March 6, 1951 T. I. MOSELEY 2,544,433

RADAR SCANNER UNIT

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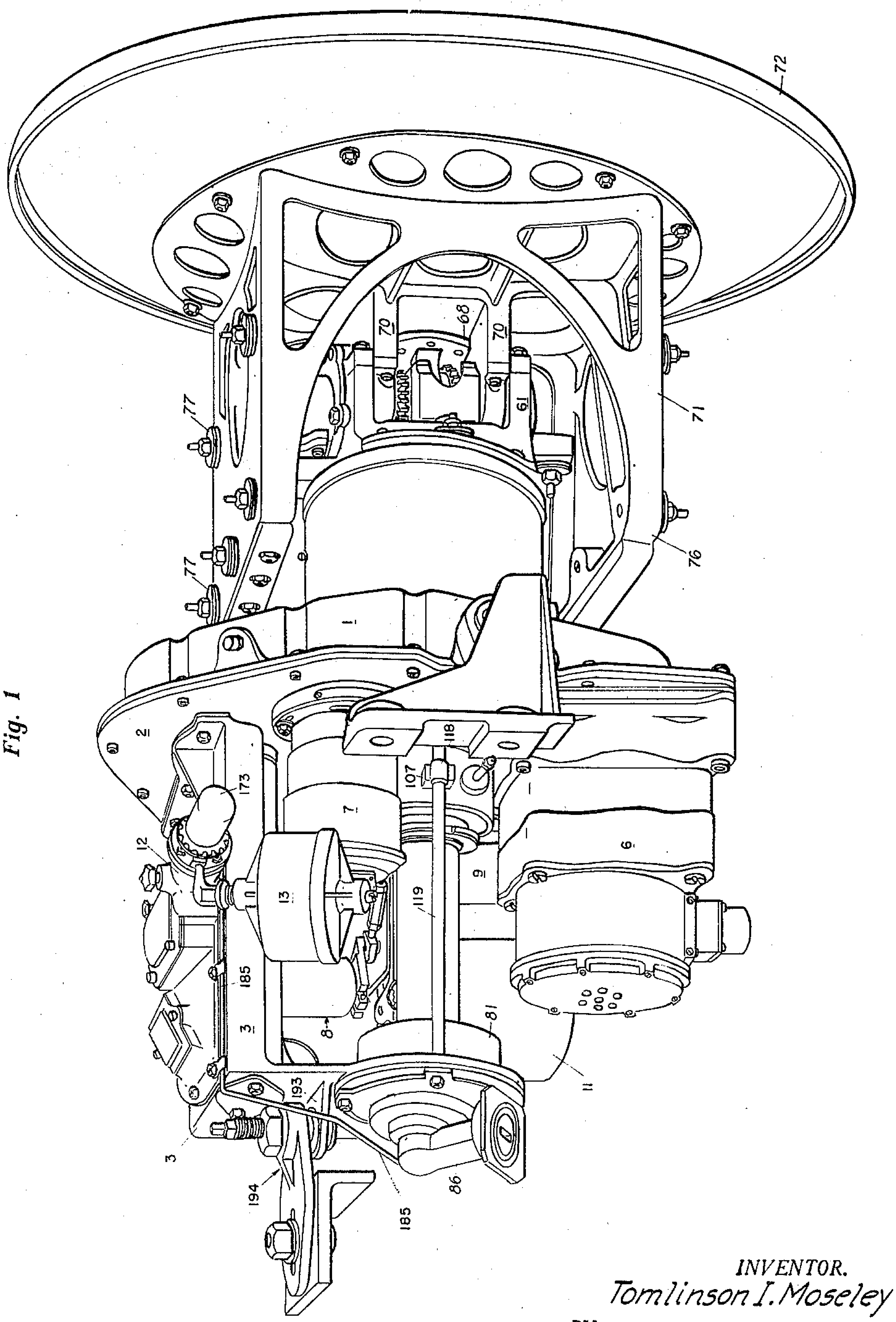

Fig. 1

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RADAR SCANNER UNIT

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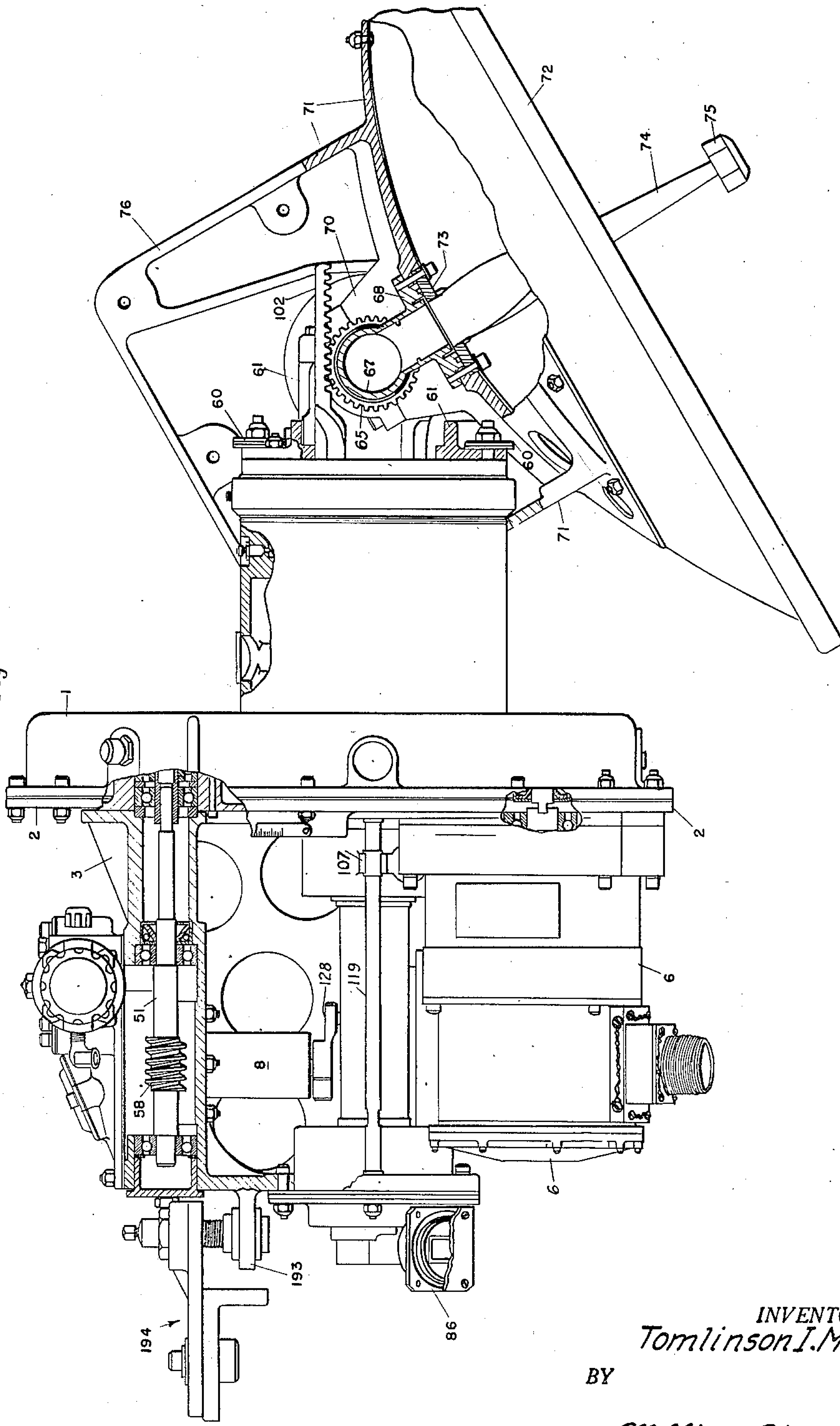

