F. J. RICHARDS.

ROTARY ENGINE.

APPLICATION FILED DEC. 22, 1913.

1,154,886.

Patented Sept. 28, 1915.

6 SHEETS—SHEET 1.

Fig. 1.

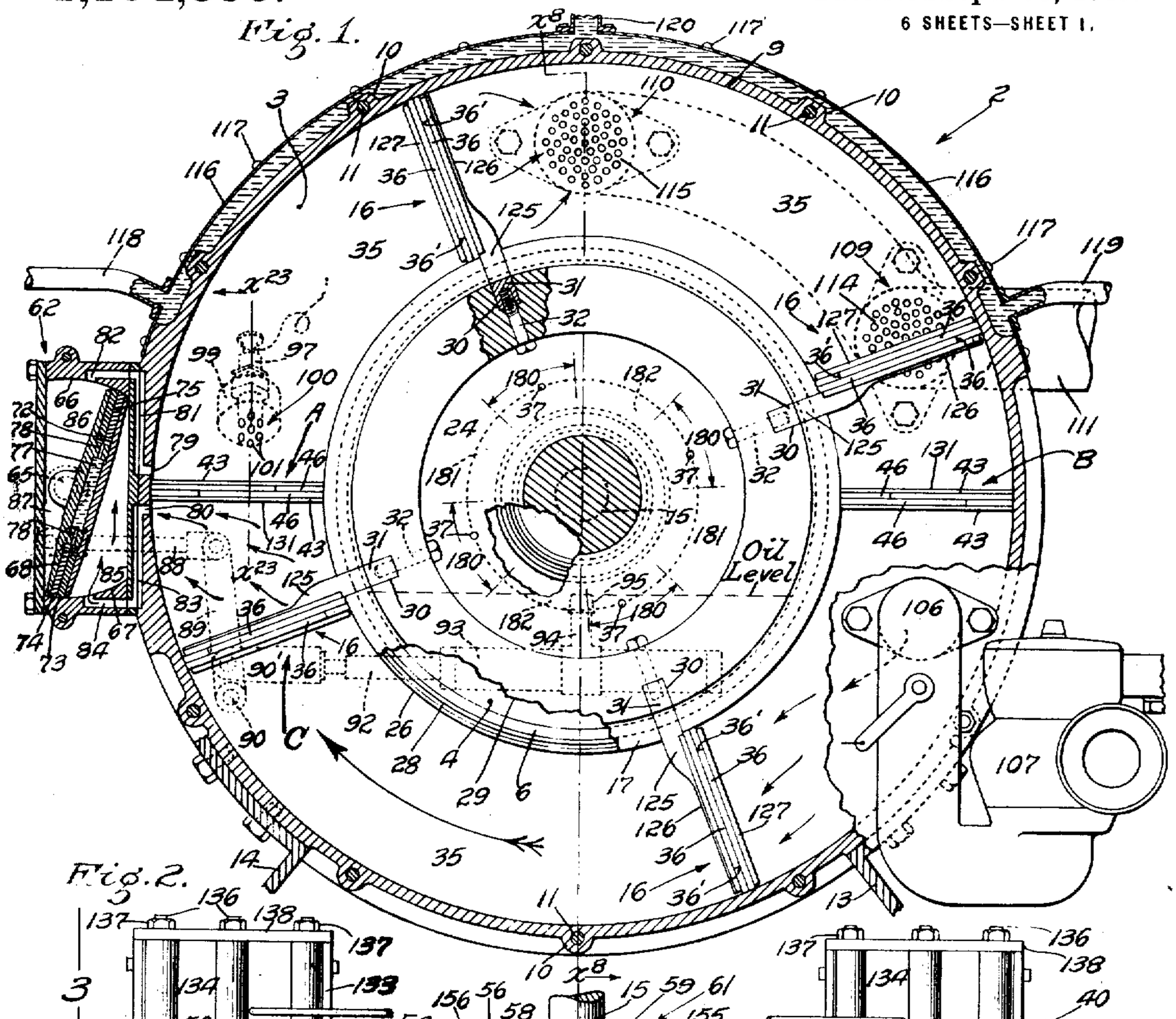

Fig. 2.

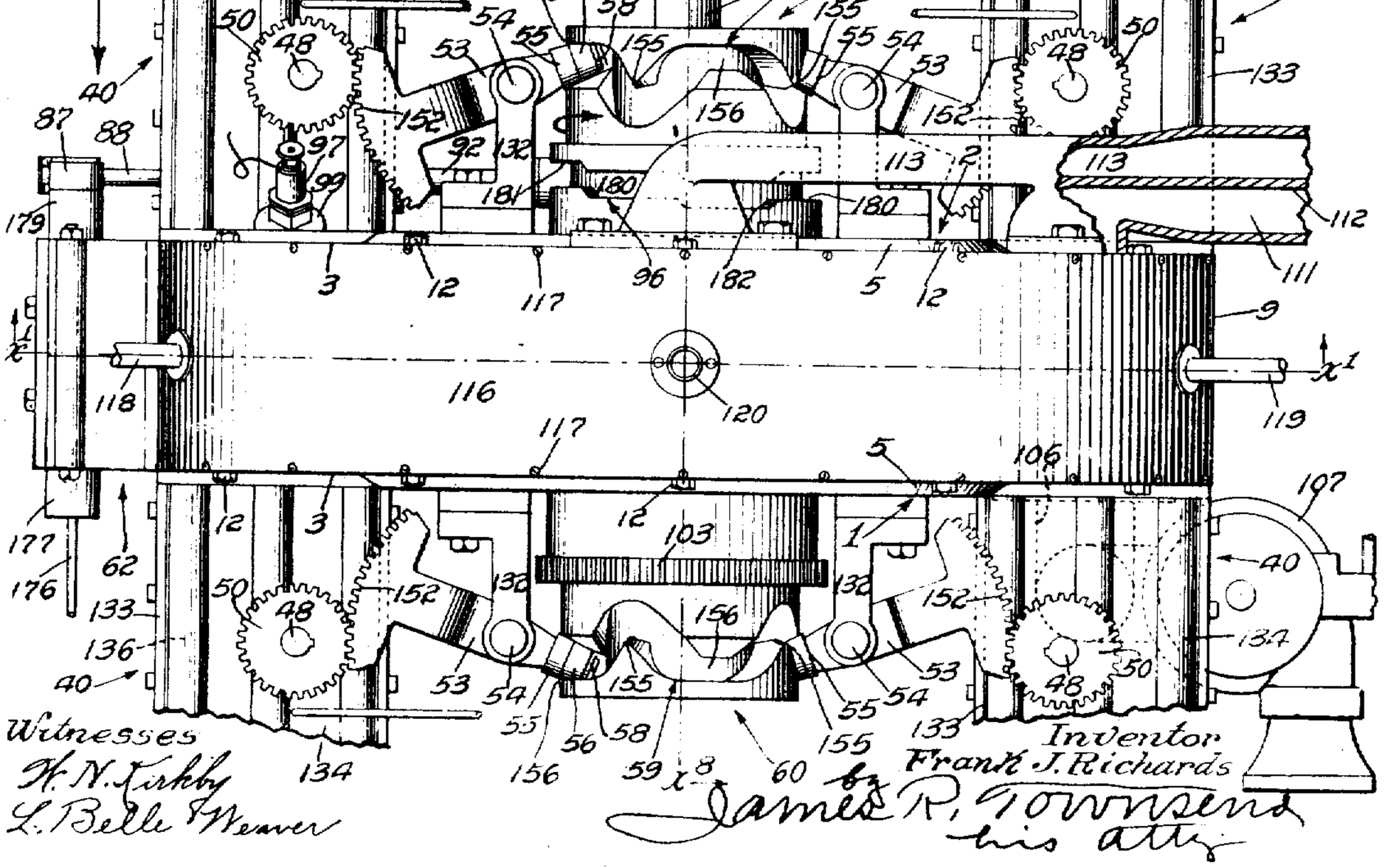

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Fig. 3.

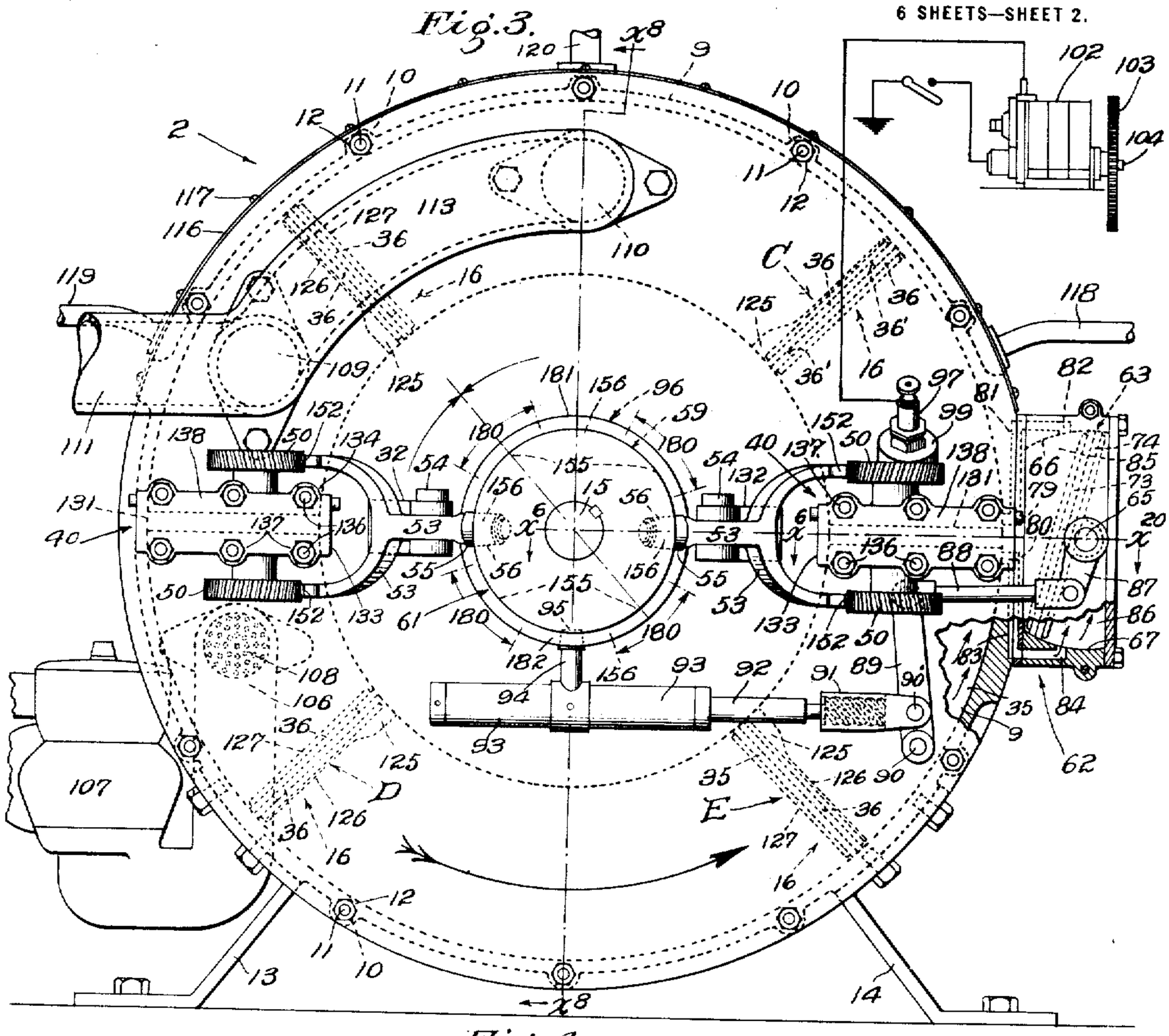


Fig. 4.

