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(54) **Compressor with piston and cylinder piston, both performing orbital movements.**

(57) A compressor comprises a housing (51) having at least two axially spaced walls and rotatable in relation to the housing (51) piston (300) and cylinder-piston (250) journaled on eccentric portions (165, 185) of two oppositely rotatable shafts. The piston (300) and cylinder-piston (250) form moveable (306, 271) walls, and axially spaced walls of the housing (51) form stationary walls of at least two compression chambers (450). Circulated fluid is drawn into the compression chambers through intake ports (133) or intake valves and is discharged through discharge valves (129).

EP 0 014 723 A1

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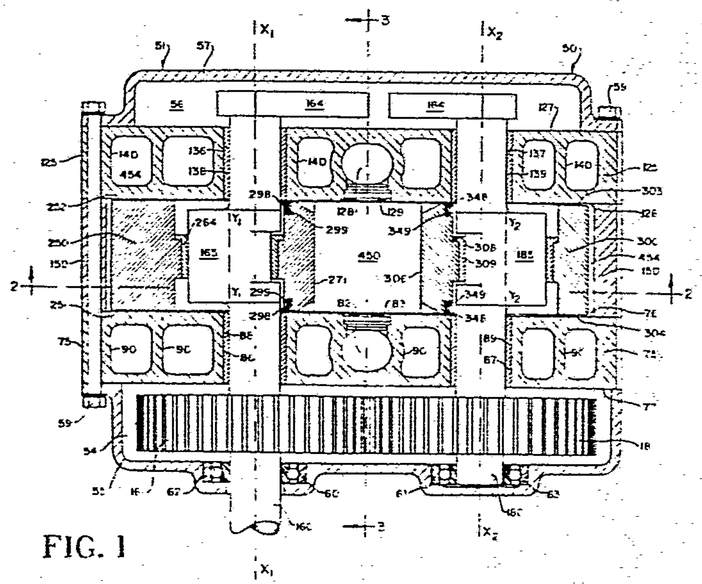

FIG. 1

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ROTARY COMPRESSOR

This invention relates particularly to a rotary compressor capable of compressing air and a variety of gases, mixtures, vapors and refrigerants.

The rotary compressor of this invention has a stationary housing and piston and cylinder-piston elements rotatable in relation to the housing and journaled on eccentric portions of two oppositely rotatable shafts. The piston and cylinder-piston elements form moveable walls and axially spaced stationary walls of the housing form stationary walls of at least one compression chamber. Fluid can be drawn into the compression chamber through intake ports or intake valves, and is discharged through discharge valves.

Reciprocating piston compressors are well known in the art. They possess, however, inherent disadvantages of having reciprocating motion of a piston causing high stresses in certain components, vibration, noise, and limiting their speeds. Due to speed limitations, the reciprocating compressors are relatively bulky and heavy machines. Further, they must be equipped with suction valves complicating their design, lowering efficiency and causing other numerous disadvantages.

Various types of rotary compressors have been proposed to replace the reciprocating piston compressor in order to overcome some of its disadvantages, and to realize new advantages. However, such efforts have not been fully successful and the reciprocating piston compressor continues to be in widespread use today.

Summary of the Invention

The rotary compressor of this invention comprises generally an outer housing within which one or more rotatable piston and cylinder-piston elements are received. The housing comprises at least two axially spaced walls, and the piston and cylinder-piston are operatively positioned between and adjacent to them. The piston and cylinder-piston are journaled on eccentric portions of two shafts. The shafts can be journaled in axially spaced walls of the housing and are interconnected by gearing means to transmit power from a drive shaft to a driven shaft and to coordinate their movements in such a way so the shafts rotate in coordinated rotations in opposite directions and with equal rotational speeds. The piston and cylinder-piston follow coordinated planetary movements in opposite directions with and about the eccentric portions of their shafts and form moveable walls of at least one compression chamber, whereas the stationary walls of the compression chamber are formed by the axially spaced walls of the housing.

Intake charge of fluid compressed by one version of the compressor of this invention can be drawn into the compression chamber or chambers through suitable intake port or ports sequentially opened and closed by the cylinder-piston and piston elements. In another version, the intake charge can be drawn into compression chamber or chambers through suitable intake valve or valves. The compressed fluid is discharged from the compression chamber through suitable discharge valve or valves.

Internal leakage between the piston and cylinder-piston, and between the piston and cylinder-piston and adjacent spaced walls of the housing can be controlled through use of a sealing system comprising sealing elements received within grooves of the piston and cylinder-piston and sealingly engaged with co-working surfaces of the cylinder-piston and axially spaced walls of the housing, or can be controlled through hydrodynamic sealing between co-working elements without use of any sealing elements, but as a result of suitable running clearances between co-working elements, suitable surface finish and use of lubricant of suitable viscosity as a sealing medium. The same lubricant can be used to lubricate bearings and gear transmission.

Statement of the Invention

The rotary compressor of this invention comprises generally:

a cylinder-piston comprising a body and spaced walls with opposing parallel surfaces extending from one end of the body and forming a U-shaped opening;

the cylinder-piston further having two side faces;

a piston positioned within the U-shaped opening of the cylinder-piston and having spaced faces adjoining the opposing parallel surfaces of the spaced walls;

the piston further having two spaced side faces;

two axially spaced housing walls adjoining side faces of the cylinder-piston and spaced side faces of the piston;

a rotatable cylinder-piston shaft comprising an eccentric portion journaled in the body of the cylinder-piston;

a rotatable piston shaft comprising an eccentric portion journaled in the piston;

gearing means interconnecting the cylinder-piston shaft and the piston shaft so both shafts follow coordinated rotations in opposite directions and the cylinder-piston and the piston follow coordinated planetary movements in opposite directions with and around the eccentric portions of the shafts;

the cylinder-piston and the piston forming moveable walls, and the axially spaced walls of the housing forming stationary walls of a variable volume compression chamber;

intake means leading to the compression chamber; and

discharge means leading from the compression chamber.