Fig. 2

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RADAR SCANNER UNIT

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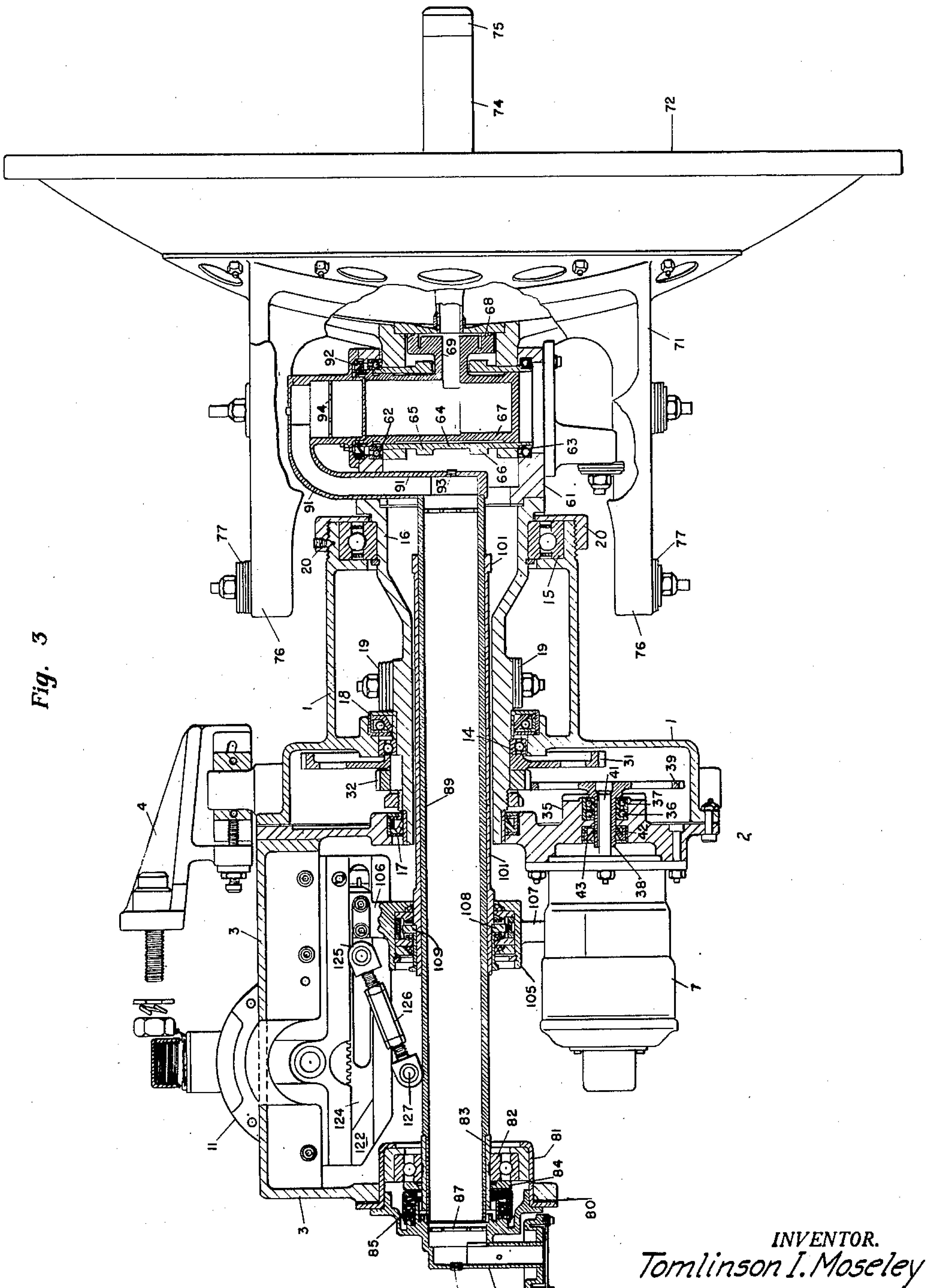