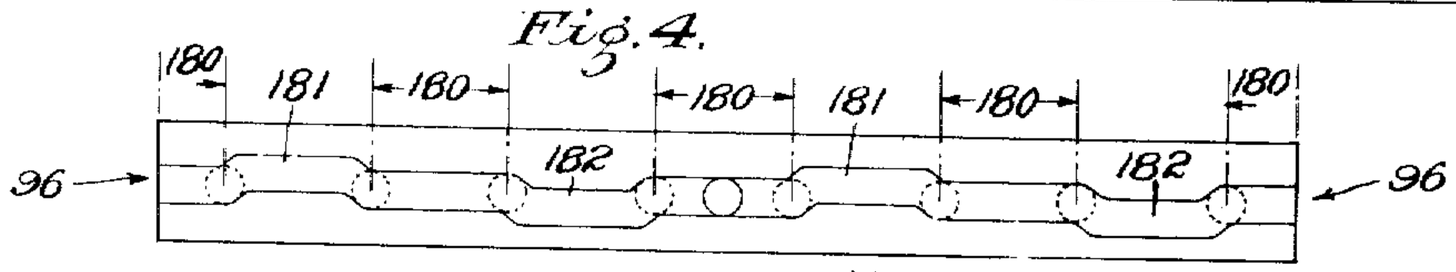


Fig. 5.

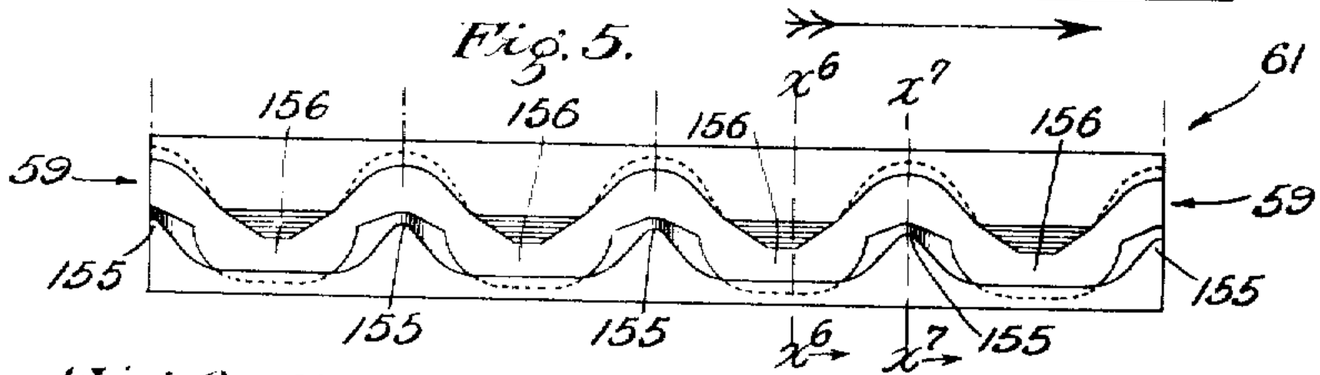


Fig. 6.

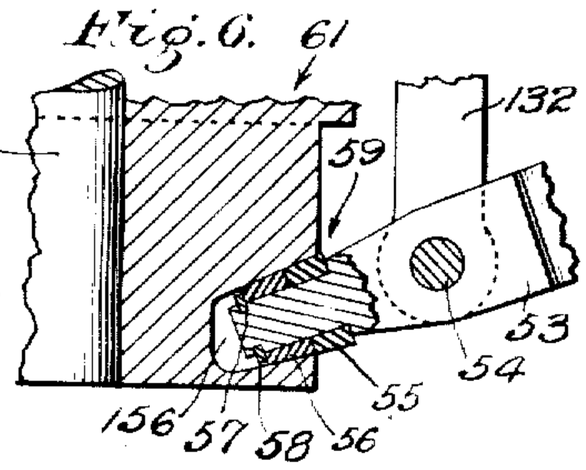
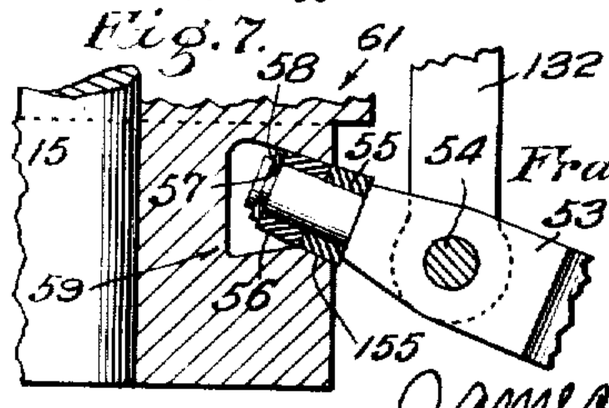


Fig. 7.



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6 SHEETS—SHEET 3.

Fig. 8

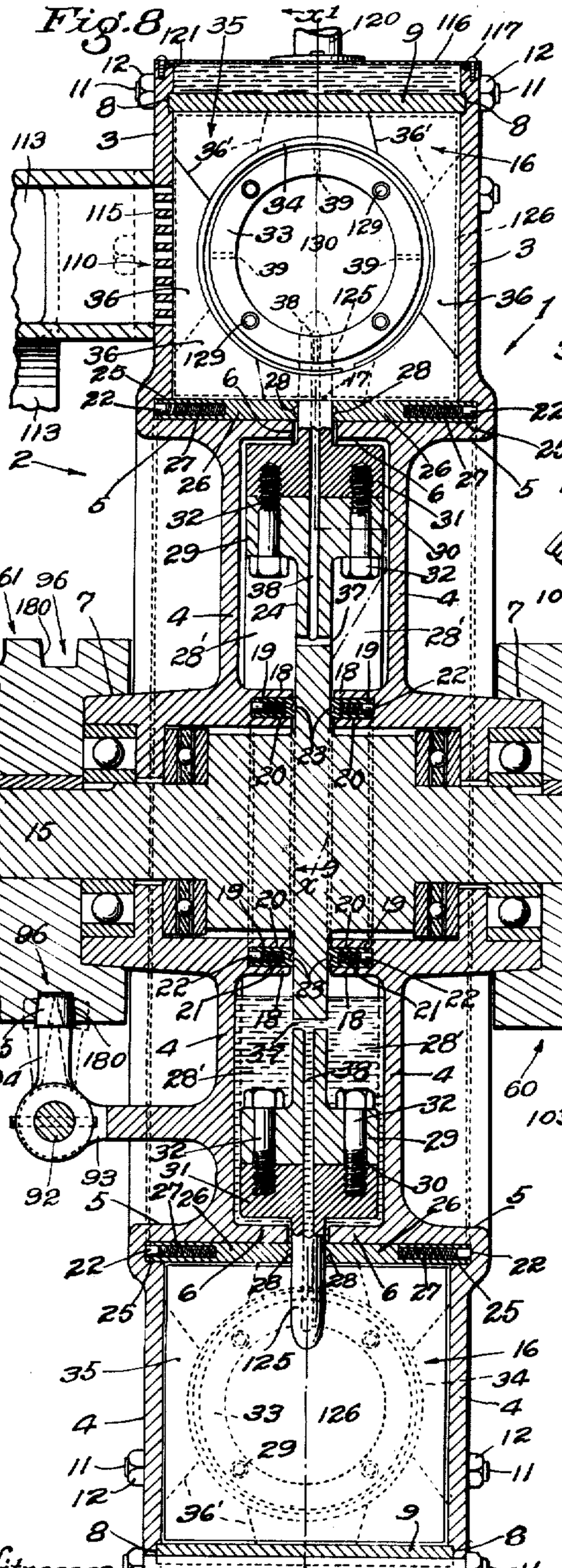

Fig. 9.

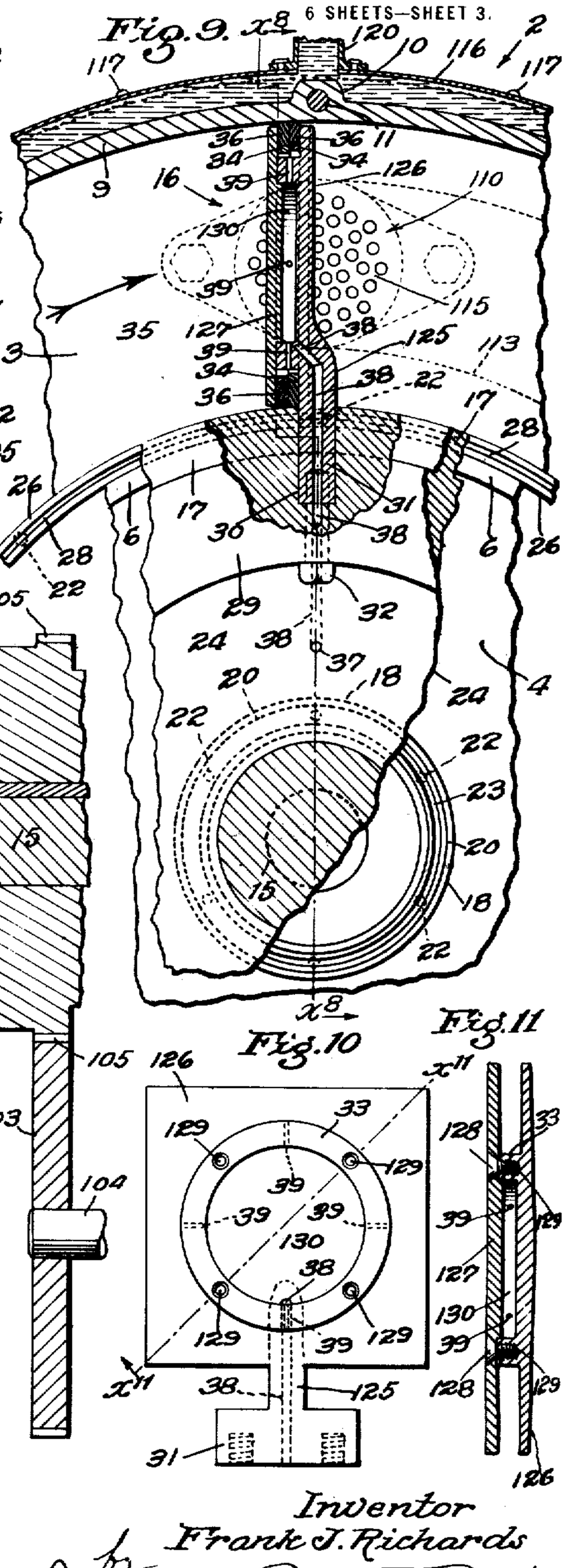

Fig. 10

Fig. 11

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6 SHEETS—SHEET 4.