Brief Description of the Drawings

Fig. 1 is a longitudinal partial sectional view through a rotary compressor of this invention having one compression chamber and intake system with intake ports, taken along lines 1-1 in Figs. 2 and 3;

Fig. 2 is a transverse partial sectional view taken along line 2-2 of Fig. 1 and showing a piston and cylinder-piston journaled on eccentric portions of their shafts;

Fig. 3 is a vertical sectional view taken along line 3-3 of Fig. 1 and showing a compression chamber with intake and discharge systems;

Fig. 4 is a perspective view of two shafts with gears and balancing elements;

Fig. 5 is a perspective view of the cylinder-piston with its bearing and elements sealing the compression chamber and intake port assembled;

Fig. 6 is a perspective fragmentary view of the elements sealing the intake port exploded;

Fig. 7 is a perspective view of the piston with its bearing exploded and with elements sealing the compression chamber assembled;

Figs. 8 through 12 show several suitable shapes of the intake ports;

Fig. 13 is a vertical sectional view taken along line corresponding to 3-3 of Fig. 1 showing the compression chamber of a compressor having intake and discharge valves;

Fig. 14 is a perspective view of the cylinder-piston without a system for sealing intake ports;

Fig. 15 is a longitudinal partial sectional view through a rotary compressor of this invention having two compression chambers;

Figs. 16 and 17 are vertical sectional views taken along lines 16-16 and 17-17 of Fig. 15 and showing two compression chambers with intake systems having intake ports;

Fig. 18 is a perspective view of the cylinder-piston of two compression chambers compressor having a system for sealing of the intake ports;

Fig. 19 is a perspective view of the piston of two compression chambers compressor;

Figs. 20 and 21 are vertical sectional views taken along lines corresponding to 16-16 and 17-17 of Fig. 15, showing two compression chambers of a compressor with intake systems having intake valves;

Fig. 22 is a perspective view of the cylinder-piston of a two compression chambers compressor without systems for sealing intake ports;

Figs. 23 through 28 are transverse partial sectional views taken along line 2-2 of Fig. 1 showing the compressor having one compression chamber and intake system with intake ports undergoing one full cycle of operation;

Figs. 29 through 32 are transverse partial sectional views taken along line 2-2 of Fig. 1 and showing one compression chamber compressor having intake valves undergoing the full cycle of operation;

Figs. 33 through 40 are transverse partial sectional views taken along line 33-33 of Fig. 15 and showing two compression chambers compressor with intake ports undergoing full cycle of operation; and

Figs. 41 through 44 are transverse partial sectional views taken along line 33-33 of Fig. 15 and showing two compression chambers compressor with intake valves undergoing full cycle of operation.

Detailed Description of the Invention

Referring first to Figs. 1, 2 and 3 of the drawings, a rotary compressor of this invention having one compression chamber and intake ports is indicated by numeral 50. Compressor 50 comprises housing 51 within which piston 300 and cylinder-piston 250 forming moveable walls of compression chamber 450 are journaled on eccentric portions 165 and 185 of rotatable shafts 160 and 180.

Housing 51 comprises axially spaced housing walls 75 and 125 having surfaces 76 and 126 interconnected by peripheral wall 150 with inside surface 151 to form cavity 52. Spaced walls 75 and 125 form stationary walls of compression chamber 450 and portions of surfaces 76 and 126 of spaced walls 75 and 125 define stationary surfaces of compression chamber 450, while other portions of surfaces 76 and 126 and surface 151 of peripheral wall 150 define stationary surfaces of chamber 454 located around cylinder-piston 250 and piston 300 and within cavity 52. Gear transmission cover 55 forms with surface 77 of spaced wall 75 gear cavity 54, and counterbalance cover 57 forms with surface 127 of spaced wall 125 counterbalance cavity 56. Elements 55, 75, 150, 125 and 57 are fastened by suitable fastening means, as for example bolts 59.

In the embodiment illustrated spaced walls 75 and 125 are spaced axially along axes X_1-X_1 and X_2-X_2 of shafts 160 and 180 by peripheral wall 150 positioned between and secured to spaced walls 75 and 125. However, any suitable spacing means, different from those described, can be used to axially space walls 75 and 125 as required for operation of cylinder-piston 250 and piston 300.

Internal structures of spaced walls 75 and 125 are best shown in Figs. 1 and 3. Wall 75 has intake channel 78 communicating with compression chamber 450 through suitable intake port 79, and discharge channel 82 connected with compression chamber 450 by suitable discharge valve or valves 83. Wall 125 has intake channel 132 communicating with compression chamber 450 through suitable intake port 133, and discharge channel 128 connected with compression chamber 450 by suitable discharge valve or valves 129. Intake port 133 and discharge valves 129 are also shown in Fig. 2.

In the embodiment illustrated, the intake and discharge systems are shown in both axially spaced housing walls 75 and 125. However, any suitable combination of the intake and discharge systems in one or both spaced walls can be used.

Spaced walls 75 and 125 may have cooling chambers or passageways 90 and 140 to circulate suitable coolant. Chambers or passageways 90 and 140 may have cooling ribs on their internal surfaces to increase heat exchange surface area.

Cylinder-piston 250 with its elements sealing compression chamber 450 and intake port 133 and bearing 264 assembled is best shown in view of Fig. 5. The term "cylinder-piston" refers to an element operating as both a cylinder and a piston, although the configuration of this element is not at all geometrically cylindrical.