Fig. 3

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Fig. 4

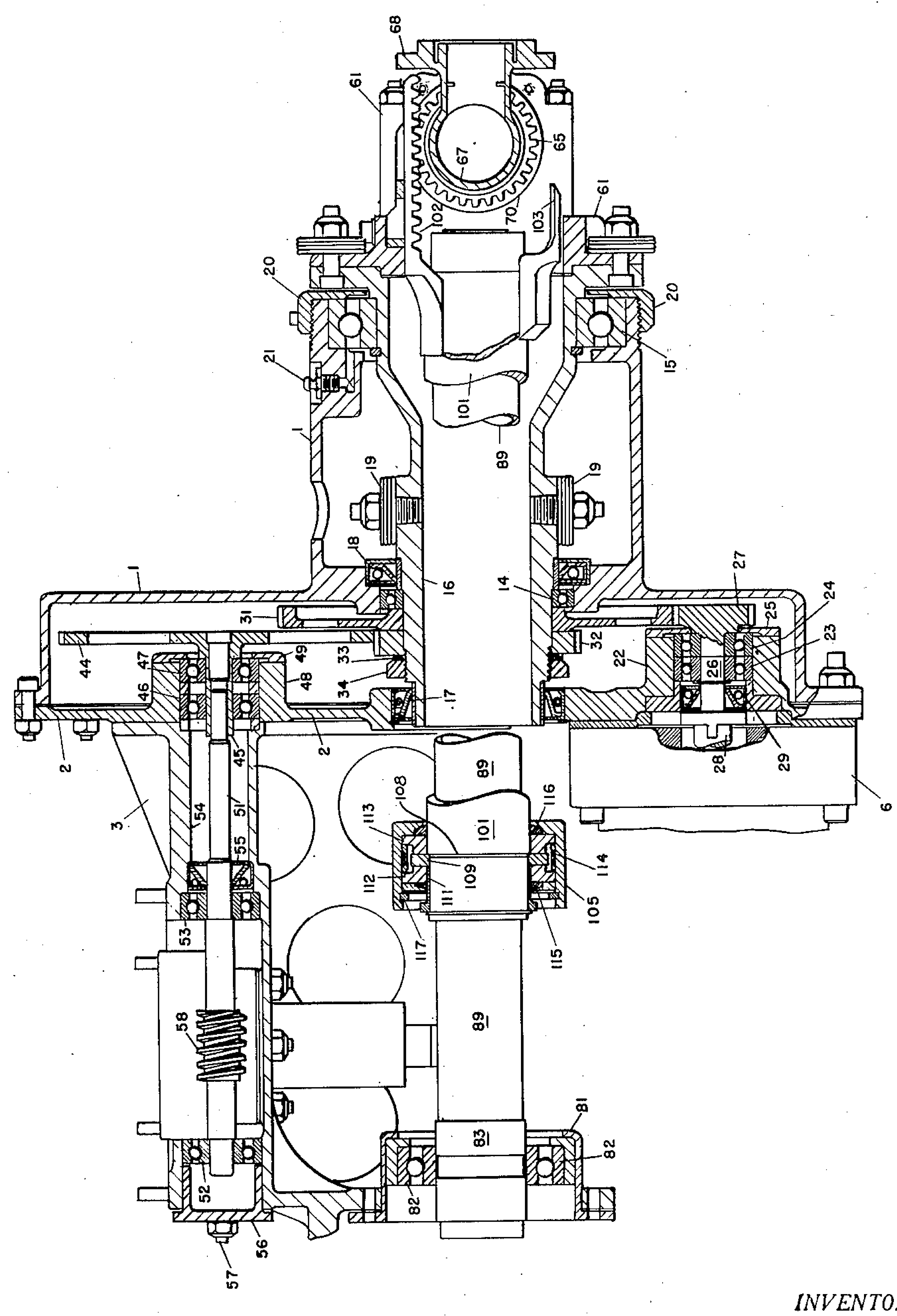

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Fig. 5

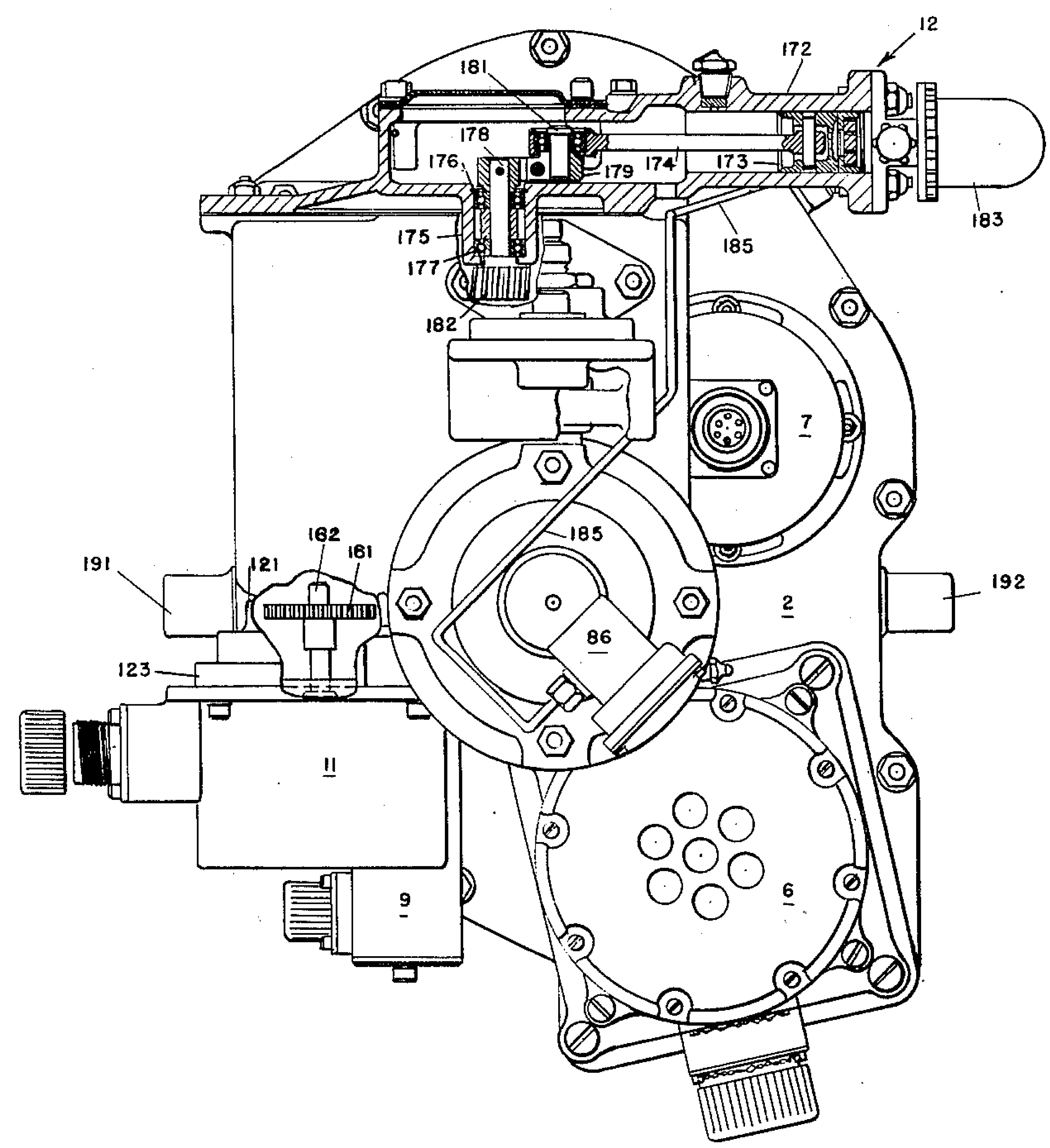

