curved end portions, electromagnet coils having arcuate open-end cores to receive said arms, magnetic pole pieces adjacent the arcs of travel of said arms and positioned between the ends of opposite coils, a shaft actuated by said armature, fixed contact means, movable contact means on said shaft engageable with said fixed contact means, means resiliently connecting said shaft and movable contact means and permitting movement of said movable contact means independently of said shaft, manually actuated means for moving said movable contact means independently of said shaft.

24. An electromagnetic switch comprising a rotary armature dynamically and statically balanced for the purpose of avoiding a tendency to move from a given position when the electromagnet is subjected to shock or motion, said armature having oppositely extending counterbalancing arms with circumferentially curved end portions, electromagnet coils having arcuate open-end cores to receive said arms, magnetic pole pieces adjacent the arcs of travel of said arms and positioned between the ends of opposite coils, a shaft actuated by said armature, control contact means moved by said shaft and non-rigidly mounted thereon, fixed contact means engageable by said movable contact means, main contact means movable by said shaft, main fixed contact means engageable by said main movable contacts, manually actuated means for moving said movable control contact means without moving said shaft.

25. An electromagnetic switch comprising a rotary armature dynamically and statically balanced for the purpose of avoiding a tendency to move from a given position when the electromagnet is subjected to shock or motion, said armature having oppositely extending counterbalancing arms with circumferentially curved end portions, electromagnet coils having arcuate open-end cores to receive said arms, magnetic pole pieces adjacent the arcs of travel of said arms and positioned between the ends of opposite coils, a shaft actuated by said armature, control contact means moved by said shaft and non-rigidly mounted thereon, fixed contact means engageable by said movable contact means, main contact means movable by said shaft, main fixed contact means engageable by said main movable contacts, manually actuated means for moving said movable control contact means without moving said shaft, each of said movable contact means and said armature being constructed, arranged and mounted on said shaft in dynamically and statically balanced condition to avoid tendency to move from a given position when the switch is subjected to shock or motion.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
365,438	Jacobs	June 28, 1887
792,860	Sundh et al.	June 20, 1905
830,209	Conkling et al.	Sept. 4, 1906
913,104	Cedergren	Feb. 23, 1909
928,516	Hellmund	July 20, 1909
1,222,431	McCarthy	Apr. 10, 1917
1,356,290	Kellum	Oct. 19, 1920

(Other references on following page)

UNITED STATES PATENTS

Number	Name	Date
1,483,962	Wood	Feb. 19, 1924
1,585,216	Tugendhat	May 18, 1926
1,744,930	Spencer	Jan. 28, 1930
1,807,955	Apple	June 2, 1931
1,835,906	Shepard	Dec. 8, 1931
1,858,876	Bossart	May 17, 1932
2,025,978	Getty	Dec. 31, 1935
2,199,775	Bassett	May 7, 1940
2,202,698	Latta	May 28, 1940
2,225,344	Kimball	Dec. 17, 1940
2,248,584	Reynolds	July 8, 1941
2,289,227	Walker	July 7, 1942
2,310,138	Whittaker	Feb. 2, 1943
2,315,633	May	Apr. 6, 1943
2,330,920	Reynolds	Oct. 5, 1943
2,334,514	Snavely	Nov. 16, 1943
2,337,375	Cramer	Dec. 21, 1943
2,339,675	Bucklen et al.	Jan. 18, 1944
2,395,572	Meuer et al.	Feb. 26, 1946
2,449,901	Kaiser	Sept. 21, 1948

FOREIGN PATENTS

Number	Country	Date
458,295	Great Britain	Dec. 16, 1936
466,782	France	Mar. 12, 1914