Cylinder-piston 250 comprises body 253 and spaced walls 254 and 255 extending from one end of body 253. Spaced walls 254 and 255 have opposing parallel surfaces 256 and 257 and form a U-shaped opening for a piston. Bearing 264 is mounted in passageway 261 of body 253.

At the end of cylinder-piston 250 body 253 remote from spaced walls 254 and 255 balancing elements 270 may be received in passageways 263. The purpose of balancing elements 270 is to balance the mases of spaced walls 254 and 255 to make the center of gravity of cylinder-piston 250 located on or close to axis Y_1-Y_1 common for bearing 264 and eccentric portion 165 of shaft 160. However, balancing of cylinder-piston 250 can be realized without use of separate balancing elements 270 when a sufficiently large portion of body 253 remote from spaced walls 254 and 255 acts as a balancing element to balance cylinder-piston 250.

Body 253 at the end adjacent to spaced walls 254 and 255 has surface 271 connecting two side faces 251 and 252, and further connecting opposing parallel surfaces 256 and 257 of spaced walls 254 and 255. Surfaces 256, 257 and 271 form three of four moveable surfaces of compression chamber 450.

Figure 7 shows piston 300 with its sealing elements assembled and bearing 309 exploded. Piston 300 has spaced side faces 303 and 304 interconnected by passageway 307 in which bearing 309 is mounted after assembly. Piston 300 has also pair of spaced faces 301 and 302 and pair of end faces 305 and 306. End face 306 connects spaced side faces 303 and 304 and spaced faces 301 and 302 and forms fourth moveable surface of compression chamber 450, changing the volume of compression chamber 450 during the operation of the compressor.

Due to its symmetrical shape piston 300 can be readily balanced to have its center of gravity located on or close to the axis Y_2-Y_2 which is common for bearing 309 and eccentric portion 185 of shaft 180.

Fig. 4 shows from the backside of the compressor shafts 160 and 180 assembled with their gears and balancing elements. Gears 161 and 181 and balancing elements 164 and 184 can be secured to shafts 160 and 180 by means such as suitable keys, splines, or any other suitable means. Gear 161 may have some material removed at 162; opposite portion 163 of gear 161 may be heavier and together with balancing element 164 may balance eccentric portion 165 and cylinder-piston 250 journaled thereon. Similarly, gear 181 may have suitable amount of material removed at 182; opposite portion 183 of gear 181 may balance, with balancing element 184 eccentric portion 185 and piston 300 journaled thereon.

Different balancing systems than above described can be used, however, to balance shafts 160 and 180. For example, a balancing system not utilizing gears but only balancing elements similar to balances 164 and 184 and suitably secured to shafts 160 and 180 can be used to balance one or both of shafts 160 and 180. Balanced shafts 160 and 180 have their centers of gravity located on or close to axes X_1-X_1 and X_2-X_2, as required for balanced operation of a rotary compressor of this invention.

Eccentric portions 165 and 185 can be cranks when shafts 160 and 180 are crankshafts, or they can be eccentrics when shafts 160 and 180 are eccentric shafts. Eccentric portions 165 and 175 have axes Y_1-Y_1 and Y_2-Y_2 eccentric from and parallel to axes X_1-X_1 and X_2-X_2 of shafts 160 and 180.

Assembled rotary compressor of the embodiment illustrated is best seen in Figs. 1 through 3.

Cylinder-piston 250 is journaled on eccentric portion 165 of shaft 160; piston 300 is journaled on eccentric portion 185 of shaft 180 and is slidably positioned between spaced walls 254 and 255 of cylinder-piston 250, forming the U-shaped opening for piston 300.

Shafts 160 and 180 are journaled in bearings 88, 89, 138 and 139 supported in their housings 86, 87, 136 and 137 in axially spaced housing walls 75 and 125.

Bearings 88 and 138 journal shaft 160, and bearings 89 and 139 journal shaft 180. Shafts 160 and 180 are spaced as required for meshing of gears 161 and 181 and operation of cylinder-piston 250 and piston 300 and are rotating around axes X_1-X_1 and X_2-X_2. This is best seen in views of Figs. 1 and 3.

Shafts 160 and 180 may be additionally journaled in bearings 62 and 63 supported in their housings 60 and 61 in gear transmission cover 55.

Also, any suitable journaling system for journaling of shafts 160 and 180 and different from above described can be used. For example, shafts 160 and 180 can be journaled in bearings suitably located in gear transmission cover 55 and in counterbalance cover 57 without being journaled in spaced walls 75 and 125, or any other suitable combination of bearings in elements 55, 75, 125 and 57, or in elements similar to covers 55 and 57 and suitalbe for supporting required bearings can be used. Elements journaling shafts 160 and 180 should be aligned by suitable means, as for example suitable dowel pins.

Bearing 309 of piston 300 is best seen exploded in view of Fig. 7. For assembly around eccentric portion 185 and between arms 186 and 187 of shaft 180 (when shaft 180 is a crankshaft) and within passageway 307 of piston 300, bearing 309 is split in to halves 310 and 311 having flanges 312 and 313. Flanges 312 and 313 may operatively position halves 310 and 311 against step 308 in passageway 307. Any other suitable means to position halves 310 and 311, different from above described, can be used instead of flanges 312 and 313. Halves 310 and 311 should be secured to piston 300 by suitable securing means, not shown. Bearing 264 of cylinder-piston 250, split in halves 265 and 267 having flange portions 266 and 268 (best visible in view of Fig. 14), can be mounted in passageway 261 in body 253 and around eccentric portion 165 of shaft 160 and between arms 166 and 167 of shaft 160 in a similar manner.

When shafts 160 and 180 are eccentric shafts having eccentrics 165 and 185 then suitable one-piece bearings can be used to journal cylinder-piston 250 and piston 300 on eccentrics 165 and 185.