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Fig. 6

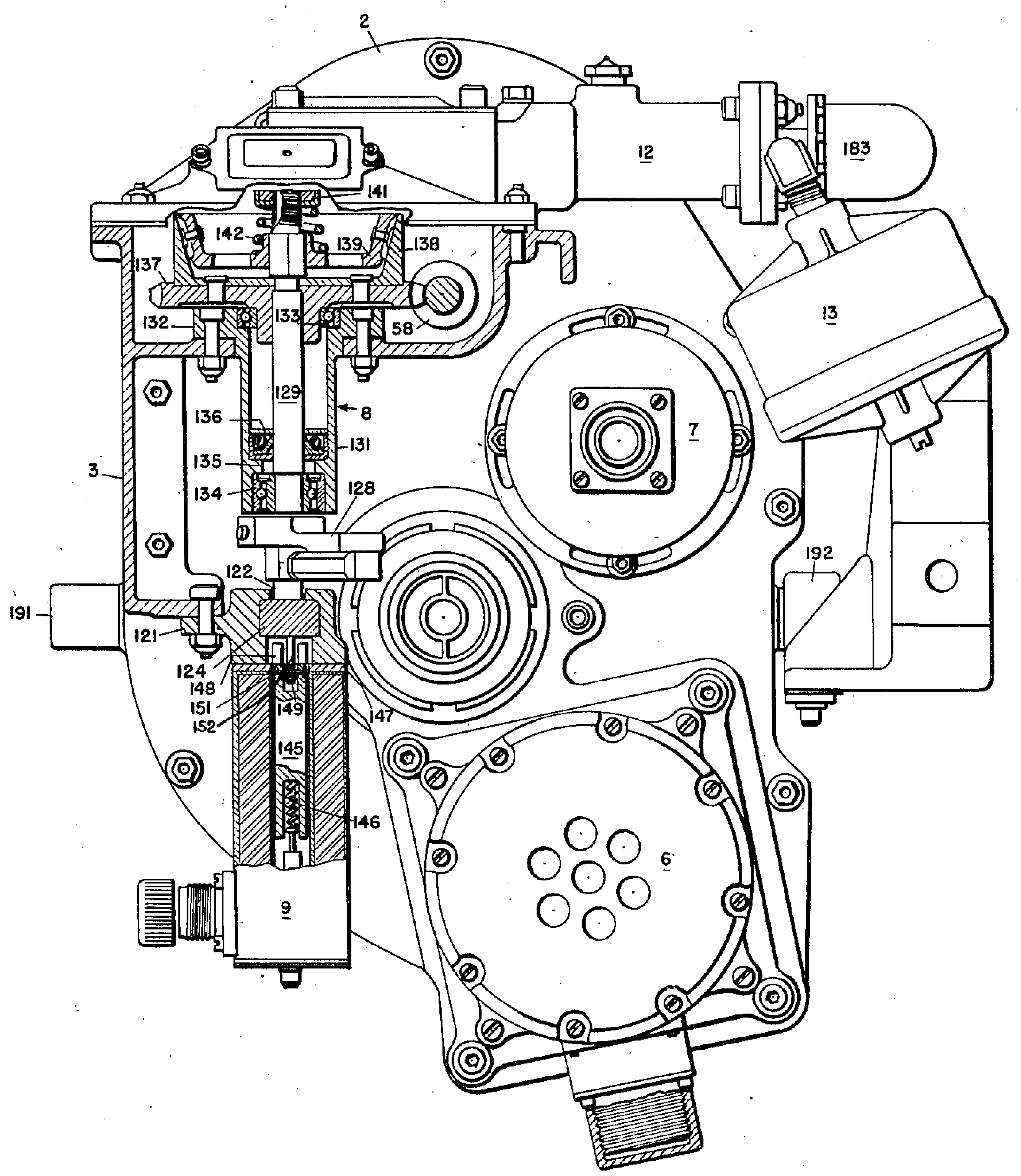

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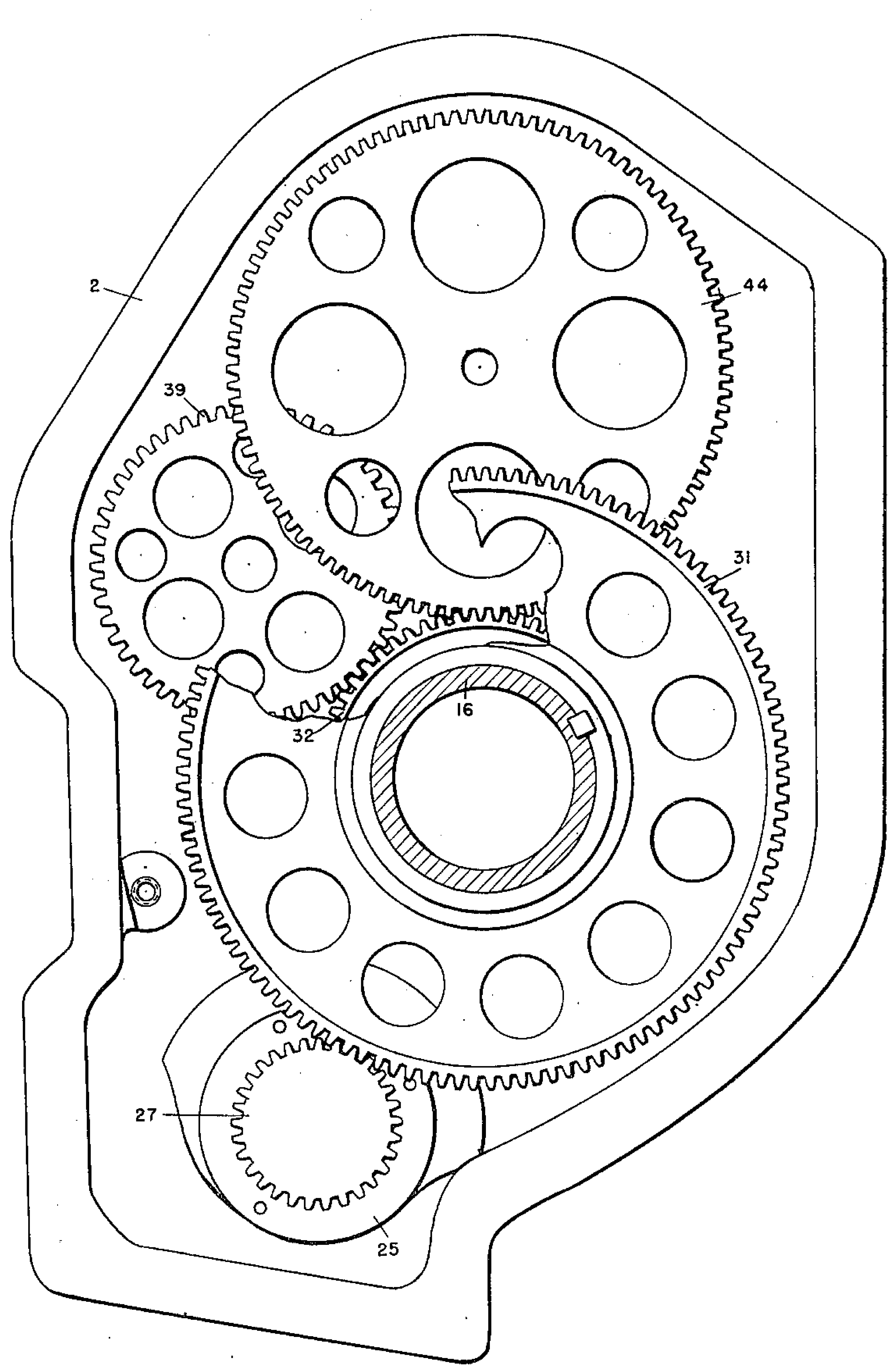
Fig. 7