Fig. 12

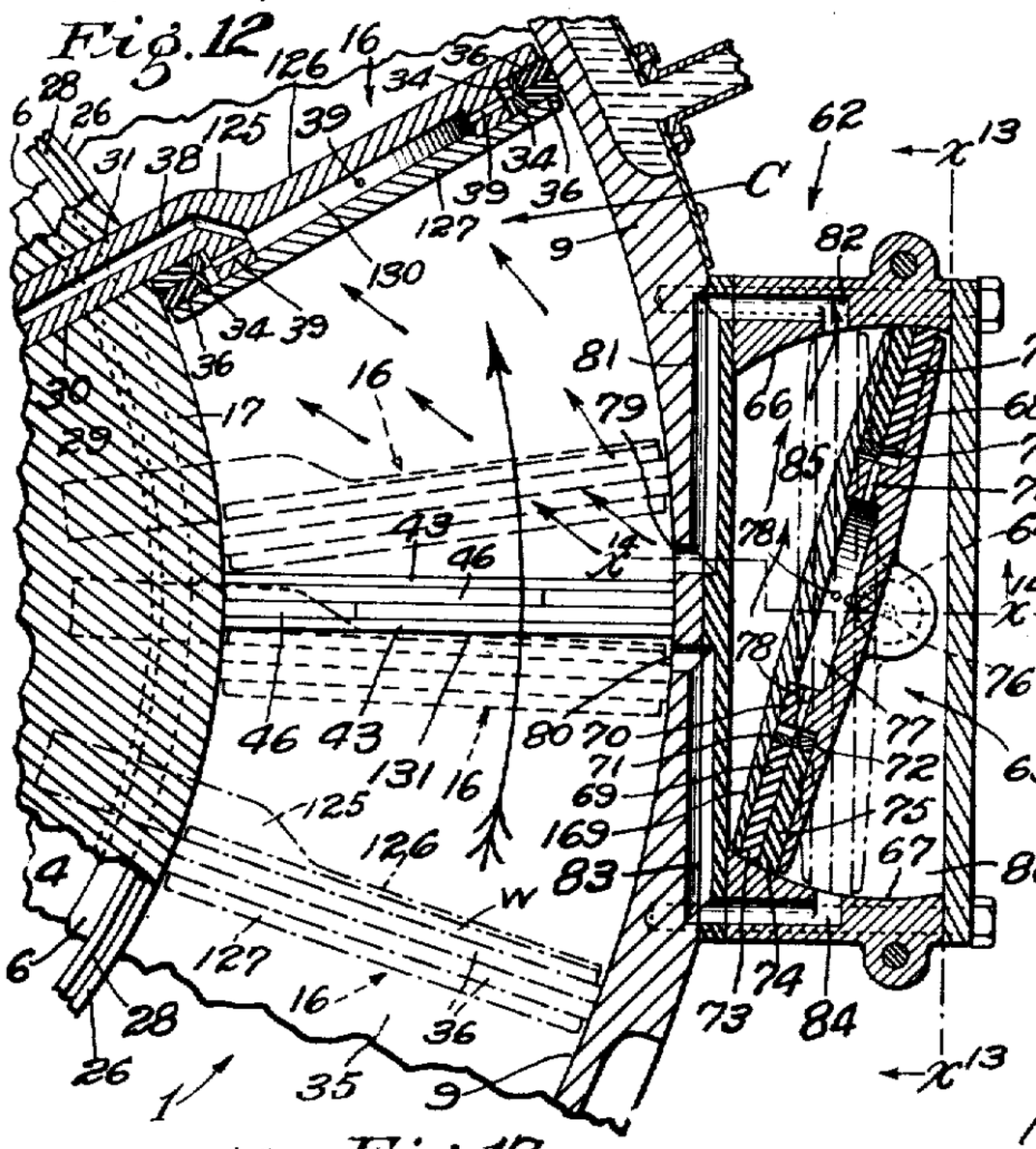


Fig. 13

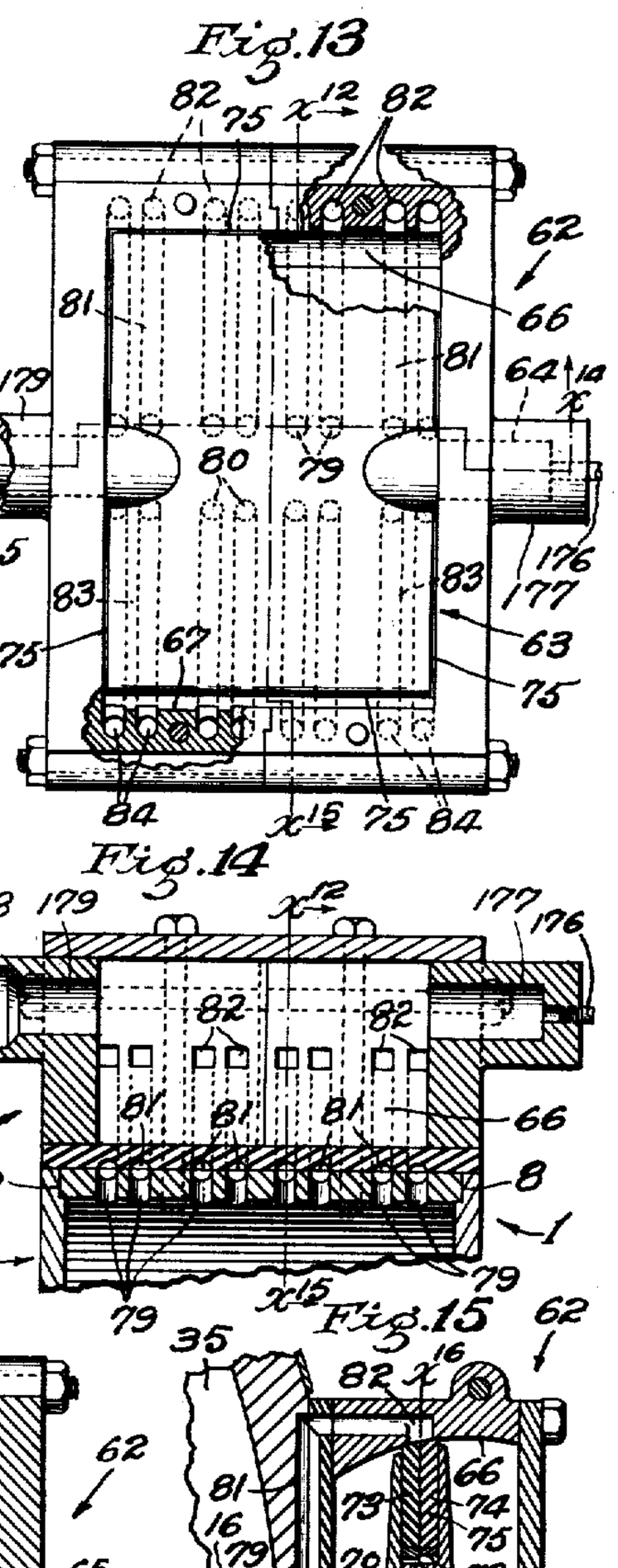


Fig. 17.

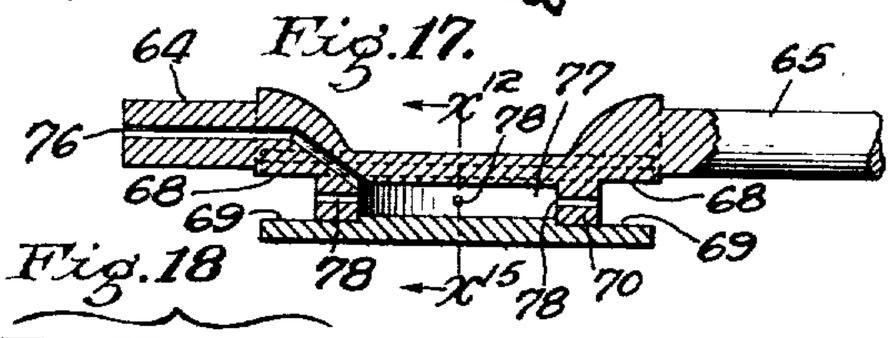


Fig. 14

Fig. 18

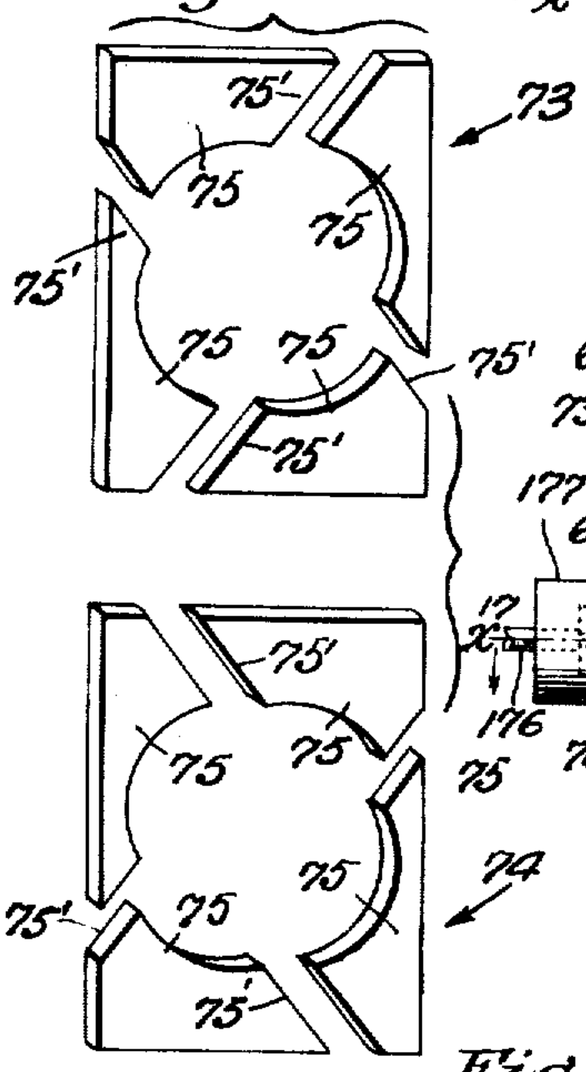


Fig. 16.

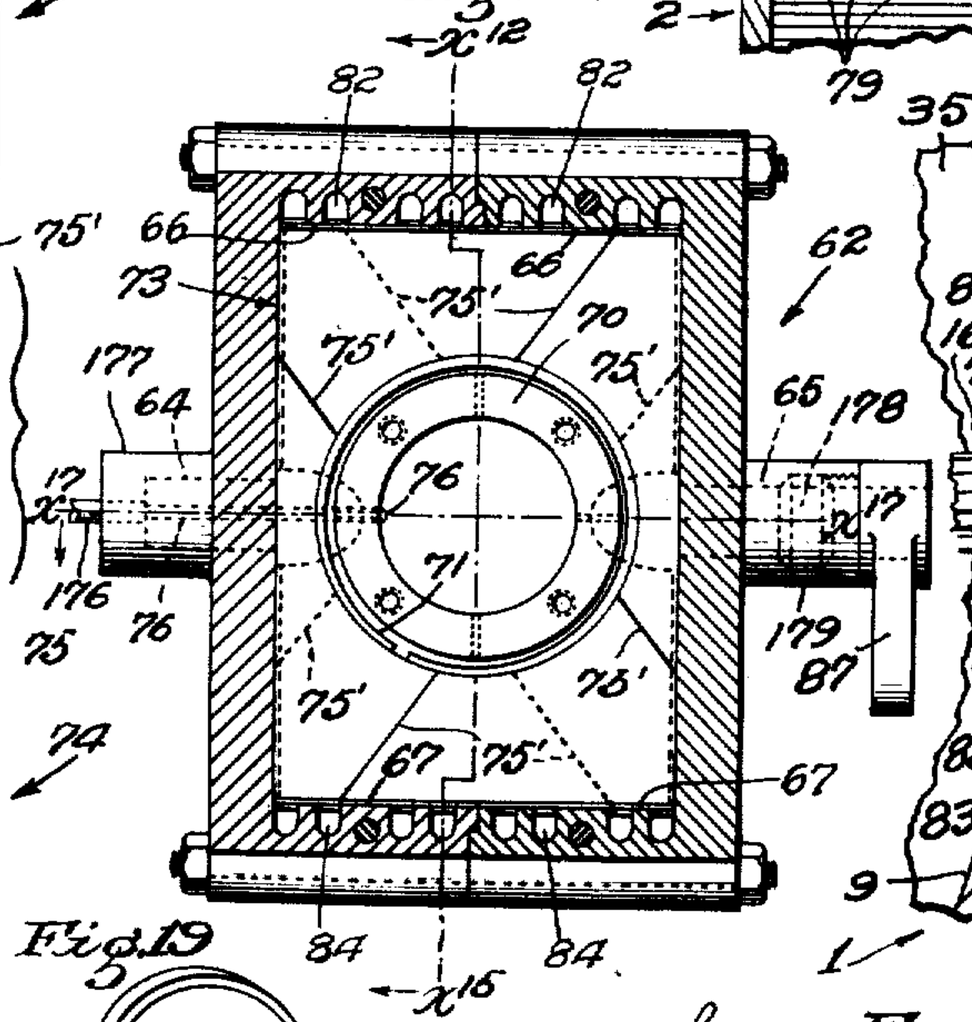


Fig. 15

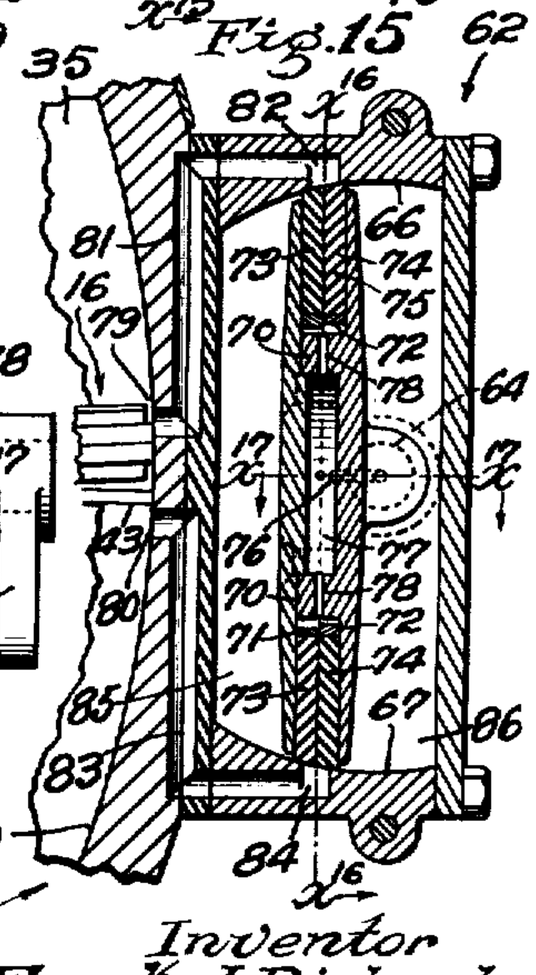
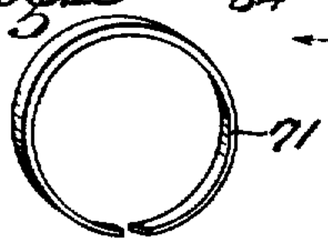


Fig. 19



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6 SHEETS—SHEET 5.