Shafts 160 and 180 are interconnected by gears 161 and 181 to transmit power from a drive shaft to a driven shaft and to coordinate their rotations and rotate in coordinated rotations in opposite directions with equal speeds. Cylinder-piston 250 and piston 300 follow coordinated planetary movements in opposite directions with and around eccentric portions 165 and 185 of shafts 160 and 180. Spaced faces 301 and 302 of piston 300 are disposed adjacent to opposing parallel surfaces 256 and 257 of spaced walls 254 and 255 of cylinder-piston 250. Side face 251 of cylinder-piston 250 and spaced side face 304 of piston 300 are adjacent to surface 76 of wall 75. Likewise, side face 252 of cylinder-piston 250 and spaced side face 303 of piston 300 are disposed adjacent to surface 126 of wall 125. Surfaces 256, 257 and 271 of cylinder-piston 250 and end face 306 of piston 300 form moveable surfaces of compression chamber 450. Movement of surface 306 of piston 300 with respect to surfaces 256, 257 and 271 of cylinder-piston 250 changes the volume of variable volume compression chamber 450. Stationary surfaces of compression chamber 450 are formed by surfaces 76 and 126 of axially spaced housing walls 75 and 125.

For efficient operation of the rotary compressor embodying this invention, its compression chamber should be sealed. One solution is to introduce suitable sealing elements between co-working surfaces defining compression chamber 450. Such sealing system can comprise cylinder-piston sealing elements 298 located with their springs 299 in suitable grooves in side faces 251 and 252 and along edges of surfaces 271, 256 and 257 of cylinder-piston 250, and forming a part of compression chamber 450 sealing system. This is best shown in view of Fig. 5; springs 299 are shown in Figs. 1 and 3.

Another portion of compression chamber 450 sealing system is formed by sealing elements 348 located with their springs 349 in suitable grooves in piston 300 around edges of end face 306 and in corners between spaced side faces 303 and 304 and spaced faces 301 and 302. This is best seen in Fig. 7; springs 349 are shown in Figs. 1 and 2.

When fully assembled, sealing elements 298 are forced away from the bottom of the grooves in side faces 251 and 252 of cylinder-piston 250 by springs 299 into sealing engagement with surfaces 76 and 126 of spaced housing walls 75 and 125, and piston 300 sealing elements 348 are forced by springs 349 away from the bottom of their gooves into sealing engagement with surfaces 256 and 257 of walls 254 and 255 of cylinder-piston 250 and with surfaces 76 and 126 of spaced housing walls 75 and 125 to form a closed sealing path around compression chamber 450.

Another way to seal compression chamber 450 is to sealingly engage all moveable and stationary elements forming compression chamber 450 without any sealing elements. Such sealing engagement between spaced sides 301 and 302 of piston 300 disposed adjacent to opposing parallel surfaces 256 and 257 of walls 254 and 255 of cylinder-piston 250; between side face 251 of cylinder-piston 250 and spaced side face 304 of piston 300 adjacent to surface 76 of wall 75, and between side face 252 of cylinder-piston 250 and spaced side face 303 of piston 300 adjacent to surface 126 of spaced wall 125 can result from a combination of suitable clearances between these elements, suitable finish of their coacting surfaces, use of lubricant of suitable viscosity and suitable rotational speed of the compressor.

However, any suitable sealing system different from systems above described can be used to seal compression chamber 450 without departing from the spirit of this invention. Also, a combination of a sealing system comprising sealing elements between some of coacting surfaces with the system without sealing elements between other coacting surfaces forming compression chamber 450 can be used to seal compression chamber 450. In some instances, housing 51 can be made as a pressure tight vessel, and an interior of housing 51 can be pressurized to a certain pressure to minimize leakage from compression chamber 450 into cavity 52 regardless of the type of sealing system used to seal the compression chamber.

Intake ports 79 and 133 can be sealed by suitable sealing plates 290 and 282 located in flanges 291 and 276 of wall 255 of cylinder-piston 250. Plate 282 can be forced by springs 280 and 281, located in grooves 278 and 279 of flange 276 from its seat 277 against surface 126 of wall 125 to seal port 133 periodically during the operation of the compressor. Plate 282 with its springs exploded is best seen in Fig. 6; assembled plate 282 is best seen in Fig. 5. Second plate 290 sealing intake port 79 and located in flange 291 of cylinder-piston 250 is best seen in Fig. 3.

However, the compressor of this invention can operate without sealing of intake ports 79 and 133 in certain applications, and in some applications intake channels 78 and 132 can be connected with cavity 52 in any desired way.

It should be understood that sealing elements are located in their grooves with suitable clearances and tightness to prevent undesirable leakage between sealing elements and grooves in cylinder-piston 250 and piston 300.

Intake ports may be of any shape suitable for desired operating characteristics of the compressor. Several possible port configurations are described in connection with intake port 133 of compression chamber 450. Positioning of any version of port 133 in wall 125 is such that axis Z-Z lies in one plane with surface 257 of spaced wall 255 of cylinder-piston 250 when compression chamber 450 is at its minimum or maximum volume. The description is equally applicable to any intake port of any compressor according to the invention.

The intake port of the shape as illustrated in Fig. 8 opens when compression chamber 450 starts to increase its volume, and closes when the chamber reaches its maximum volume.

In the port having the shape as illustrated in Fig. 9, portion 141 of axially spaced wall 125 extending into port 133 allows for delayed opening of the port. This allows, when required, for decompression of the remaining compressed fluid in the compression chamber and for port opening after pressure equalization between the intake channel and compression chamber. For example, Fig. 24 shows intake port 133 of compression chamber 450 partially open, while the intake port featuring the shape as seen in Fig. 9 would still be closed.