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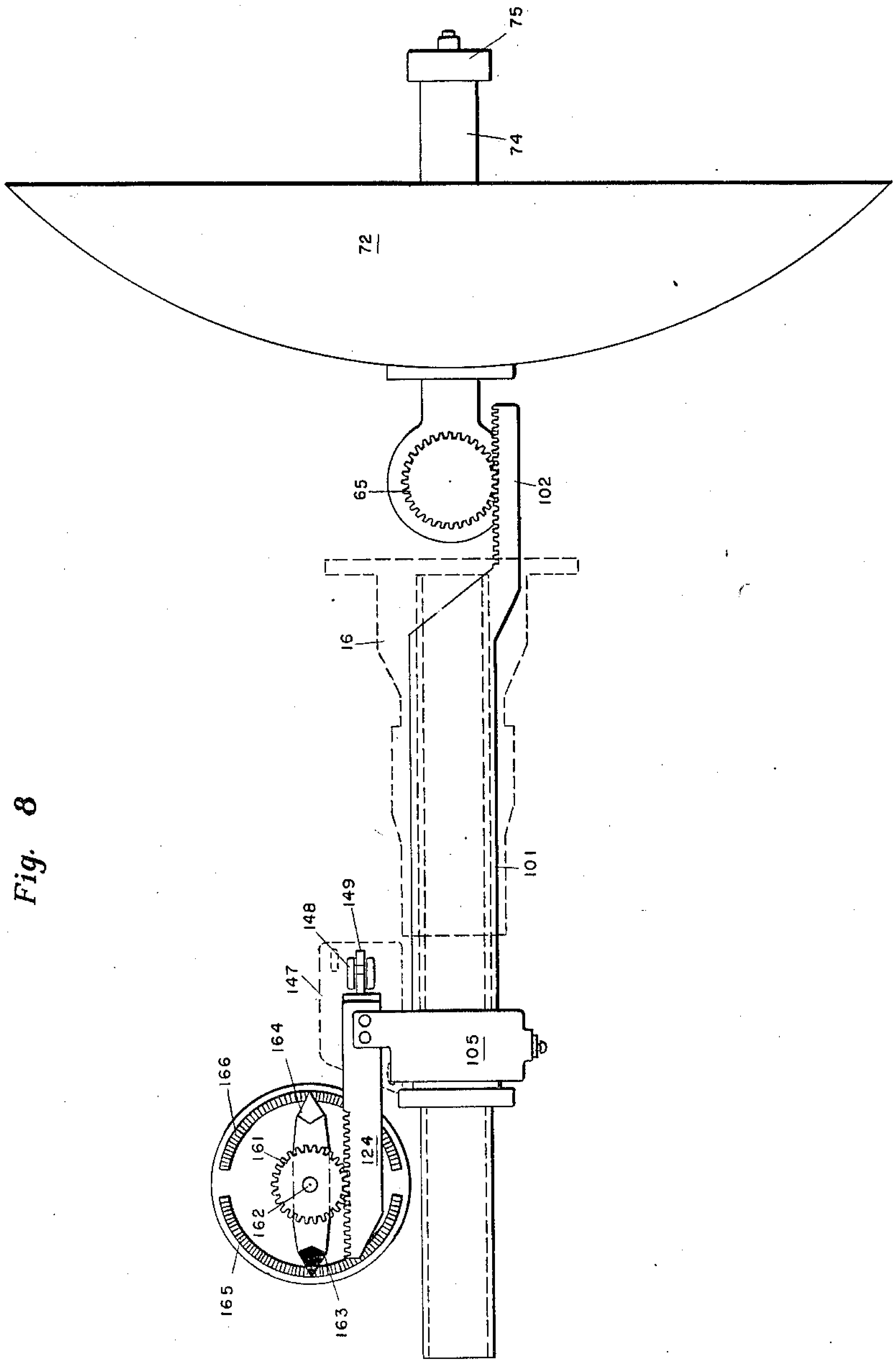

Fig. 8

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UNITED STATES PATENT OFFICE

2,544,433

RADAR SCANNER UNIT

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Application May 27, 1946, Serial No. 672,462

7 Claims. (Cl. 250—33.65)

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This invention relates to radar equipment and in general has for its object the provision of a rotary and oscillatory reflector and feed horn arranged continuously and progressively to scan a conical zone with a radio frequency wave and a generator and a potentiometer operating in synchronism with the antenna and reflector for continuously indicating on a screen, the angular position of the reflector with reference to its axis of rotation and the angular position of the reflector with respect to the axis of oscillation.

A further object of the invention is the provision of a simple and effective driving mechanism for simultaneously rotating and oscillating the parabolic reflector of a radar scanner and for actuating a generator and potentiometer in synchronism with the movement of the reflector.

Another object of the invention is the provision of a frame on which a parabolic reflector is mounted through a universal joint and which is so constructed and counterbalanced that it can readily be brought into dynamic balance with respect to its axis of rotation as well as with respect to its axis of oscillation.

Still another object of this invention is the provision of a radar scanning unit having a wave guide conduit, the interior of which within limits, can be maintained at any predetermined gaseous pressure irrespective of the pressure external thereto.

More specifically the object of this invention is the provision of a dynamically balanced scanning device including a frame in which a spindle is journaled for rotation by a motor through a suitable gear train. Swiveled to the spindle is a dynamically balancing head bracket on which is mounted a parabolic reflector provided with a feed horn extending along the axis of the reflector. Rotatably disposed within the spindle is a tubular wave guide terminating at its forward end in a goose neck through which it communicates with the feed horn. Slidably mounted over the wave guide is a reciprocating rack sleeve provided at its forward end with a rack operatively associated with a pinion secured to the head bracket so that the reciprocating movement of the sleeve will cause the reflector and its feed horn to oscillate or nod. Reciprocation of the rack sleeve is produced by the gear train through a clutch controlled crank arm. Normally the reflector is made to nod through a relatively wide angle (±60) but when a target has been brought into a specific position on the screen, it is desirable to restrict the angle of nod so that scanning takes place only in a zone immediately surrounding the target. Conveniently the nodding of the reflector is restricted by means of a solenoid operated latch, the solenoid being under the remote control of an operator. Mechanically coupled to the reciprocating rack sleeve are the arms of a potentiometer having an elevation section and an azimuth section connected across both phases of a two-phase generator driven by the scanner motor. The position of the two potentiometer arms determines the amplitude of both phases of the generator, the amplitudes of these phases being utilized to indicate the relative elevation and azimuth of the reflector through a suitable electrical circuit forming per se no part of the present invention.

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The invention possesses other advantageous features, some of which with the foregoing will be set forth at length in the following description where that form of the invention, which has been selected for illustration in the drawings accompanying and forming a part of the present specification is outlined in full. In said drawings, one form of the invention is shown, but it is to be understood that it is not limited to such form, since the invention, as set forth in the claims, may be embodied in a plurality of forms.

Fig. 1 is a perspective view of a radar scanner embodying the objects of my invention.

Fig. 2 is a side elevation of the scanner illustrated in Fig. 1 with portions broken away better to illustrate its construction and with its reflector assembly shown in a full nod position.

Fig. 3 is a longitudinal horizontal mid-section of the scanner shown in Fig. 1 except for the reflector and generator which are shown in plan.

Fig. 4 is a partial vertical mid-section of the scanner illustrated in Fig. 1 particularly showing the construction of its main gear housing, spindle housing, reciprocating rack sleeve and pinion, and rack sleeve driving mechanism.

Fig. 5 is a rear end elevation of the scanner with portions broken away better to illustrate the construction of its air pump.

Fig. 6 is a rear end elevation similar to that illustrated in Fig. 5 but showing in section the mechanism by which reciprocating motion is imparted to the rack sleeve from the gear train.

Fig. 7 is an interior view of the gear train looking rearwardly, with the gear housing removed and with portions of the gears broken away better to illustrate its construction.

Fig. 8 is a schematic top-plan view of the rack sleeve and oscillating mechanism, the potentiometer drive and solenoid stop mechanism.

The scanner shown in the various figures above described includes a gear housing 1, to which is bolted a housing cover 2 and a clutch unit bracket 3, all of which constitute a frame for the scanner.

Mounted on the housing cover 2 is a twenty-six volt motor 6, and a two-phase, twenty-cycle generator 7. Mounted on the clutch bracket 3 is a clutch unit 8, a solenoid 9, a potentiometer 11 and an air pump 12, and supported by the pump is an air filter and dehydrator 13.