Fig. 20.

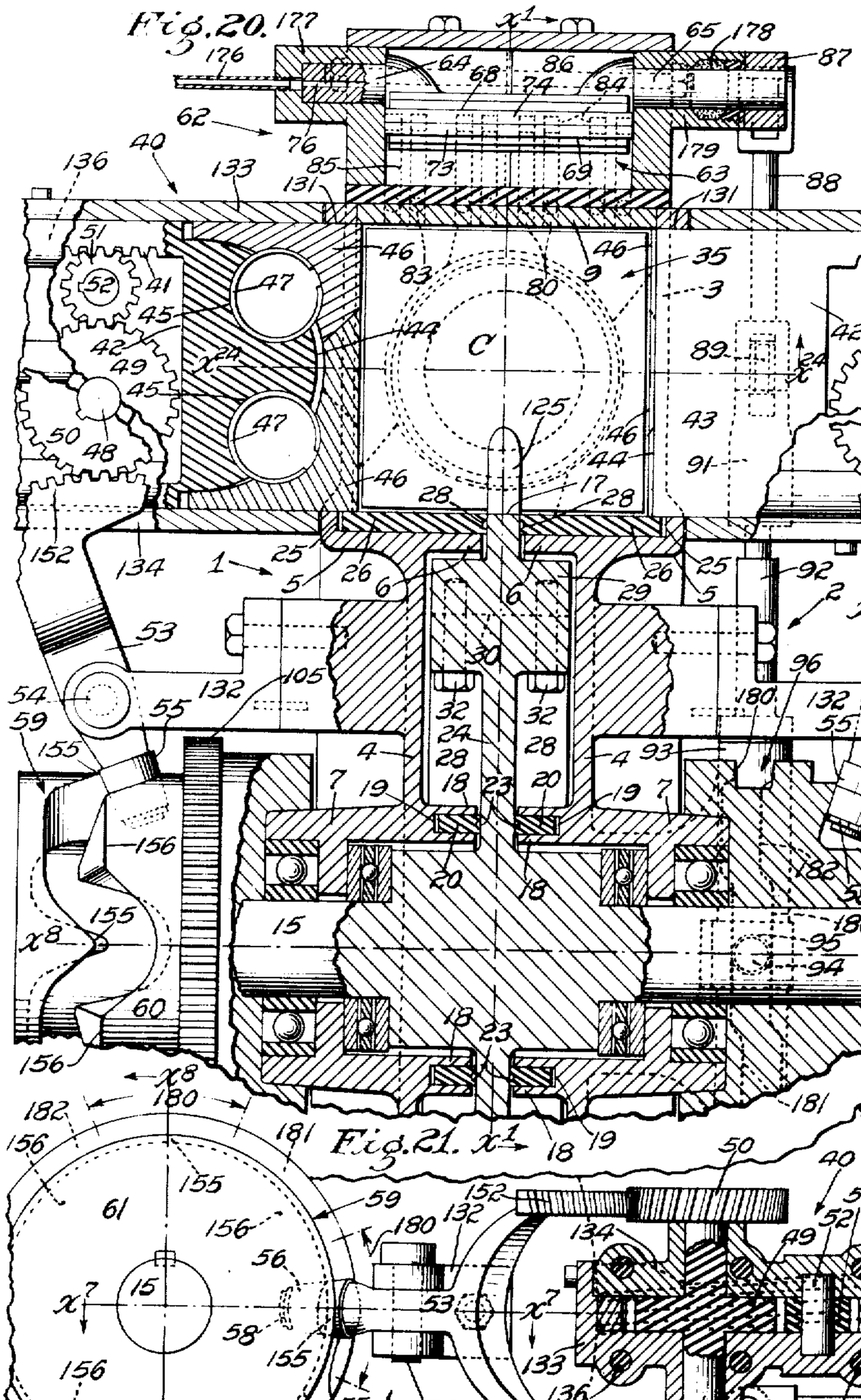
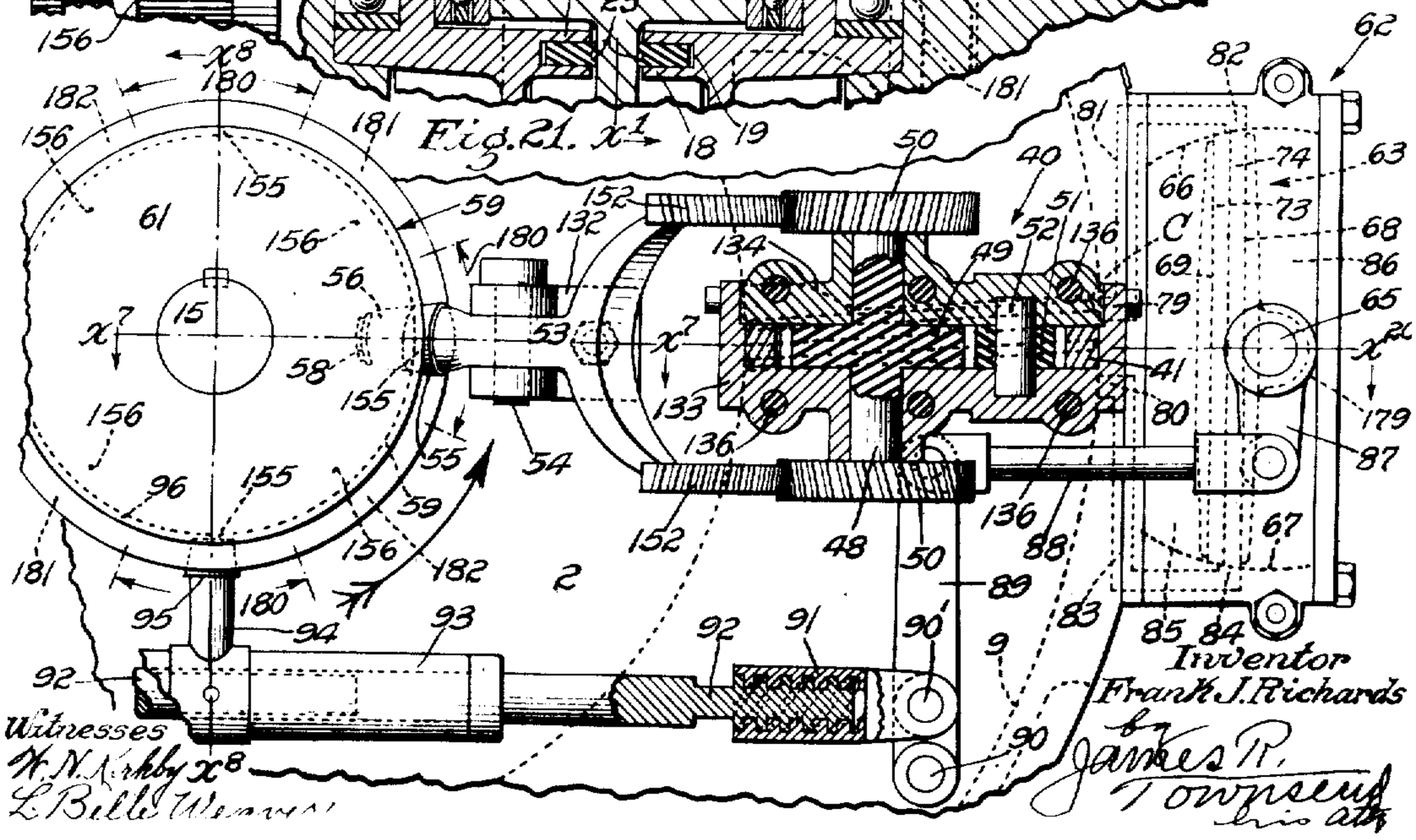


Fig. 21.



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6 SHEETS—SHEET 6.

Fig. 22.