The intake port as seen in Fig. 10 allows for opening of the port at the same time as illustrated in Fig. 8, but for delayed port closing. Portions of 142 of port 133 extending into spaced wall 125 deeper than in the port of Fig. 8 and enlarging the throughflow area of the port remain open after compression chamber 450 has reached its maximum volume. This allows for prolonged opening during which an additional amount of incoming charge may be forced into the compression chamber at the expense of the kinetic energy of the intake fluid flowing through the port at certain velocities. Thus, higher volumetric efficiencies could be realized than those possible with intake port as shown in Fig. 8.

Fig. 11 shows the intake port 133 which is a combination of shapes illustrated in Figs. 9 and 10. This allows for delay in both opening and closing of the port, thus improving the timing of the intake of the compressor.

Fig. 12 shows the intake port having two separate port openings 143 and 144, divided by a bridge section 145. Operation of this type of intake port is similar to operation of the port as illustrated in Fig. 11, but the opening time is still further delayed. Also, the presence of bridge 145 may be beneficial in guiding sealing elements of the compression chamber passing over the port during the operation of the compressor.

The compressor having one compression chamber with intake valves instead of intake ports is best illustrated in Fig. 13. In this version intake of fresh charge of compressible fluid takes place through intake channel 80 connected with compression chamber 450 by intake valves 81. Compressed fluid is discharged through discharge valves 129 into channel 128, as in the compressor having intake ports and shown in view of Fig. 3.

Fig. 14 shows cylinder-piston 250 with its bearing 264 exploded. Cylinder-piston 250 of Fig. 14 is shown without systems sealing intake ports, and can be used in compressors having intake valves, or in compressors having intake ports, but wherein the sealing of such intake ports is not required.

The two compression chamber compressors according to the invention are shown in Figs. 15 through 22.

The two compression chamber compressor having intake system with intake ports is best shown in Figs. 15, 16 and 17. In addition to features described in connection with the one chamber compressor (as shown in Figs. 1, 2 and 3), housing 51 of the two compression chamber compressor comprises additional intake and discharge systems located in walls 75 and 125 and serving second compression chamber 451. This is best shown in Figs. 15 and 17. Intake channel 86 is connected with compression chamber 451 by port 87 and is located in wall 75, and intake channel 132 with intake port 135 is located in wall 125. Discharge system of chamber 451 comprises discharge valves 85 and discharge channel 84 located in housing wall 75, and discharge valves 131 with discharge channel 130 located in spaced housing wall 125.

Cylinder-piston 250 of the two compression chamber compressor is best seen in Fig. 18. Cylinder-piston 250 of Fig. 18 comprises body 253 and spaced walls 254 and 255 extending from one end of body 253 and connected at their ends remote from body 253 by connecting wall 258. Spaced walls 254 and 255 have opposing parallel surfaces 256 and 257; body 253 has surface 271, and connecting wall 258 has surface 259 opposing surface 271 of body 253. Surfaces 256, 257, 259 and 271 define an opening in cylinder-piston 250 in which piston 300 operates adjacent to surfaces 256 and 257 and between surfaces 259 and 271.

Cylinder-piston 250 of Fig. 18 comprises also systems for sealing intake ports. System of wall 255 of cylinder-piston 250 of Fig. 5 is identical with sealing system of wall 255 of Fig. 18.

of such system applies here. System of sealing intake ports 87 and 135 of compression chamber 451 consists of plates 287 and 288, located with their springs in flanges 285 and 286 of wall 254 of cylinder-piston 250. This is best seen in Figs. 17 and 18.

Balancing of cylinder-piston 250 of Fig. 18 is similar to balancing of cylinder-piston 250 of Fig. 5, and spaced walls 254 and 255 with connecting wall 258 are balanced by suitable balances 270 or sufficiently heavy balancing portion of body 253 remote from spaced walls 254 and 255.

Piston 300 as shown in Fig. 19, is similar to the piston of Fig. 7, and the description of piston 300 of Fig. 7 and its balancing applies here.

Assembled two compression chamber compressor having intake system with intake ports is best seen in Figs. 15, 16 and 17 and in Figs. 33 through 40. The description of the assembled one compression chamber compressor applies here with the following additions.

Piston 300 of Fig. 19 is slidably positioned between spaced walls 254 and 255 of cylinder-piston 250 of Fig. 18. Spaced faces 301 and 302 of piston 300 are disposed adjacent to opposing parallel surfaces 256 and 257 of spaced walls 254 and 255 of cylinder-piston 250. Side face 251 of cylinder-piston 250 and spaced side face 304 of piston 300 are adjacent to surface 76 of wall 75, and side face 252 of cylinder-piston 250 and spaced side face 303 of piston 300 are adjacent to surface 126 of spaced wall 125. Surfaces 256, 257 and 271 of cylinder-piston 250, and end face 306 of piston 300 form moveable surfaces of compression chamber 450, while surface 259 of connecting wall 258, and surfaces 256 and 257 of spaced walls 254 and 255 of cylinder-piston 250, together with end face 305 of piston 300 form moveable surfaces of second compression chamber 451. Stationary surfaces of compression chambers 450 and 451 are formed by surfaces 76 and 126 of axially spaced housing walls 75 and 125. Movement of surface 306 of piston 300 with respect to surfaces 256, 257 and 271 of cylinder-piston 250 changes volume of compression chamber 450, while movement of surface 305 of piston 300 with respect to surfaces 256, 257 and 259 of cylinder-piston 250 changes volume of compression chamber 451. This is best illustrated in Figs. 33 through 40.

The two compression chamber compressor having intake valves is best seen in Figs. 20 and 21, showing both compression chambers 450 and 451 with their intake and discharge systems. Compression chamber 450 has intake valves 81 connected with intake channel 80, and discharge valves 129 leading into discharge channel 128. Compression chamber 451 has intake valves 89 connected with intake channel 88, and discharge valves 131 leading to discharge channel 130.