Journaled for rotation within the housing 1 on ball bearings 14 and 15 is a forwardly diverging and flanged main spindle 16, the spindle being sealed to the housing cover 2 by a seal ring 17, and to the housing 1 by a seal ring 18. Screwed to the main spindle 16 are a plurality of peripherally spaced balancing washers 19 by which the spindle and its associated parts can be brought into dynamic balance. Screwed over the forward end of the spindle 16, is a bearing retaining ring 20 and provided in the housing 1 adjacent to and communicating with the ball bearing 15, is a lubricating nipple 21.

The housing cover 2 is formed with a forwardly extending boss 22 in which is mounted a pair of ball bearings 23 and 24, held in place by a retainer 25 (Fig. 4). Mounted in the ball bearings 23 and 24 is the shaft 26 of a motor drive pinion 27, the rear end of the shaft 26 being keyed to the forward end of the motor shaft 28. Surrounding the rearward end (left hand end as shown in Fig. 4) of the shaft 26 is a seal ring 29 for sealing the shaft to the housing cover 2. Meshing with the pinion 27 is a main gear 31, which, together with a concentric auxiliary gear 32, is locked to the main spindle 16 by a washer 33 and a lock nut 34. Formed in the housing cover 2 in alignment with the generator 7 is a boss 35 in which is mounted a pair of ball bearings 36 and 37, and journaled in these bearings is the hollow shaft 38 of a generator drive gear 39, the shaft 38 being keyed to the shaft 41 of the generator 7. Accommodated within a countersink 42, formed in the left face of the housing cover 2, is a seal ring 43, by which the hollow shaft 38 is sealed to the housing cover 2. The gear 39 meshes with the auxiliary gear 32 and is therefore driven by the motor 6 through the main gear 31 and the pinion 27. Also in mesh with the auxiliary gear 32 is a clutch drive gear 44 mounted on a hollow shaft 45, the shaft 45 being journaled in a pair of ball bearings 46 and 47 mounted in a boss 48 extending forwardly of the housing cover 2. Secured over the forward end of the boss 48 is a ball bearing retainer 49. Keyed to the hollow shaft 45 is a worm gear shaft 51 journaled in a pair of longitudinally spaced ball bearings 52 and 53, the ball bearings being mounted in a longitudinally extending chamber 54 formed in the clutch housing 3. Disposed between the chamber 54 and the shaft 51 is a seal ring 55, and closing the left end of the chamber 54 (as viewed in Fig. 4) is a cap 56 bolted to casting 3 by means of bolt 57. Provided intermediate the ends of shaft 51 is a worm gear 58, the function of which will be presently described.

Bolted to the right end of the main spindle 16, is a head pivot bracket 61, in which is mounted a pair of transversely spaced ball bearings 62 and 63 and to which is screwed a plurality of balancing washers 60 symmetrically disposed about its periphery. Journaled in the bearings 62 and 63 is an oscillating pinion sleeve 64, provided on its periphery with a pair of transversely spaced pinions 65 and 66. Disposed within the sleeve 64, and having a force fit therewith is an oscillating tube body 67, provided with an antenna feed connection 68, extending forwardly through an opening 69, formed in the sleeve 64 along the axis of the main spindle 16. Fixed to the sleeve 64 by means of rearwardly extending ears 70 is a U-shaped head bracket 71 to which is bolted a parabolic reflector 72, and bolted to the reflector 72 coaxially therewith and to the connection 68 is the base 73 of a feed horn 74. The feed horn 74 terminates in a cup 75 provided on its rear face with a pair of opposed windows through which a radio frequency wave or signal can pass to and from the reflector. It should be particularly noted that the legs 76 of the U-shaped bracket 71 extend rearwardly of and on either side of the oscillating tube body 67 and are provided with a plurality of balancing washers 77 (Fig. 3) so that the entire oscillating assembly can be brought into dynamic balance about its center of movement.

Mounted in the rear face of the clutch bracket 3 (see Figs. 3 and 4) over a gasket 80 is a bearing housing 81 in which is seated a ball bearing 82. Journaled in the bearing 82 is a collar 83 over which is seated a mating ring 84 for an oil and air seal 85. Fixed to the rear face of the bearing housing 81 and sealed with the oil and air seal 85 is a right angle wave guide connection 86 for connecting the scanner with a suitable source of radio frequency energy. Disposed across the connection 86 is a resonance ring 87 and screwed in its rear wall is a tuning button 88. A resonance ring is a filter for an unsymmetrical mode resulting from a rectangular to circular transition as is found in a rotary joint. Thus, whenever a transition is made from a rectangular guide to a circular guide both the $TE_{1,1}$ and $TM_{0,1}$ modes are excited. The $TM_{0,1}$ mode is a symmetrical mode which allows relative rotation of the upper and lower sections of the rotary joint with a minimum variation in power. However, the $TE_{1,1}$ mode is an unsymmetrical mode which causes a variation of power with rotation. The resonance ring 87 is introduced into the wave guide to filter out the unwanted $TE_{1,1}$ mode.

Secured within the sleeve 83 is the rear end of a wave guide tube 89 having its forward end secured and sealed to the inner end of a goose neck wave guide fitting 91. The outer end of the fitting 91 is sealed to the oscillating tube body 67 and head pivot bracket 61 by a seal ring 92. Screwed to the fitting 91 along the axis of the wave guide tube 89 is a tuning button 93 and extending across its outer end is a resonance ring 94.

From the above description it may be seen that a radio frequency energy wave or signal initiated from any suitable source can be made to traverse the wave guide connection 86, the wave guide tube 89, the goose neck fitting 91, the oscillating tube body 67 and the feed horn 74.

The antenna cup 75 directs the wave rearwardly to the reflector 72 which then reflects the wave outwardly in a divergent beam having a solid angle of about 6°. When the scanner is "on target" the returning "echo" wave or signal is picked up by the reflector and traverses in reverse, the path above described. During operation, the tube 89, fitting 91, tube body 67, reflector 72, feed horn 74, and cup 75 all rotate as an integral unit with the main spindle 16 which, as above described, is rotated by the motor 6 through the pinion 27 and the main gear 31. However, since the pinion sleeve 64 is journaled in the head pivot bracket 61 and since the reflector 72 and feed horn 74 are formed as integral units with the sleeve 64, the reflector 72 and feed horn 74 in addition to being free to rotate about the axis of the main spindle 16, are free to oscillate or nod about the axis of pinion sleeve 64. By oscillating these members through a plane angle of 60° on either side of the spindle axis, and simultaneously rotating them about the spindle axis, the 6° radio frequency energy beam can be made continuously and progressively to scan a solid angle of 120°, four times during each complete nod cycle.

Oscillation or nodding of the reflector and its associated parts is effected through a reciprocating mechanism including a rack sleeve 101 having a sliding fit over the wave guide tube 89 and with which the sleeve 101 rotates. Secured to the forward end of the sleeve 101 on one side thereof is a pair of longitudinally extending laterally spaced racks 102, one in mesh with each of the transversely spaced pinions 65 and 66 carried by the pinion sleeve 64. To balance the weight of the racks 102, the sleeve rack is provided on its side diametrically opposite the racks 102, with a pair of laterally spaced balancing members 103 (see Fig. 4). The reciprocation of the sleeve rack with its racks 102 in mesh with the pinions 65 and 66 therefore produces the required oscillation of the reflector 72 and its associated parts.