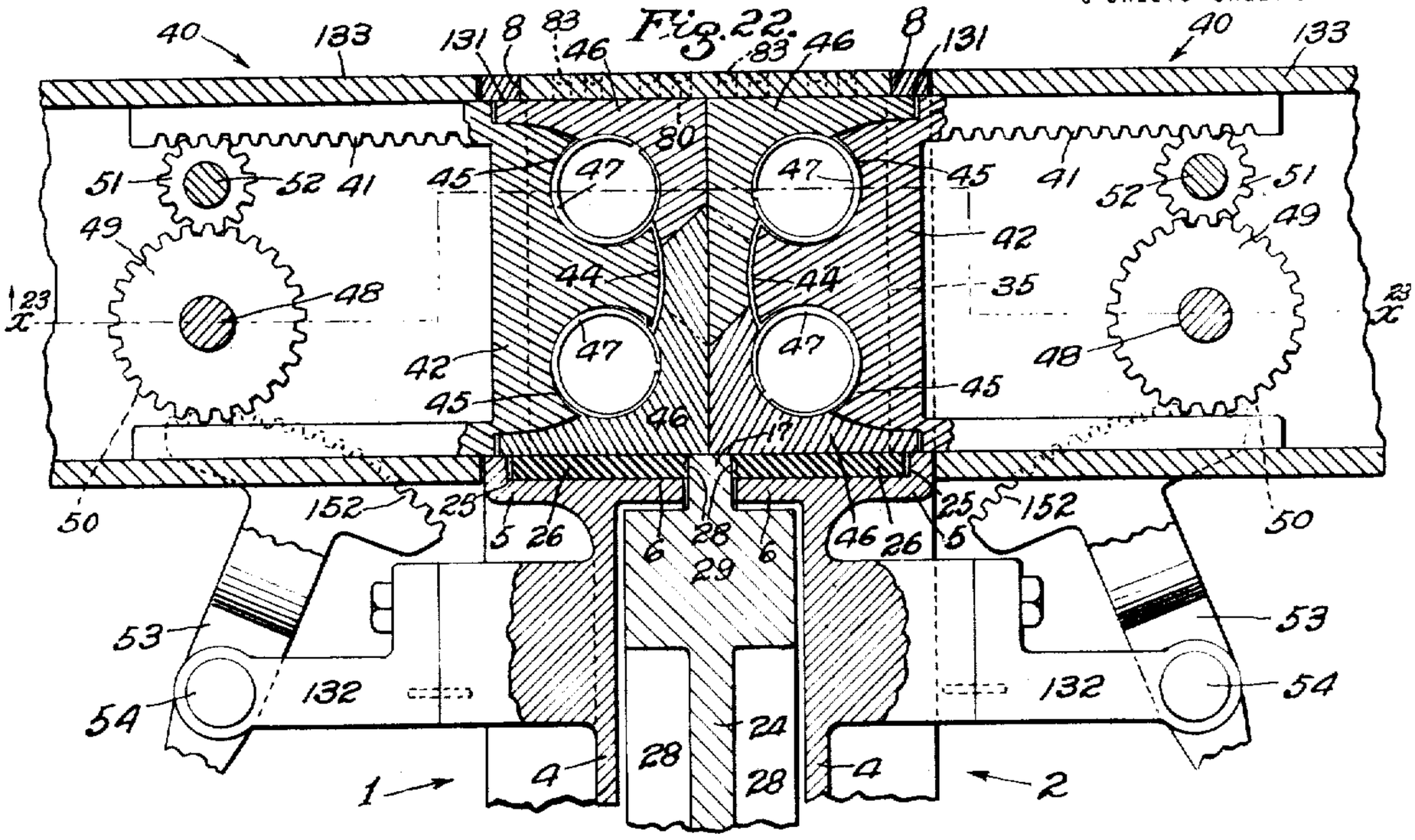


Fig. 23

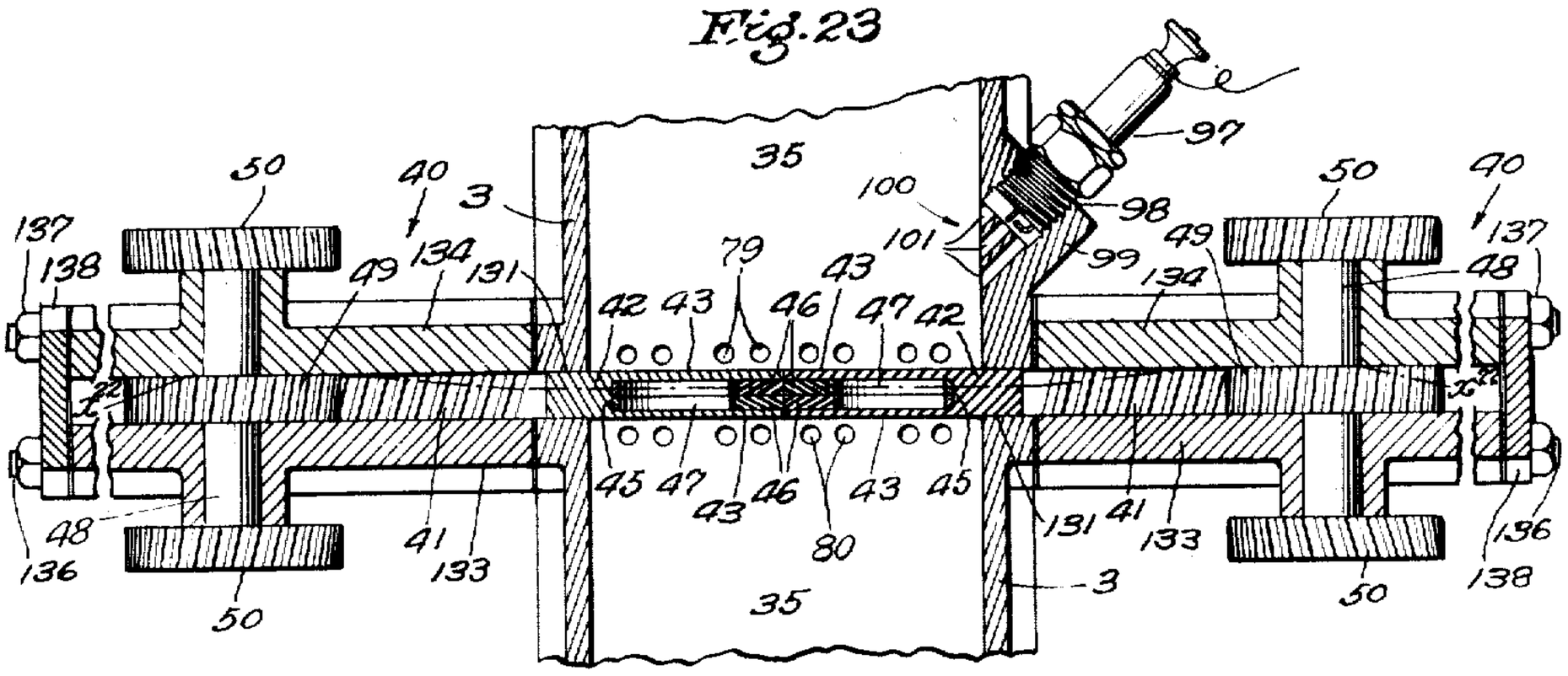
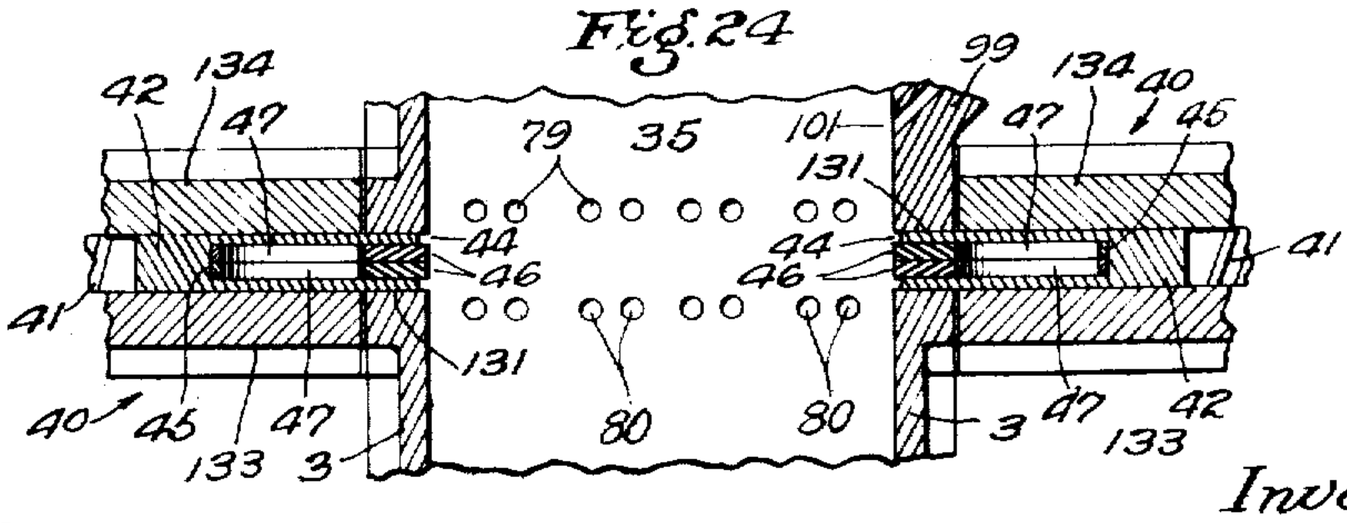


Fig. 24



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UNITED STATES PATENT OFFICE.

FRANK JAY RICHARDS, OF LOS ANGELES, CALIFORNIA, ASSIGNOR OF FORTY-NINE ONE-HUNDREDTHS TO DON M. BROCKWAY, OF LOS ANGELES, CALIFORNIA.

ROTARY ENGINE.

1,154,886. Specification of Letters Patent. Patented Sept. 28, 1915.

Application filed December 22, 1913. Serial No. 808,292.

To all whom it may concern:

Be it known that I, FRANK J. RICHARDS, a citizen of the United States, residing at Los Angeles, in the county of Los Angeles and State of California, have invented a certain new and useful Rotary Engine, of which the following is a specification.

This invention relates to the general class of engines having rotors, and more especially designed to produce a practical rotary engine of the internal combustion type.

Difficulties to be overcome in the construction and operation of internal combustion engines are numerous and among these may be mentioned the difficulty of properly admitting and compressing the combustible charges, the difficulty of preventing leakage of the impelling gases, and the difficulty of lubricating the pistons.

Objects of this invention are to overcome the difficulties above enumerated, and to provide a rotary internal combustion engine that will occupy little space, that will be of comparatively little weight and that will possess great power.

An object of the invention is to provide and properly mount a set of abutment members so that in the operation of said engine the abutment members will move to and fro across the path of the rotor blades to form compression chambers and explosion chambers with the rotor blades, and to provide and properly mount another set of abutment members, so that in the operation of the engine such members will move to and fro across the path of the rotor blades to cooperate with the rotor blades to form a vacuum whereby to draw in a fuel supply.

An object of the invention is to provide a non-leak packing for the rotor blades. To this end the engine is constructed with an annular piston way or chamber that is bounded laterally and peripherally by walls, the transverse traces of which are stranght—that is to say, the intersections of the plane of any of said walls with the planes of projection extending transversely of said walls are right lines—and each rotor blade or piston is made to conform thereto, each of the piston's edges being straight to fit a corresponding wall of the piston way, and said piston or rotor blade is formed with movable segmental packing members to constitute such edges.

Still another object is to provide a packing arrangement that will minimize the pressure of exploding gas against the shaft and other working parts that should be free from such pressure.

A still further object of the invention is to provide a valve that through the action of suitable mechanism will coöperate with the abutment members to receive a charge of fuel after compression of the same, and then conduct such charge into the explosion chamber.

Another object of the invention is to provide a lubricating chamber that will serve as a lubricating source to automatically supply lubricant to all of the working parts of the rotor.

A feature of the invention is the mechanism for opening and closing the abutment members and for changing the position of the valve coöperating with one set of such abutment members to form in the annular chamber a compression chamber and an explosion chamber. The mechanism consists of grooves formed in cams mounted to rotate with the shaft of the rotor, said grooves being adapted to actuate means whereby to transmit movement to said abutment members and valve.

More specifically my rotary engine comprises a practical rotor having a plurality of piston blades that are impelled around in an annular chamber by an explosive force to revolve the rotor.

In carrying out this invention I provide abutments extending across the chamber, each abutment consisting of sliding members adapted to open and close to permit the blades to pass therebetween and as successive charges of explosive mixture are drawn into the chamber by the piston blades each of said charges is successively impinged against an abutment and compressed into a compression chamber from which the charges are passed again to the rotary chamber rearwardly of the blades upon the other side of the abutment after said blades have passed therebetween. This charge is then exploded to impel the blades around in the rotary chamber to drive the rotor.

These and other features, capabilities and advantages of the invention will become apparent from the detail subjoined description of one specific embodiment of the invention.

The accompanying drawings illustrate the invention.

Figure 1 is a view partly in vertical longitudinal mid-section on line x^1, Figs. 2, 8 and 20, illustrating a rotary internal combustion engine constructed in accordance with this invention, parts being broken away for clearness of illustration and a fragment of the intake side being shown, together with the carbureter. Parts are in the position assumed when the valve is just about to move preparatory to receiving a compressed charge as the abutments open and close to permit the blades to pass therethrough. The large feathered arrow indicates the direction of rotation. Fig. 2 is a plan view, parts being broken away to contract the view and a portion of the exhaust manifold being shown in section. The position of the operating parts corresponds to that shown in Fig. 1. Fig. 3 is an elevation from the exhaust side of the engine, looking in the direction of arrow 3, Fig. 2, the direction of rotation of the rotor shaft being counter-clockwise. The rotor and shaft are shown as advanced approximately one fifth of a revolution from the position shown in Fig. 1, the compressing blade of Fig. 1 having passed through the abutment and arrived at an advanced position when the next succeeding blade acts to compress a charge into the valve chamber, a portion of which is broken away. Fig. 4 is a development of the valve-actuating cam. The position of the cam relative to the roller, shown by a solid circle, corresponds to the relative positions shown in Figs. 20 and 21. Fig. 5 is a development of an abutment-actuating cam. Fig. 6 is an enlarged sectional detail viewed from line x^6—x^6, Fig. 3, with parts in a corresponding position. Fig. 7 is a detail analogous to Fig. 6, viewed from line x^7—x^7, Fig. 21, with parts in a corresponding position. Fig. 8 is an enlarged fragmental vertical transverse section viewed from line x^8, Figs. 1, 2, 3, 9, 20 and 21, illustrating means of lubricating and packing. Fig. 9 is a fragmental sectional detail from irregular line x^1—x^9, Fig. 8, illustrating the construction and mounting of a rotor blade. Fig. 10 is a view of a rotor blade detached and stripped of its packing, the cover being also removed. Fig. 11 is a cross section on diagonal line x^{11}, Fig. 10. Fig. 12 is a fragmental vertical longitudinal mid-section, the valve being in section on line x^{12}—x^{15}, Figs. 13, 14, 16 and 17. Solid lines show a position of parts at the moment of firing a released charge, the abutment having just closed after a blade has passed through. Dot and dash lines indicates the position of a rotor blade at the beginning of the opening movement of the abutment, also the corresponding position of the valve, while dotted lines indicate the blade position at the completion of the opening movement and broken lines indicate the blade position at the beginning of the closing movement. Fig. 13 is an elevation of the valve and chamber detached and viewed from line x^{13}, Fig. 12. Parts are broken away for clearness of illustration. Fig. 14 is a fragmental cross-section viewed from irregular line x^{14}, Figs. 12 and 13, omitting the valve. Fig. 15 is a fragmental section analogous to Fig. 12, showing the valve in mid-position in the valve chamber. Fig. 16 is a sectional elevation, illustrating the valve-packing means, the chamber being shown in section on line x^{16}, Fig. 15. The packing retainer cover is removed to expose the packing. Fig. 17 is a sectional view on line x^{17}, Figs. 15 and 16, showing the valve detached from the valve chamber and stripped of its packing. Fig. 18 is a perspective view illustrating two complementary plates of valve-packing segments. Fig. 19 is a view of one of the packing rings detached. Fig. 20 is an enlarged fragmental horizontal mid-sectional view, partly in section on line x^6—x^{20}, Fig. 3 and x^7—x^{20}, Fig. 21. Parts are shown in positions assumed when a rotor blade passes between the open abutments, a compressed charge being shown in the compression chamber. Fig. 21 is an enlarged fragmental elevation looking in the direction of arrow 3, Figs. 2 and 20. The abutment is shown in section on line x^{21}, Fig. 20 and parts are in the same position as those of Fig. 20. Fig. 22 is a fragmental sectional detail analogous to Fig. 20 viewed from irregular line x^{22} Fig. 23, illustrating the abutment packing. The abutment members are shown closed. Fig. 23 is a fragmental vertical transverse section on line x^{23}, Figs. 1 and 22, parts being in the positions shown in Fig. 22. Fig. 24 is a fragmental view analogous to Fig. 23, showing the abutment members open.