The intake and discharge valves of any version of the compressor of this invention can be any suitable intake or discharge valves, preferably compressor-type intake or discharge valves, and are not described here in more detail because their design and operation is well known to those skilled in the art.

Cylinder-piston 250 shown in Fig. 22 is identical with cylinder-piston shown in Fig. 18, but it does not have systems for sealing intake ports, and can be used in two compression chamber compressors having intake valves or intake ports but wherein the sealing of such intake ports is not required.

Sealing of compression chambers 450 and 451 of two compression chamber compressors can be accomplished by the hydrodynamic sealing, as described previously, or by use of suitable sealing elements. When sealing elements are used, system sealing chamber 450 can be identical with system sealing chamber 451. This is best visible in Fig. 18, wherein systems of sealing elements sealing chambers 450 and 451 are identical with system sealing chamber 450 of one compression chamber compressor version.

Sealing elements, sealing chambers 450 and 451 and located in piston ·300 are best seen in Fig. 19. Sealing elements 348 located around edges of end face 305 are similar to elements located around edges of end face 306, as described in one compression chamber compressor version. However, both sealing paths, located close to end faces 305 and 306 in two compression chambers compressor version are connected by corner seals 316, 317, 318 and 319, sealing corners of compression chambers 450 and 451. Corner seals 316, 317, 318 and 319 are best seen in Fig. 19.

A compressor of this invention having any desired number of compression chambers can be build by assembling desired number of cylinder-piston assemblies along suitable shafts having desired number of eccentric portions. More than two axially spaced stationary walls must then be used; such walls may have suitable bearings for journaling shafts between their eccentric portions, and any desired combination of the intake and discharge systems can be incorporated in the design of such axially spaced housing walls.

It is understood that intake channels of the compressor of this invention can be connected to an appropriate source of compressible fluid, and discharge channels can be connected to an appropriate receiver of compressed fluid. Flow of the intake charge is illustrated in Figs. 3, 13, 16, 17, 20 and 21 by clear arrows, and the discharge flow is illustrated in these figures by dotted arrows.

Bearings of the rotary compressor of this invention can be lubricated by any suitable lubricant which can be delivered to the bearings by suitable delivery lines located in stationary elements or in rotating shafts in accordance with the recognized parctice. The lubricant can be the same as lubricating gears 161 and 181 and coacting surfaces of cylinder-piston 250 and piston 300 with their seals and surfaces 76 and 126 of axially spaced housing walls 75 and 125. Lubricant from a suitable reservoir (not shown) can be distributed to lubricate bearings and other coacting surfaces by any suitable splash, gravity or pump-feed lubricating system. This compressor can also be built as an unlubricated or so-called oil-less machine by using suitable self-lubricating materials for bearings and coacting surfaces.

The rotary compressor of this invention can be constructed of any suitable materials dependent upon the particular use desired, and can be powered by any suitable prime mover.

<u>The Operation of the Invention</u>

During the operation of the rotary compressor of this invention, cylinder-piston 250 and piston 300 follow coordinated planetary movements in opposite directions with and around eccentric portions 165 and 185 of shafts 160 and 180. Movement of piston 300 in relation to cylinder-piston 250 results in changing volumes of compression chambers 450 and 451. Intake ports are opened and closed by cylinder-piston 250, and intake and discharge valves are opened and closed as required for intake and discharge of fluid circulated through the compressor. The operation of four versions of the compressor of this invention is now described in view of the drawings showing several representative positions of the piston and cylinder-piston elements:

1. The operation of the compressor having one compression chamber with intake ports and discharge valves:

Fig. 23 shows compression chamber 450 at its minimum volume – it represents the end of the discharge and the beginning of the intake stroke;

Fig. 24 shows the intake in progress; intake port 133 is partially open;

Fig. 25 shows the intake in progress with intake port 133 fully open;

Fig. 26 shows the intake still in progress but with intake port 133 partially closed;

Fig. 27 shows intake port 133 fully closed – it represents the end of the intake and the beginning of the compression stroke;

Fig. 28 shows compression in progress in compression chamber 450 – discharge will take place through discharge valves 129 and 83 when pressure in compression chamber 450 will reach desired level and when discharge valves open. Full cycle of operation will be completed when cylinder-piston 250 and piston 300 will again reach positions as illustrated in Fig. 23.

2. The operation of the compressor having one compression chamber and intake and discharge valves:

Fig. 29 shows compression chamber 450 at its minimum volume – it represents the end of the discharge and the beginning of the intake stroke when valve 79 opens;

Fig. 30 shows the intake stroke in progress;

Fig. 31 shows compression chamber 450 at its maximum volume – it represents the end of the intake and the beginning of the compression stroke;

Fig. 32 shows the compression stroke in progress in compression chamber 450 – discharge will begin when the pressure in chamber 450 will reach desired level and when discharge valves 129 will open.

The operation of the two compression chamber version of the compressor of this invention is described in shorter form, and some of the details of the operation of one compression chamber compressor may be applied here by the reader:

3. The operation of compressor having two compression chambers with intake ports and discharge valves:

Fig. 33 shows compression chamber 450 at the end of the discharge and the beginning of the intake stroke, and compression chamber 451 at the end of the intake and the beginning of the compression stroke;

Fig. 34: chamber 450 — intake in progress through intake ports, chamber 451 — compression in progress;

Fig. 35: chamber 450 — intake in progress, chamber 451 — compression in progress;

Fig. 36: chamber 450 — intake in progress, chamber 451 — compression in progress with the discharge taking place when pressure in chamber 451 reaches desired level;

Fig. 37: chamber 450 — the end of the intake stroke and the beginning of the compression stroke, chamber 451 — the end of the discharge and the beginning of the intake stroke;

Fig. 38: chamber 450 — compression in progress, chamber 451 — intake in progress through intake ports;

Fig. 39: chamber 450 — compression in progress with discharge taking place after the pressure in compression chamber 450 reaches desired level, chamber 451 — intake in progress.