Disposed over the left end of the sleeve rack 101 (Figs. 3 and 4) is a thrust bearing housing 105 provided with a laterally extending slide lug 106 and with an opposed forked guide receiver 107. Fixed to the sleeve rack 101 in abutment with a shoulder 108 formed thereon is a thrust bearing rack 109 and abutting the rack 109 is a sleeve 111. Mounted on either side of the rack 109 and having running contact therewith are locking rings 112 and 113 and located between these two locking rings is a spacing ring 114. Disposed on either side of the rings 112 and 113 are gaskets 115 and 116, the assembly so described being held together by a split locking ring 117.

Seated in the forked guide receiver 107 (Fig. 1) is a guide bushing 118 slidably mounted on a guide rod 119, extending between and secured to the main housing cover 2 and to the rear face of the clutch bracket 3.

Bolted to the side face of the clutch bracket 3 (see Figs. 3, 5 and 6) is a potentiometer bracket 121 formed with an undercut runway or channel 122 and provided on the lower face of its rear end with an upwardly recessed potentiometer seat 123 to which the potentiometer 11 is bolted. Slidably mounted in the channel 122 is a potentiometer slide rack 124, and bolted to the forward end of this slide rack is a slide lug 106 (Fig. 3). Mounted on the potentiometer rack 124 is an upwardly extending connecting rod pin 125 on which one end of a longitudinally adjustable connecting rod 126 is journaled (Fig. 3). Secured to the opposite end of the connecting rod by a pin 127 is a crank 128 (Fig. 6) mounted on the lower end of a clutch shaft 129 of the clutch unit 8.

As shown in Fig. 6, the clutch unit 8 includes a housing 131 provided at its upper end with a flange 132 by which it is bolted to the clutch bracket 3. Mounted in the upper and lower ends of the clutch housing 131 are ball bearings 133 and 134 by which the clutch shaft 129 is journaled in the clutch housing, the bearing 134 being seated against an internal flange 135. Seated on the upper face of the flange 135 is a seal ring 136. Journaled on the shaft 129 somewhat below its upper end is a worm gear 137 arranged to mesh with and be continuously driven by the worm 58 formed on the shaft 51 (Figs. 2, 4 and 6). Screwed to the upper face of the worm gear 137 is a friction cone 138 and slidably keyed to the upper end of the shaft 129 is a conical clutch plate 139. Threaded over the upper end of the shaft 129 is a nut 141 and disposed between the nut 141 and the upper face of the clutch plate 139 is a spring 142 for continuously holding the clutch plate in frictional driving engagement with the friction cone 138.

As a result of the construction just described it will be seen that the worm 58 is driven by the motor 6 through the motor drive pinion 27, the auxiliary gear 32 and the clutch drive gear 44; that the worm 58 continuously drives the worm gear 137 and that unless there is slippage between the friction cone 138 and the clutch plate 139, the rotation of the worm gear 137 will be imparted to the shaft 129 and to the crank 128 carried on its lower end. Through the action of the connecting rod 126, the rotary movement of the crank 128 is translated into a reciprocatory movement of the potentiometer rack 124 and the thrust bearing housing 105 to which it is attached. Since the sleeve rack 101 is fixed to the housing 105, it will reciprocate with the potentiometer rack to cause the reflector 72 and its associated parts to nod or oscillate as above explained while on search for a target.

Sometimes it is desirable to limit scanning to a relatively small solid angle in the order of 15°. This results is produced by locking the potentiometer slide rack 124 against further reciprocation in such a position that the reflector 72 is held at an angle of about 3° off the axis of rotation. To this end the solenoid 9 is provided with a soft iron plunger 145 normally held in its elevated position by a spring 146. Mounted on the base 147 of the solenoid is a bifurcated bracket 148 on which is fulcrumed a latch or stop lever 149, the inner end of the stop lever being provided with a slot 151 for the reception of a pin 152 carried by the forked upper end of the solenoid plunger. Normally the free end of the stop lever 149 is in its depressed inactive position. However when the solenoid coil is energized, the plunger 145 is drawn downward, thereby causing the free end of the stop lever to swing upwardly into engagement with the rear end of the slide rack 124 and to thereby limit its stroke and the amplitude of nod of the reflector 72. It is to be noted that when this occurs slippage takes place between the friction cone 138 and clutch plate 139.

The potentiometer slide rack 124 in addition to imparting reciprocatory movement to the rack sleeve 101 is arranged to mesh with a pinion 161 fixed to the potentiometer shaft 162. Mounted on the shaft 162 are a pair of diametrically opposed coplanar and electrically independent potentiometer arms 163 and 164, arranged respectively to traverse over electrically independent resistance windings 165 and 166. Each of these windings subtends an angle of 170° and each of the contact arms travels over an arc of 160°, corresponding to the full 120° nod travel of the reflector. Although per se, the electrical circuit associated with scanner now under consideration forms no part of the present invention, it should be noted that the contact arms 163 and 164 traverse (back and forth) their respective potentiometer windings 165 and 166 in synchronism with the nodding of the reflector 72; that one of these windings constitutes an elevation section and the other an azimuth section; and that by connecting the potentiometer across both phases of the two-phase generator 7, the position of contact arms 163 and 164 can be made to determine the amplitude of these phases. By means of a suitable receiver-amplifier unit this electrical information can be interpreted and presented visually on the face of an indicator tube or screening, in a known manner, so as to indicate the relative elevation and azimuth of the reflector with respect to its frame and the airplane on which it is mounted at the instant that the echo signal is received.

Preferably the wave guide system or conduit including the guide tube 89, and its associated fittings should be maintained under a clean and dry, normal atmospheric pressure so as to prevent electrical breakdown when the aircraft on which the scanner is mounted, is operating in high altitudes. To insure this, a reciprocating pump (Fig. 5) generally designated by the reference numeral 12 and including a cylinder 172 is mounted on the upper face of the clutch bracket 3. Operatively disposed within the cylinder 172 is a piston 173 to which is secured a connection rod 174. Journaled in a bearing housing 175 by means of ball bearings 176 and 177 is a shaft 178, to the upper end of which is secured a crank 179, the free end of the connecting rod 174 being journaled to a pin 181 mounted on the outer end of the crank 179. Fastened to the lower end of the shaft 178 is a worm gear 182 arranged to mesh with and be driven by the worm gear 137 which in turn is driven by worm 58 formed on the shaft 51 (Fig. 2). Mounted over the outer end of cylinder 172 is a pressure chamber 183 provided with a spring loaded outwardly opening check valve set to open at normal atmospheric pressure. Communicating with the pump intake is the air filter and dehydrator 13 having an air intake provided with a suitable inwardly opening spring-loaded check valve. The pump discharge communicates through a line 185 with the wave guide connection 86.

For the purpose of mounting the scanner unit above described on the nacelle of an airplane and for adjusting it for elevation and azimuth the main housing 1 is provided with opposed, laterally extending trunnion pins 191 and 192 (see Fig. 5) which carry the main load of the scanner, and the clutch bracket 3 is provided with a bracket 193 mounting a suitable altitude adjustment mechanism 194, for bore-sighting. Azimuth adjustment for bore-sighting can be provided for in conjunction with one of the lateral trunnion pins 191 and 192 in conjunction with suitable mounting brackets provided on the nacelle.