Arrows on the various section lines indicate the direction of sight.

In the embodiment shown, a cylinder is provided which is preferably composed of two circular sections 1 and 2 having outer annular side walls 3, inner receding side walls 4, shoulder members 5 between the walls 3 and 4, each continued inwardly to form inner annular flanges 6, and bearings 7. The outer side walls 3 are each provided upon the inside with annular recesses 8 in which seat the edges of the outer circumferential wall 9 that has a boss 10 at intervals therearound to accommodate studs 11 which extend through the side walls 3 and receive nuts 12 to secure the wall 9 firmly in place

between the sections 1 and 2. The lower outer side of the wall 9 is provided with standards 13 and 14 whereby the rotor is suitably mounted and secured in place.

The rotor shaft 15 is supported in the bearings 7 to which shaft is suitably fixed the rotor blades 16, four being provided in the present instance, which revolve in the annular chamber formed between the outer annular walls 3, the circumferential wall 9, the shoulders 5 and annular flanges 6. The rotor shaft 15 is of sufficient length so that a belt (not shown) or other connecting means may be applied to transmit power from it. (See Figs. 2 and 20.)

Oil chamber.—An annular oil chamber is provided to properly lubricate the rotor blades 16. The annular bearings 7 have inward extensions 18 which have annular recesses 19 to receive packing rings 20 provided with interiorly mounted springs 21 having buttons 22, the buttons being adapted to engage the bottom of the recess 19. The inner edge of said packing rings each have an annular oil-receiving channel 23. These spring-pressed packing rings 20 are adapted to press their inner edges, having the oil channel 23, against the rotor disk member 24. The shoulder members 5 and their adjacent flanges 6 form one continued surface on their outer faces, the shoulders 5 forming annular recesses 25 with the outer side walls 3. Packing rings 26 are positioned on the outer surfaces formed by the shoulders 5 and flanges 6. The annular rings have interiorly located springs 27 provided with the buttons 22, the outer edges of the annular rings 26 being positioned in the annular recesses 25. The inner edges of the packing rings 26 are each provided with an annular oil-receiving channel 28. The inner edges of the packing rings having these oil channels are adapted to be pressed snugly against the sides of the outer web portion 17 upon the outside of the rotor rim 29 by means of their springs 27. Thus, there are formed two chambers 28′, one on each side of the disk member 24, by means of the receding side walls 4, the flanges 6 and their packing rings 26 at their outer ends and the extensions 18 and their packing rings 20 at their inner ends. These chambers 28′ are filled with lubricant which is supplied to the oil-receiving channels 23 and 27 to form an oil seal between the oil chambers 28′ and annular chamber 35 to thereby prevent any leak therebetween. The chambers 28′ also supply lubricant to the rotor blades 16 which will be explained when describing the construction of the rotor blades.

Rotor blades.—The rotor or piston blades 16 may be formed integral with the rotor if desired. In the present instance, the disk member 24 of the rotor is provided with an annular reinforced rim 29 forming a flange over each face of the disk member 24. Four recesses 30 are provided in said rim at 90° from one another, to receive the inner enlarged arms 31 of the rotor blades 16, said arms being secured in said recesses 30 by any suitable means, such as screws 32.

The edges of the blades are substantially rectangular. In the present embodiment the necks 125 of the blades form bosses with respect to the blade bodies 126 which form the front faces of said blades. Blade covers 127, forming the rear faces of said blades, are spaced apart from the blade bodies by means of annular rims 33 which are positioned at a distance from the outer edge of said faces. Each of said covers 127 is secured in place upon the blade bodies by screws 128 extending into tapped holes 129 in the rims 33. Outside the annular rim and in the recess formed by the rim with the adjacent faces of the blades there is provided resilient split rings 34 which have a tendency to spread outward. Around these split rings segmental packing members are provided which are pressed outward by the split rings to form a tight fit with the side walls 3, the circumferential wall 9, and inner face of the annular chamber 35 in which the blades 16 are adapted to travel.

The segmental packing members are of particular construction. (See Fig. 18.) The segments 36 of the packing members when fitted together form two distinct plates, there being four segments for each plate. The outer edges of these plates are of a rectangular outline when fitted together and have an inner circular opening. The divisions of the segments of a particular plate with one another are inclined, as at 36′, so that when placing the packing members in position for use, the inclined divisions of two abutting plates will be in staggered relation to one another in order that each division of one plate will be opposite the intact face of a segment of the abutting plate. (See Figs. 8 and 16.)

The working faces of the annular chamber 35 are lubricated through the blades 16 from the lubricating chambers 28′ in the following novel manner: (See Fig. 8.) A transverse passage 37 provided in the disk member 24 communicates with the oil chambers 28′ one such passage 37 being provided beneath each blade 16. Communicating with each passage 37 is a cylindrical passage 38 which passes up through the disk member 24, the neck 125 of the blade body and into the cylindrical chamber 130 formed within the annular rim 33, orifices 39 being formed in the rim 33, whereby lubricant from the chamber 130 may be supplied to the split rings 34 from where the lubricant will ooze out between the segments 36 to the working faces of the annular chamber 35. The oil film contained between the segments

acts as a seal to prevent any leakage from an inclined division 36′ of one segmental plate, and between the segments 36 to an inclined division of the other segmental plate to thus provide a non-leak rotor blade.

Abutments or gates.—Novel abutments or gates are provided, one set of which assists to draw in a charge of fuel, and the other set of which operates to compress said charge. These abutments continuously open and close to obstruct the passage in the annular chamber 35, they moving transversely of the chamber, one for each side thereof.

The outer annular side walls 3 are provided with housing extensions 40, one for each abutment member, each housing comprising a lower portion 133 and top portion 134 suitably secured together to form a space to receive an abutment member, said space communicating with the annular chamber 35 through a rectangular opening 131. Said housing extensions 40 are, in the instance shown, mounted upon the sections 1 and 2 of the cylinder by means of studs 136 that extend through the portions 133, 134 and into the side walls 3, the other end of said studs being threaded to receive nuts 137 that secure an end piece 138 in position against the housing members to close the end of the housing. Each abutment comprises an outer rack member 41 integral with its main body portion 42, which is composed of two substantially rectangular faces 43 and having a recess 44. The bottom outline of each is of particular conformation. (See Figs. 20 and 22.) The bottom of the recess is substantially concave having two convex recesses 45, the radius of the convex recess being smaller than that of the concave conformation of the main recess 44. In the concave recess 44 segmental packing members 46 are provided, four being provided for each abutment, which are in pairs to form two distinct plates similar to the packing members of the blades 16. The divisions of the segments of each plate when in packing position is opposite to the intact face of the segment of the adjacent plate. In the recess 45 split rings 47 are provided, which have a tendency to press the packing segments 46 outward.

Two members are provided for each abutment, which are actuated to approach and recede from one another simultaneously through the rectangular opening 131 into the annular chamber 35. When they approach one another they will, by means of their packing segments 46, meet one another and form a non-leak obstruction in the annular chamber 35.

Abutment actuating mechanism.—These abutment members are actuated by a cam and gear arrangement. A shaft 48 is mounted in each housing 40 which shaft has a pinion 49 fixed on it to rotate inside of the housing 40, and two pinions 50 to rotate outside of the housing 40, one on each side of said housing. The inner pinion 49 is in mesh with a small spur wheel 51 fixed to rotate with a shaft 52 mounted at one side of the shaft 48, the spur wheel 51 being in mesh with the rack bar 41 of an abutment member. The two outside pinions 50 are in mesh with segmental gear portions, one formed on each bifurcated end 152 of a lever 53, which is fulcrumed at 54 to a supporting arm 132 secured on the receding side wall 4 of the cylinder. The end of the lever 53 on the other side of the fulcrum 54 is diminished and is provided with two rollers 55 and 56 which are mounted on such shaft or diminished portion. At a distance on said shaft beyond the two rollers, when they are in working position, an annular recess 57 is provided which is adapted to receive a split washer 58 whereby to maintain said rollers 55 and 56 on said lever 53. The two rollers 55 and 56 together form a continuing outward taper.

These rollers 55 and 56 are adapted to travel in a cam groove 59 formed in cams 60 and 61, which are fixed to rotate with the shaft 15 of the rotor, one on each side of the cylinder. The cam groove, as shown in Fig. 5, has four crests 155 and four troughs 156, the arrangement being so timed that the abutment members will recede whenever the rollers ride over the crests 155 which is four times in every revolution of the shaft 15, thereby permitting each of the four blades to pass in the annular chamber 35.

The two rollers 55 and 56 are provided so as to compensate for the different velocities which are imparted to them as they travel over the crests 155 of the cam grooves 59. The roller 55 when passing over each of said crests will roll at a much slower velocity than the roller 56 which is rolling over the opposite wall of the cam groove at this time. This arrangement avoids any undue friction and wear and greatly facilitates in the easy and smooth operation of the abutments.

Valve.—At one side of the cylinder and on the circumferential wall 9 is formed a valve housing 62 in which is a valve 63, pivotally mounted at its middle by trunnions 64 and 65. (See Figs. 3 and 12.) The upper and lower faces 66 and 67 respectively of the valve housing which are parallel to the axis of the trunnions 64, are concave so as to form a tight working face for the valve 63. The valve is provided with packing segments similar to those of the rotor blades 16. The valve has an outer face 68 and an inner face 69 which are substantially of rectangular outline and are spaced apart from one another by an annular rim 70 which is at a distance from the edges of the faces 68 and 69. Said inner

face 69 is preferably formed by a packing retainer cover 169 suitably secured in place upon the annular rim 70 and around this rim and between the faces 68 and 69 are positioned the split rings 71 and 72, one for each of the segmental plates 73 and 74 respectively, which are each composed preferably of four segments 75, the divisions between the segments being inclined as at 75 and so arranged that the division of two segments of each plate is opposite the intact segment of the opposite plate. The working faces of the valve housing 62 are lubricated by means of a lubricating passage 76 formed in the trunnion 64, the passage 76 being supplied from any suitable source, as through an oil pipe 176 communicating with the blind trunnion bearing 177. The passage 76 (see Fig. 17) communicates with the cylindrical chamber 77 formed within the annular rim 70 which is provided with orifices 78 through which lubricant in the chamber 77 oozes out and between the segments 75 to the working faces of the housing 62. The oil film between the segments 75 acts as a seal to pack the valve 63, similar to the packing of the rotor blades 16, to prevent any leakage between the chambers 85 and 86. One set of abutments or gates is positioned adjacent to this valve. There are provided two series of openings 79 and 80, respectively, which are so positioned that when the adjacent abutments are closed one series of openings 79 will be on one side of the abutments and the other series 80 will be on the other side of the abutments. The series of openings 79 communicates with the interior of the valve housing 62 by means of passages 81, and a second series of openings 82 formed in a line approximately in the middle of the valve housing 62; and the other series of openings 80 communicate with the interior of the housing 62 by means of passages 83; and a second series of openings 84 formed in a line approximately in the middle of the valve housing 62, but at the opposite side of the housing to that where the openings 82 are formed. The lines of the openings 82 and 84 are such that when the valve 63 is in an intermediate position it will shut off communication from both these series of openings 82 and 84.