4. The operation of the compressor of this invention having two compression chambers and intake and discharge valves:

Fig. 41: chamber 450 — end of compression and discharge and the beginning of the intake stroke, chamber 451 — the end of the intake and the beginning of the compression stroke;

Fig. 42: chamber 450 — the intake in progress, chamber 451 — the compression in progress;

Fig. 43: chamber 450 — the end of the intake and

the beginning of the compression stroke, chamber 451 – the end of the compression and discharge and the beginning of the intake stroke; and

Fig. 44: chamber 450 – the compression (and discharge after pressure in chamber 450 reaches desired level) in progress, chamber 451 – the intake stroke in progress.

While in the foregoing specification this invention has been described in relation to certain preferred embodiments thereof, and many details have been set forth for purpose of illustration, it will be apparent to those skilled in the art that the invention is susceptible to additional embodiments and that certain of the details described herein can be varied considerably without departing from the basic principles of the invention.

I CLAIM:

1. A rotary compressor comprising:

a cylinder-piston (250) comprising a body (253) and spaced walls (254, 255) with opposing parallel surfaces (256, 257), said spaced walls (254, 255) extending from one end of said body (253) and forming a U-shaped opening;

said cylinder-piston (250) further having two side faces (251, 252);

a piston (300) positioned within said U-shaped opening of said cylinder-piston (250) and having spaced faces (301, 302) adjoining said opposing parallel surfaces (256, 257) of said spaced walls (254, 255) of said cylinder-piston (250);

said piston (300) further having two spaced side faces (303, 304);

two spaced housing walls (75, 125) adjoining said side faces (251, 252) of said cylinder-piston (250) and said spaced side faces (303, 304) of said piston (300);

a rotatable cylinder-piston shaft (160) comprising an eccentric portion (165) journaled in said body (253) of said cylinder-piston (250);

a rotatable piston shaft (180) comprising an eccentric portion (185) journaled in said piston (300);

gearing means (161, 181) interconnecting said cylinder-piston shaft (160) and said piston shaft (180) so said shafts (160, 180) follow coordinated rotations in opposite directions and said cylinder-piston (250) and said piston (300) follow coordinated planetary movements in opposite directions with and around said eccentric portions (165, 185) of said shafts (160, 180);

said cylinder-piston (250) and said piston (300) forming moveable surfaces (256, 257, 271, 306), and said spaced housing walls (75, 125) forming stationary surfaces (76, 126) of a compression chamber (450) located between said body (253) of said cylinder-piston (250) and said piston (300) and varying in volume upon said coordinated planetary movements in opposite directions of said cylinder-piston (250) and said piston (300);

intake means leading to saie compression chamber (450); and

discharge means leading from said compression chamber (450).

2. The compressor of Claim 1 wherein said cylinder-piston shaft (160) and said piston shaft (180) are journaled in bearings (88, 89, 138, 139) located in said spaced housing walls (75, 125).

3. The compressor of Claim 1 wherein said gearing means comprise gears (161, 181) having equal number of teeth so said cylinder-piston shaft (160) and said piston shaft (180) interconnected by said gears (161, 181) rotate with equal rotational speeds in opposite directions.

4. The compressor of Claim 1 wherein said eccentric

portion (165) of said cylinder-piston shaft (160) is journaled in bearing (264) located in said body (253) of said cylinder-piston (250), and wherein said eccentric portion (185) of said piston shaft (180) is journaled in bearing (309) located in said piston (300).

5. The compressor of Claim 4 wherein said cylinder-piston shaft (160) and said piston shaft (180) are crankshafts and wherein said eccentric portions (165, 185) of said cylinder-piston shaft (160) and said piston shaft (180) are cranks, and wherein said bearings (264, 309) located in said body (253) of said cylinder-piston (250) and in said piston (300) are split in halves (256, 267, 310, 311) to allow for assembly in said body (253) of said cylinder-piston (250) and in said piston (300) and around said cranks of said crankshafts.

6. The compressor of Claim 4 wherein said cylinder-piston shaft (160) and said piston shaft (180) are eccentric shafts and wherein said eccentric portions (165, 185) of said cylinder-piston shaft (160) and said piston shaft (180) are eccentrics, and wherein said bearings (264, 309) located in said body (253) of said cylinder-piston (250) and in said piston (300) are one piece bearings.

7. The compressor of Claim 1 which further comprises a balancing means, wherein said balancing means comprise cylinder-piston (250) balancing means comprising said cylinder-piston (250) balancing portion located in a part of said body (253) of said cylinder-piston (250) remote from said spaced walls (254, 255), said balancing portion making the center of gravity of said cylinder-piston (250) located on or close to the axis (Y_1-Y_1) of said bearing (264) mounted in said body (253) of said cylinder-piston (250); and wherein said balancing means

comprise piston (300) balancing means, said piston (300) balancing means being such design of said piston (300) so said piston (300) has its center of gravity located on or close to the axis (Y_2-Y_2) of said bearing (309) mounted in said piston (300); and wherein said balancing means further comprise cylinder-piston shaft (160) and piston shaft (180) balancing means, said last mentioned means comprising balancing elements (164, 184) secured to said shafts (160, 180) and making the centers of gravity of said shafts (160, 180) assembled with said cylinder-piston (250) and said piston (300) located on or close to the axes (X_1-X_1, X_2-X_2) of said cylinder-piston shaft (160) and said piston shaft (180).