The motor 6 operates at 26 volts plus or minus 3.5 volts and delivers power to the scanner at 6,000 R. P. M. plus or minus 1,000 R. P. M. at loads varying from 400 to 600 watts and preferably should be of the ball-bearing, air-cooled continuous duty type. At normal ambient temperatures (approximately 70° F.) the motor draws between 20 and 28 amperes and should drive the scanner at approximately 1,200 R. P. M. and 15 nod cycles per minute.

Conveniently the reflector can be made 17 inches in diameter with a focal length of 5⅔ inches and preferably is driven at a speed of 1,200 R. P. M.

In operation, radio frequency microwaves pass forwardly through the substantially air-tight wave-conduit or wave-guide and emerge from the opposed windows on the lower face of the antenna head or cup 74, as rings of electric energy with associated magnetic lines. The emerging microwave energy is reflected from the dish or reflector 72 in such a manner that the rays form a cone of approximately 6° solid angle. When the scanner is on target the echo wave is picked up by the reflector and then, as already explained, traverses in reverse, the path followed by the outgoing wave in passing through the wave-guide.

From the above description it will be observed that I have provided a scanning unit wherein the reflector assembly and its rotating and oscillating mechanism can be readily brought into dynamic balance; wherein the amplitude of nod of the reflector can be limited when the reflector is "on target"; wherein the wave-guide conduit can be maintained under any desired gaseous pressure; wherein means including a potentiometer and a generator driven in synchronism with the reflector, is provided by which the altitude and azimuth of the reflector with respect to the scanner frame can be determined; and which involves a relatively simple construction.

I claim:

1. A scanning unit comprising: a frame; a spindle journaled in said frame; a gear journaled on one end of said spindle for rotation on an axis perpendicular to the axis of said spindle; a parabolic reflector fixed to said gear and provided with a feed horn extending along the axis of the reflector; a wave guide communicating with the base of said feed horn; a rack sleeve mounted within said spindle for reciprocatory movement with respect thereto, said sleeve being provided with a rack in mesh with said gear; a potentiometer mounted on said frame and including a pair of resistance-coil sectors and a pair of contact arms arranged to traverse said sectors; means responsive to the movement of said rack sleeve for oscillating said contact arms; a generator mounted on said frame; and power means for simultaneously rotating said spindle continuously, reciprocating said sleeve and rotating said generator continuously in the same direction.

2. A scanning unit comprising: a frame; a spindle journaled on said frame; a gear journaled on one end of said spindle with its axis perpendicular to the axis of the spindle; a parabolic reflector fixed to said gear for bodily movement therewith; a feed horn mounted on said reflector along the axis thereof; a rotatable, longitudinally slidable rack sleeve mounted on said frame and extending through said spindle, said sleeve being provided with a rack arranged to mesh with and oscillate said gear on the axis thereof; a wave guide tube extending through said sleeve and communicating at its forward end with the base of said feed horn; a potentiometer mounted on said frame and including a pair of resistance-coil sectors and a pair of oscillating contact arms movable about a common axis and each arranged to traverse one of said sectors; means responsive to the sliding movement of said rack sleeve for oscillating said contact arms; a two-phase generator in electric circuit with said resistance-coil sectors; and means for simultaneously rotating said spindle continuously, reciprocating said rack sleeve and rotating said generator continuously in the same direction.

3. A scanning unit comprising: a frame; a

parabolic reflector swiveled to said frame for rotation about a first axis and simultaneous oscillation about a second axis intersecting said first axis at right angles thereto; a feed horn fastened to the apex of said reflector along the axis thereof; a wave guide tube communicating with the lower end of said feed horn; a pinion fixed to said reflector coaxial with said second axis; a rack mounted on said frame in mesh with said pinion for reciprocatory movement along a line parallel with said first axis; a potentiometer and a two-phase generator mounted on said frame, said potentiometer being in electrical circuit with said generator so as to control the amplitude of both of its phases; means for bodily rotating said reflector on said first axis and for simultaneously rotating said generator continuously in a single direction in synchronism therewith; means for reciprocating said rack; and means responsive to the movement of said rack for actuating said potentiometer so as to vary the amplitude of both phases of said generator in synchronism with the oscillatory movement of said reflector.

4. A scanning unit comprising: a frame; a spindle journaled in said frame for rotation on its own axis; a gear journaled on one end of said spindle with its axis intersecting the spindle axis at right angles thereto; a parabolic reflector fixed to said gear for oscillation therewith and for rotation with said spindle; a feed horn mounted on said reflector along the axis thereof; a rack sleeve extending through said spindle and mounted for rotation therewith and for longitudinal movement with respect thereto; a rack mounted on said rack sleeve in mesh with said gear; a wave guide tube extending through said sleeve and connected with said spindle for rotation therewith; means for establishing communication between said wave guide tube and the base of said feed horn; a potentiometer mounted on said frame, said potentiometer including a pair of fixed coaxial resistance-coil sectors, a shaft mounted coaxial with said sectors, a pair of contact arms secured to said shaft and arranged to traverse said sectors and a pinion fastened to said shaft; a potentiometer rack slidably mounted on said frame in mesh with said pinion; a friction clutch mounted on said frame including a fixed member and a spring-loaded rotary member; a clutch shaft fastened to said rotary member; a crank fastened to said clutch shaft; a connection journaled at one end to the outer end of said crank and pivoted at its other end to said potentiometer slide rack; a bracket fixed at one end to said slide rack and having at its other end a rotary but longitudinally fixed connection with said sleeve rack; generator supported by said frame in electrical circuit with said potentiometer; and means for simultaneously rotating said spindle, driving said clutch shaft and driving said generator.

5. A scanning unit comprising a frame, a spindle journaled in said frame, an antenna carried by said spindle for oscillation about an axis perpendicular to the spindle axis, a gear fixed to said antenna, a rack reciprocably mounted in said spindle and meshing with said gear for oscillating said antenna, means for rotating said spindle and antenna, and variable drive means connected to said rack for reciprocating it at any selected one of a plurality of linear extents along said spindle.

6. A scanning device comprising a frame, a reflector mounted thereon for nodding about a nod axis, a spindle for said reflector operable to rotate the same about a spin axis intersecting said nod axis, means for rotating said spindle, means for nodding said reflector, said nodding means comprising a reciprocable member, and electrical means including a pair of oscillatable contact members actuated simultaneously by said reciprocable member, one of said contact members having a traverse indicative of the elevation of said reflector and the other of said contact members having a traverse indicative of the azimuth of said reflector.

7. A scanning device comprising a frame, a reflector mounted thereon for nodding about a nod axis, a spindle for said reflector operable to rotate the same about a spin axis intersecting said nod axis, means for rotating said spindle, means for simultaneously nodding said reflector, said nodding means comprising a reciprocable member including a rack, a potentiometer having electrically independent arms traversing electrically independent resistance windings, and a pinion engaging said rack and operable when said rack is reciprocated to oscillate said arms, one of said arms having a traverse indicative of the elevation of said reflector and the other of said arms having a traverse indicative of the azimuth of said reflector.

TOMLINSON I. MOSELEY.

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