The valve 63 forms two working chambers 85 and 86 in the housing 62. When the valve 63 is in the position shown in Fig. 12, that is with its upper edge inclined outwardly communication will be established from the annular chamber 35 to the inner chamber 85 through the openings 79, passages 81 and openings 82. The valve 63 is then swung over to the intermediate position (see Fig. 15) where it momentarily cuts off communication between the housing 62 and annular chamber 35, and then swings over to a position where its upper edge inclines inwardly, (see Fig. 1) so that communication between the chamber 85 and the annular chamber 35 is established by means of the openings 84, passages 83 and openings 80. At the same time when the upper edge of the valve 63 is inclined inwardly, communication will also be established from annular chamber 35 with the outer chamber 86 of the housing 62 by means of openings 79, passages 81 and openings 82; and then by succeeding movements of the valve 63 communication between this chamber 86 will be established with the annular chamber 35 by means of openings 84, passages 83 and openings 80.

The valve 63 is moved to and fro direct from the shaft 15 of the rotor.

Valve-actuating mechanism.—The trunnion 65 of the valve 63 has fixed to it outside the stuffing-box 178 of the trunnion bearing 179 an arm 87 to which is pivoted a link 88 which is pivoted at its other end to a lever 89 which is fulcrumed at 90 to the outer side wall 3 of the cylinder and is connected at 90′ to a sleeve member 91 which has an internal helical thread to receive an external helical thread formed on one end of a rod 92, the other end of which is located in a sleeve 93 fixed to the receiving wall 4 of the cylinder, the rod 92 having a finger 94 which has a roller 95 provided at its end to travel in the cam groove 96 of the sleeve 61. The cam groove 96 comprises normal limbs 180 each connecting outer and inner laterally extending limbs 181 and 182 to form a continuous groove around the cam, there being four normal limbs 180, two outer limbs 181 and two inner limbs 182, (see Fig. 4,) said limbs being so timed that the valve 63 is moved to and fro four times for each revolution of the shaft 15 to coöperate with each of the four blades 17 of the rotor, the roller 95 riding in the normal limb 180 to maintain the valve in intermediate position in the valve chamber 62 as the rollers 55 and 56 ride over the crests 155 and open and close the abutment members to permit the blades to pass therethrough.

Ignition.—A spark plug 97 is mounted in the bore 98 of a boss 99 provided in the outer annular wall 3 of the cylinder which is in the vicinity of the set of abutments cooperating with the valve 63. The boss 99 is in an inclined position to said side wall 3 with its bore 98 pointing in the direction of the set of abutments as shown in Fig. 23. The inner end of the bore 98 has a perforated obstruction 100 provided with a series of perforations 101 pointing in the same direction as the bore, the inner face of the obstruction 100 being in a plane with the face of the annular chamber 35, the series of perforations 101 permitting the spark from the spark plug 97 to enter the chamber 35, while

the obstruction 100 itself will prevent sagging of the piston blades 16 when passed by said spark plug communication.

A suitable magneto 102 (see Fig. 3) is provided for energizing the spark plug 97. The magneto 102 is connected up in the usual manner as by a gear 103 on the magneto shaft 104 which gear is in mesh with the annular toothed face 105 on the cam 61.

Intake and exhaust.—In the outer side wall 3 of the cylinder, preferably at a distance from the base, as shown in Fig. 3; and on the opposite side from the valve 63, an intake 106 is provided to which, in the present instance, is connected a carbureter 107. A perforated cover 108 is provided at the entrance of this intake into the annular chamber 35, which cover is flush with the inner face of the annular chamber 35, so that when the piston blades 16 pass the intake they will be prevented from sagging into the opening of the intake.

Above the intake 106 and preferably on the opposite side therefrom the side wall 3 of the cylinder is provided with an outlet opening 109 adapted to permit exhaust to escape. In the present instance, there are two such outlet openings provided, another opening 110 being formed a short distance from the opening 109 in the side wall 3. An exhaust manifold 111 is connected to the outlet 109. A partition 112 is provided in this exhaust manifold 111 which prevents communication between the outlet 109 and the outlet 110 through the branch 113 which communicates between opening 110 and the exhaust pipe 111. The manifold 111 passes off the exhaust which escapes through the outlet openings 109 and 110.

There are provided covers 114 and 115 respectively for the outlet openings 109 and 110, the covers being flush with the inner faces of the annular chamber 35, so that the piston blades 16 may freely pass over the same, and, due to the covers 114 and 115, will be prevented from sagging into the openings.

Operation.—Assuming that the gates A and B are in closed position as shown in Fig. 1 when turning the rotor in the direction of the feathered arrow that piston blade 16, which is just moving from the gate B will tend to form a vacuum with such gate B, and consequently, when it passes over the intake 106 it will draw in a charge of fuel. In its continued rotation it will carry this charge of fuel over to the gate A and after said blade has passed through, and the gate is again closed, the following blade C as it approaches the closed gate A, will compress the charge, which compressed charge by means of the series of openings 80, passages 83 and second series of openings 84 will be passed into the inner chamber 85 of the housing 62. A normal limb 180 of the cam groove 96 will then ride upon the roller 95 to actuate the valve connections to move the valve 63 into a middle position whereby it will cut off further communication between the annular chamber 35 and the chamber 85. A crest 155 of the cam groove 59 will at this same time advance upon the rollers 55 and 56 to actuate the abutment connections to open the abutments A and B to permit said following piston blade C to pass between abutment members A and continue in its passage through the chamber 35, meanwhile permitting the blade D to pass between the gates B preparatory to drawing in a full charge. As soon as said piston blade C has passed beyond the abutment A, said crest 155 retreats from the rollers 55 and 56 to again close the abutment A whereupon after closing, an outer limb 181 of the cam groove 96 will immediately ride upon the roller 95 to move the valve 63 out of middle position, so that communication will be established between the chamber 35 and the chamber 85 by means of the series of openings 82, passages 81 and openings 79, (see Fig. 12) the compressed charge rushing into the chamber 35 rearwardly of the blade C. The spark plug 106 is timed to then fire the charge contained between the blade C and the closed abutment A from which the blade is moved. The fired charge, as is usual, cannot move the abutment A, and will spend itself in thrusting forward the said blade C. As this blade C then arrives at the outlet 110 the burnt gas will be passed out therethrough. Upon the continued rotation the succeeding blade E, see Fig. 3, will compress a charge through the openings 84 into the outer chamber 86 in which it will be held as the succeeding normal limb 180 and roller 95 move the valve again into a middle position while the blade E passes between the abutment A, opened by the next succeeding crest 155. Upon the closing of the abutment A the valve is moved again into the aslant position shown in Fig. 1 by the next succeeding limb 182 and roller 95, whereupon the compressed charge rushes into the chamber 35 rearwardly of the blade E through the openings 82 where said charge is fired. This operation completes one-half of the engine revolution, the other half revolution being a repetition of the operation just described.

The pressure in the annular chamber 35 to the explosion in the firing chamber is practically prevented from exercising any force on the shaft 15 and the rotor disk member 24, thus enhancing the easy operation of the engine and minimizing the power required to drive the engine. This is accomplished by means of the outer faces formed on the shoulders 5 and flanges 6 and the outer packing rings 26 thereon which fit snugly against the sides of outer portion 17

of the disk member 24 leaving just a narrow edge of said disk member exposed to the annular chamber 35.

Obviously but one of the outlets 110 or 109 may be used. In high speed engines, it is preferable to use the outlet 110, the one nearer the place of explosion, whereas in slow speed engines the more remote outlet 109 would be more desirable.

Water jacket.—As is apparent from the operation above described practically only the upper part of the cylinder between the exploding place of the charge and the outlets 109 and 110 will be heated. Therefore, it is only necessary to provide a water jacket from this upper portion of the cylinder.

The annular wall 9 is located a short distance from the edges of the cylinder sections 1 and 2. Therefore, in the present instance, it is only necessary to provide a copper plate 116 to secure to the outer edges of the upper portions of the sections 1 and 2 over the bosses 10 where it is fastened by means of screws 117, or other suitable means. To provide a non-leak fit a recess 121 is formed along the edges of the sections 1 and 2 inwardly of the screws 117 in which recess a rubber fillet or the like may be positioned. There are two inlet pipes 118 and 119 passed into this water jacket, one near each end of the jacket, and one outlet pipe 120 which is approximately at the middle upper side of the water jacket. These inlet and outlet pipes may be connected to a radiator or the like in any suitable manner.

It is obvious that various changes and modifications may be made to the details of construction of this engine without departing from the general scope of the invention.

I claim:—

1. A rotary engine comprising a cylinder and a rotor mounted to rotate in said cylinder, piston blades formed on said rotor, an outer annular chamber in said cylinder in which said blades travel, an annular lubricating chamber formed between said outer annular chamber and the axis of the rotor and in the place of rotation of said rotor, and a passage formed in said piston blades to afford communication between said lubricating chamber and the working faces of said outer annular chamber whereby said working faces will be lubricated from said lubricating chamber.

2. A rotary internal combustion engine comprising a casing forming an outer annular chamber and an inner annular chamber, a rotor mounted to rotate having a disk member adapted to travel in said inner annular chamber, and a plurality of piston blades on the periphery of said disk member and adapted to travel in said outer annular chamber, said inner annular chamber being adapted to be filled with lubricant, and means to feed said lubricant from said inner annular chamber to the working faces of said outer annular chamber.

3. A rotary internal combustion engine comprising a casing forming an outer annular chamber and an inner annular chamber, a rotor mounted to rotate in said casing having a disk member adapted to travel in said inner annular chamber and a plurality of piston blades formed on the periphery of said disk member and adapted to travel in said outer annular chamber, said inner annular chamber being adapted to be filled with lubricant, an annular opening between said outer and inner annular chambers in which the disk member of said rotor is adapted to rotate, packing means for said annular opening to provide a non-leak fit between said inner and outer chambers, and means to feed the lubricant from said inner annular chamber to the working faces of said outer annular chamber through said piston blades.

4. A rotary internal combustion engine comprising a casing forming an outer annular chamber and an inner annular chamber, a rotor mounted to rotate in said casing having a disk member adapted to travel in said inner annular chamber and a plurality of piston blades formed on the periphery of said disk member and adapted to travel in said outer annular chamber, said inner annular chamber being adapted to be filled with lubricant, an annular opening between said outer and inner chambers in which the disk member of said rotor is adapted to rotate, packing means for said annular opening to provide a non-leak fit between said inner and outer chambers, and a passage in said piston blades to afford communication between said inner chamber and the working faces of said outer chamber whereby said working faces will be lubricated from said inner chamber.

5. A rotary internal combustion engine comprising an outer annular chamber and an inner annular chamber, a disk member mounted to rotate in said inner annular chamber, a plurality of piston blades formed on the periphery of said disk member and adapted to travel in said outer annular chamber, said inner annular chamber being adapted to be filled with lubricant, an annular opening between said outer and inner annular chambers in which the outer edge of said disk member is adapted to travel, packing means for said annular opening to provide a non-leak fit between said inner and outer chamber, an annular recess in said packing means adapted to contain lubricant and presenting a lubricating face to the disk member traveling in said annular opening, and means to feed lubricant from said

inner chamber to said annular recess and the working faces of said outer annular chamber.

6. A rotary internal combustion engine comprising an inner and an outer annular chamber, a disk member adapted to travel in said inner annular chamber, a plurality of piston blades formed on the periphery of said disk member and adapted to travel in said outer annular chamber, said inner annular chamber being adapted to be filled with lubricant, an annular opening between said outer and inner annular chambers in which the outer edge of said disk member is adapted to rotate, packing rings for said annular opening to provide a non-leak working fit between said inner and outer annular chambers, annular recesses provided in the packing rings adjacent the edge of the disk member, said annular recesses being adapted to contain lubricant to form an oil seal and to present lubricating faces for said disk member, and means for supplying lubricant from said inner chamber to said annular recesses and the working faces of said outer chamber.

7. A rotary internal combustion engine comprising a casing having an annular chamber, a rotor comprising a plurality of piston blades adapted to rotate in said annular chamber, packing means for said piston blades to form tight working fits with the working faces of said annular chamber, said packing means comprising segmental plates, and a resilient ring for pressing the segments outward into contact with the working faces of said annular chamber.

8. A rotary internal combustion engine comprising a casing having an annular chamber, a rotor comprising a plurality of piston blades adapted to rotate in said annular chamber, packing means for said piston blades to form tight working fits with the working faces of said annular chamber, said packing means comprising segmental plates, the segments of the several plates being in staggered relation to one another so that the divisions between each two segments of one plate will be positioned opposite to an intact face of a segment of the adjacent plate, and a resilient ring adapted to maintain said segments in contact with the working faces of said annular chamber.

9. A rotary engine comprising a casing having an annular chamber, a rotor comprising a plurality of piston blades adapted to rotate in said annular chamber, said piston blades being composed of a front plate, a rear plate and an annular rim interposed between said plates, packing means for said piston blades to form tight working fits with the working faces of said annular chamber, said packing means comprising a resilient member positioned around the annular rim, and segmental plates positioned on said resilient member, said resilient member operating to press said segmental plates into contact with the working faces of said annular chamber.

10. A rotary engine comprising a casing having an annular chamber, a rotor comprising a plurality of piston blades adapted to rotate in said annular chamber, said piston blades being composed of a front plate, a rear plate and an annular rim positioned between said plates, packing means for said piston blades positioned around said annular rim to form tight working fits with the working faces of said annular chamber, said annular rim forming a cylindrical chamber inside of it with the front and rear plates for containing lubricant, and means for conveying said lubricant through the packing means to the working faces of the annular chamber.

11. A rotary engine comprising a casing having an annular chamber, a rotor comprising a plurality of piston blades adapted to rotate in said annular chamber, said piston blades being composed of a front plate, a rear plate and an annular rim positioned between said plates, packing means for said piston blades positioned around said annular rim to form tight working fits with the working faces of said annular chamber, said annular rim forming a cylindrical chamber inside of it with the front and rear plates for containing lubricant, means for supplying lubricant to said cylindrical chamber, and means for conveying said lubricant to the working faces of said annular chamber.

12. A rotary engine comprising a casing having an inner annular chamber and an outer annular chamber, a rotor comprising a plurality of piston blades adapted to rotate in said outer annular chamber, said inner annular chamber being adapted to contain lubricant, said piston blades being composed of a front plate, a rear plate and an annular rim between said plates, packing means for said piston blades positioned around said annular rim to form tight working fits with the working faces of said annular chamber, said annular rim forming a cylindrical chamber inside of it with the front and rear plates for containing lubricant, a passage formed in the plates to afford communication between the inner annular chamber and said cylindrical chamber to supply lubricant to said cylindrical chamber from said inner annular chamber, and means for conveying lubricant from said cylindrical chamber to the working faces of said outer annular chamber.

13. A rotary engine comprising a casing forming an outer annular chamber and an inner annular chamber, a rotor mounted to rotate in said casing having a reinforced rim adapted to travel in said inner annular

chamber, an outer web portion upon the outside of said rim, a plurality of piston blades secured on the rim and adapted to travel in said outer annular chamber, an annular opening between said outer and inner chambers in which the outer web portion of said rotor rim is adapted to rotate, spring pressed packing rings having inner edges adapted to press against each side of said outer web portion, annular oil channels in each of said inner edges, said oil channels being adapted to contain lubricant to form an oil seal between said outer and inner annular chambers to practically eliminate any pressure in said outer annular chamber from entering said inner annular chamber.

14. An internal combustion engine comprising a casing having an annular chamber, a rotor comprising a plurality of piston blades adapted to rotate in said annular chamber, packing means for said piston blades to form tight working fits with the working faces of said annular chamber, said packing means comprising segmental plates, the segments of the several plates being in staggered relation to one another so that the divisions between each of two segments of one plate will be positioned opposite to the intact face of a segment of the adjacent plate, means for maintaining said segments in contact with the working faces of the said annular chamber, and means for conveying lubricant between said segmental plates, said lubricant forming a film between said plates whereby gas or the like is prevented from leaking from one side of a piston blade to the other side through such segmental plates.

15. An internal combustion engine comprising a casing forming an annular chamber, a shaft mounted in said casing, four piston blades connected to rotate with said shaft and adapted to travel in said annular chamber, a fuel inlet communicating with said annular chamber, a set of abutments mounted in said annular chamber to form a vacuum with each piston blade as it passes whereby to suck in a charge of fuel from the fuel inlet, a second set of abutments operatively mounted in said annular chamber to form a compression chamber with each piston blade whereby to compress the charge of fuel carried by said blade, cam means fixed to rotate with said shaft and rack and gear means connecting said cam means to said abutments whereby said abutments are opened and closed, said cam means being formed so that they will operate to open said abutments four times for every revolution of said shaft and being so timed that they will open for every blade as it passes through and to again close when said blade has passed through.

16. An internal combustion engine comprising a casing forming an annular chamber, piston blades adapted to travel in said annular chamber, a set of abutments operatively mounted in said annular chamber to form a compression chamber with a piston blade whereby to compress the charge of fuel carried by said blade, and then to form a firing chamber with the same blade, a valve chamber adapted to communicate with said annular chamber and coöperating with said set of abutments, a valve pivotally mounted in said valve chamber adapted to swing therein to successively establish communication between said valve and said annular chamber at one time to receive the fuel after it has been compressed, then to cut off communication and then to again establish communication with said annular chamber to convey said compressed charge to the annular chamber there to be fired.

17. An internal combustion engine comprising a casing forming an annular chamber, piston blades adapted to travel in said annular chamber, a set of abutments operatively mounted in said annular chamber to form a compression chamber with a piston blade whereby to compress the charge of fuel carried by said blade, and then to form a firing chamber with the same blade, a valve chamber adapted to communicate with said annular chamber and coöperating with said set of abutments, a valve mounted in said valve chamber adapted to establish communication between said valve chamber and said annular chamber at one time to receive the fuel after it has been compressed, then to cut off communication and to again establish communication with said annular chamber to convey said compressed charge to the annular chamber there to be fired, said abutments opening to permit said piston blade to pass while communication with said valve chamber is cut off and to again close before communication is again reëstablished with said valve chamber.

18. An internal combustion engine comprising a casing forming an annular chamber, piston blades adapted to travel in said annular chamber, a set of abutments operatively mounted in said annular chamber having a front face and a rear face, the front face being adapted to form a compression chamber with a piston blade whereby to compress the charge of fuel carried by said blade, the rear face of said abutments being adapted to form a firing chamber with said piston blade, the valve chamber having two series of openings adapted to be in communication with the annular chamber, one series of openings affording communication between the valve chamber and the annular chamber beyond the front face of said set of abutments, and the other series of openings affording communication between the valve chamber and the annular chamber beyond the rear face of said set of abutments, a

valve dividing said valve chamber into an inner and an outer compartment, said valve being adapted to successively establish communication between the inner compartment and the annular chamber which is beyond the front face of said set of abutments to permit the fuel after being compressed to enter said valve chamber while the outer compartment is in communication with the annular chamber beyond the rear face of said abutment members to pass out a charge from the valve chamber to the firing chamber, then to cut off communication of both the inner and outer chamber with the annular chamber, and then to establish communication between the inner compartment and the annular chamber beyond the rear face of said set of abutments at which time to permit the charge received to be passed into the firing chamber while the outer compartment is then in communication with the annular chamber beyond the front face of said set of abutments to receive a new charge of fuel after being compressed.

19. In the rotary engine having an annular chamber and piston blades adapted to travel in said chamber, a set of abutments mounted to contact with one another to form compression and firing chambers with said piston blades, each abutment comprising a body member having two rectangular plates, a primary recess between said plates having a concave bottom, a secondary recess in said concave bottom, resilient rings located in said secondary recess, segmental packing plates mounted in said primary recess and being pressed outward so as to present a resilient contacting edge for said abutments so that when the abutments meet they will form a non-leak fit between them.

20. In an internal combustion engine, the combination with a casing forming an annular chamber of a shaft mounted in said casing, piston blades connected to rotate with said shaft and adapted to travel in said annular chamber, sets of abutments reciprocatingly mounted to intermittently form firing and compression chambers and to operate to form a vacuum, cam means for reciprocating said sets of abutments, said cam means comprising cam grooves provided with crests, levers adapted to coöperate with said cam grooves to reciprocate said sets of abutments, and a pair of rollers rotatably mounted adjacent one another on the end of the lever, one of said rollers riding over said crests and the other of said rollers riding against the cam groove walls opposite said crests, so that the change in velocity imparted to the rollers as they roll around said cam groove will be compensated for.

21. A rotary engine having an annular chamber, piston blades having a tight working fit with said annular chamber, an inlet communicating with said annular chamber and adapted to supply fuel thereto, exhaust outlets communicating with said annular chamber, and perforated covers provided for said inlet and exhaust outlets which are flush with the face of said annular chamber to permit a tight working fit and yet prevent sagging of the piston blades when passing over said inlet and outlets.

22. In an internal combustion engine, the combination with a casing forming an annular chamber, pistons adapted to travel in said annular chamber, of a valve mechanism coöperating with said annular chamber to receive the charge of fuel from said annular chamber after being compressed, and then to re-deliver said charge to said annular chamber, said valve mechanism comprising a chamber, a valve dividing said chamber into an inner and an outer compartment, said valve being adapted to swing in said chamber to successively establish communication between the inner compartment and said annular chamber, to entirely shut off communication with said annular chamber, then to establish communication between the outer compartment and said annular chamber, and then to again shut off communication with said annular chamber, and two walls of said annular chambers being curved to form a tight working fit for said valve so as to prevent leakage between said inner and outer compartments.

23. In an internal combustion engine the combination with a casing forming an annular chamber, of a shaft mounted in said casing, piston blades connected to rotate with said shaft and adapted to travel in said annular chamber, sets of housing extensions upon the outer side walls of said casing, sets of abutments reciprocatingly mounted in said housing extensions and adapted to extend across said annular chamber to intermittently form firing and compression chambers and to operate to form a vacuum, the abutments of each set being provided with an outer rack member, a spur wheel mounted inside of each housing extension and adapted to mesh with said rack member, levers having segmental gear portions connected with said spur wheels, cams fixed to rotate with said shaft and provided with cam grooves, said cam grooves coöperating with said levers to rotate the spur wheels and move the rack members to thereby reciprocate said abutments.

24. In an internal combustion engine the combination with a casing forming an annular chamber, of a shaft mounted in said casing, piston blades connected to rotate with said shaft and adapted to travel in said annular chamber, valve mechanism coöperating with said annular chamber to receive the charge of fuel from said annular chamber after being compressed, and then to re-

deliver said charge to said annular chamber, said valve mechanism comprising a chamber, a valve dividing said chamber into an inner and an outer compartment, said valve being adapted to swing in said chamber to successively establish communication between the inner compartment and said annular chamber, to entirely shut off communication with said annular chamber, then to establish communication between the outer compartment and said annular chamber, and then to again shut off communication with said annular chamber, a lever fulcrumed at the side of the casing and connected to the valve, a sleeve member connected to said lever and provided with an internal helical thread, a rotatably mounted rod having an external helical thread adapted to engage with said internal helical thread, cams fixed to rotate with said shaft and provided with cam grooves, said cam grooves coöperating with said rotatably mounted rod to turn said rod to operate said internal and external helical threads to thereby move the lever to swing the valve.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 13th day of December, 1913.

FRANK JAY RICHARDS.

In presence of—

JAMES R. TOWNSEND,

WILLIAM N. KIRKLY.

Corrections in Letters Patent No. 1,154,886.

It is hereby certified that in Letters Patent No. 1,154,886, granted September 28, 1915, upon the application of Frank Jay Richards, of Los Angeles, California, for an improvement in "Rotary Engines," errors appear in the printed specification requiring correction as follows: Page 1, line 44, for the word "stranght" read *straight;* page 5, line 9, for the reference-numeral "75" read *75';* page 6, line 120, after the reference-numeral "35" insert the word *due;* page 11, second-named witness to the signature of the specification, for "William N. Kirkly" read *William N. Kirkby;* and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of November, A. D., 1915.

[SEAL.]

R. F. WHITEHEAD,

Acting Commissioner of Patents.