8. The compressor of Claim 1 wherein said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125) are sealingly engaged in forming said compression chamber (450).

9. The compressor of Claim 8 wherein said sealing engagement between said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125) results from use of sealing means comprising sealing elements (298, 348) located with springs (299, 349) in grooves in said cylinder-piston (250) and in said piston (300) and forming sealing path around said compression chamber (450).

10. The compressor of Claim 8 wherein said sealing engagement between said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125) results from a combination of suitable running clearances between said cylinder-piston (250) and said piston (300) and between said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125), suitable finish of coacting surfaces (251, 252, 256, 257) of said cylinder-piston (250), coacting surfaces (301, 302, 303, 304) of said piston (300) and coacting surfaces (76,

126) of said spaced housing walls (75, 125), and use of lubricant of suitable viscosity to lubricate said coacting surfaces (251, 252, 256, 257, 301, 302, 303, 304, 76, 126) of said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125).

11. The compressor of Claim 1 wherein said intake means leading to said compression chamber (450) comprise at least one intake port (79 or 133) located in one of said spaced housing walls (75, 125), said intake port (79 or 133) being sequentially opened and closed by said cylinder-piston (250) and said piston (300) to allow for required flow of incoming charge into said compression chamber (450).

12. The compressor of Claim 11 wherein said intake port (79 or 133) is opened by said cylinder-piston (250) and said piston (300) when said compression chamber (450) is at about its minimum volume, and wherein said intake port (79 or 133) is closed by said cylinder-piston (250) when said compression chamber (450) is at about its maximum volume.

13. The compressor of Claim 11 wherein said intake port (79 or 133) comprises a portion (141) of said spaced housing wall (75 or 125) extending into a mid-portion of said intake port (79 or 133), and wherein said portion (141) of said spaced housing wall (75 or 125) extending into said mid-portion of said intake port (79 or 133) delays the opening of said port (79 or 133) by said cylinder-piston (250) and said piston (300).

14. The compressor of Claim 11 wherein said intake port (79 or 133) has portions (142) extending from said port (79 or 133) into said spaced housing walls (75, 125) and delaying the closing of said port (79 or 133) by said cylinder-piston (250).

15. The compressor of Claim 1 wherein said intake means leading to said compression chamber (450) comprise

at least one intake valve (81) located in at least one (75) of said spaced housing walls (75, 125).

16. The compressor of Claim 1 wherein said discharge means leading from said compression chamber (450) comprise at least one discharge valve (83 or 129) located in at least one of said spaced housing walls (75, 125).

17. The compressor of Claim 1 which further comprises lubricating means, said lubricating means comprising a lubricant reservoir containing suitable lubricant lubricating said coacting surfaces (251, 252, 256, 257, 301, 302, 303, 304, 76, 126) of said cylinder-piston (250), said piston (300), said spaced housing walls (75, 125), further lubricating said gears (161, 181) interconnecting said cylinder-piston shaft (160) and said piston shaft (180), and said bearings (88, 264, 138, 89, 309, 139) of said cylinder-piston shaft (160) and said piston shaft (180).

18. The compressor of Claim 1 which further comprises a cooling means, said cooling means comprising a plurality of passageways (90, 140) located in said spaced housing walls (75, 125) in which suitable coolant is circulated.

19. The compressor of Claim 1 wherein said cylinder-piston (250) further comprises a connecting wall (258) connecting said spaced walls (254, 255) of said cylinder-piston (250) at their ends remote from said body (253) of said cylinder-piston (250), and wherein said spaced walls (254, 255) and said connecting wall (258) of said cylinder-piston (250) and said piston (300) form moveable surfaces (256, 257, 259, 305), and said spaced housing walls (75, 125) form stationary surfaces (76, 126) of a second compression chamber (451) located between said piston (300) and said connecting wall (258) of said cylinder-piston (250) and varying in

volume upon said coordinated planetary movements in opposite directions of said cylinder-piston (250) and said piston (300), and wherein said second compression chamber (451) has intake means leading to, and discharge means leading from said second compression chamber (451).

20. The compressor of Claim 19 wherein said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125) are sealingly engaged in forming said second compression chamber (451).

21. The compressor of Claim 20 wherein said sealing engagement between said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125) forming said second compression chamber (451) results from use of sealing means comprising sealing elements (298, 316, 317, 318, 319, 348) located with springs (299, 349) in grooves in said cylinder-piston (250) and in said piston (300) and forming a sealing path around said second compression chamber (451).

22. The compressor of Claim 20 wherein said sealing engagement between said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125) forming said second compression chamber (451) results from a combination of suitable running clearances between said cylinder-piston (250) and said piston (300) and between said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125), suitable finish of coacting surfaces (251, 252, 256, 257) of said cylinder-piston (250), coacting surfaces (301, 302, 303, 304) of said piston (300) and coacting surfaces (76, 126) of said spaced housing walls (75, 125), and use of lubricant of suitable viscosity to lubricate said coacting surfaces (251, 252, 256, 257, 301, 302, 303, 304, 76, 126) of said cylinder-piston (250), said piston (300) and said spaced housing walls (75, 125).

23. The compressor of Claim 19 wherein said intake means leading to said second compression chamber (451) comprise at least one intake port (87 or 135) located in at least one of said spaced housing walls (75, 125), said intake port (87 or 135) being sequentially opened and closed by said cylinder-piston (250) and said piston (300) to allow for required flow of incoming charge into said second compression chamber (451).

24. The compressor of Claim 19 wherein said intake means leading to said second compression chamber (451) comprise at least one intake valve (89) located in at least one (75) of said spaced housing walls (75, 125).

25. The compressor of Claim 19 wherein said discharge means leading from said second compression chamber (451) comprise at least one discharge valve (131) located in at least one (125) of said spaced housing walls (75,125).

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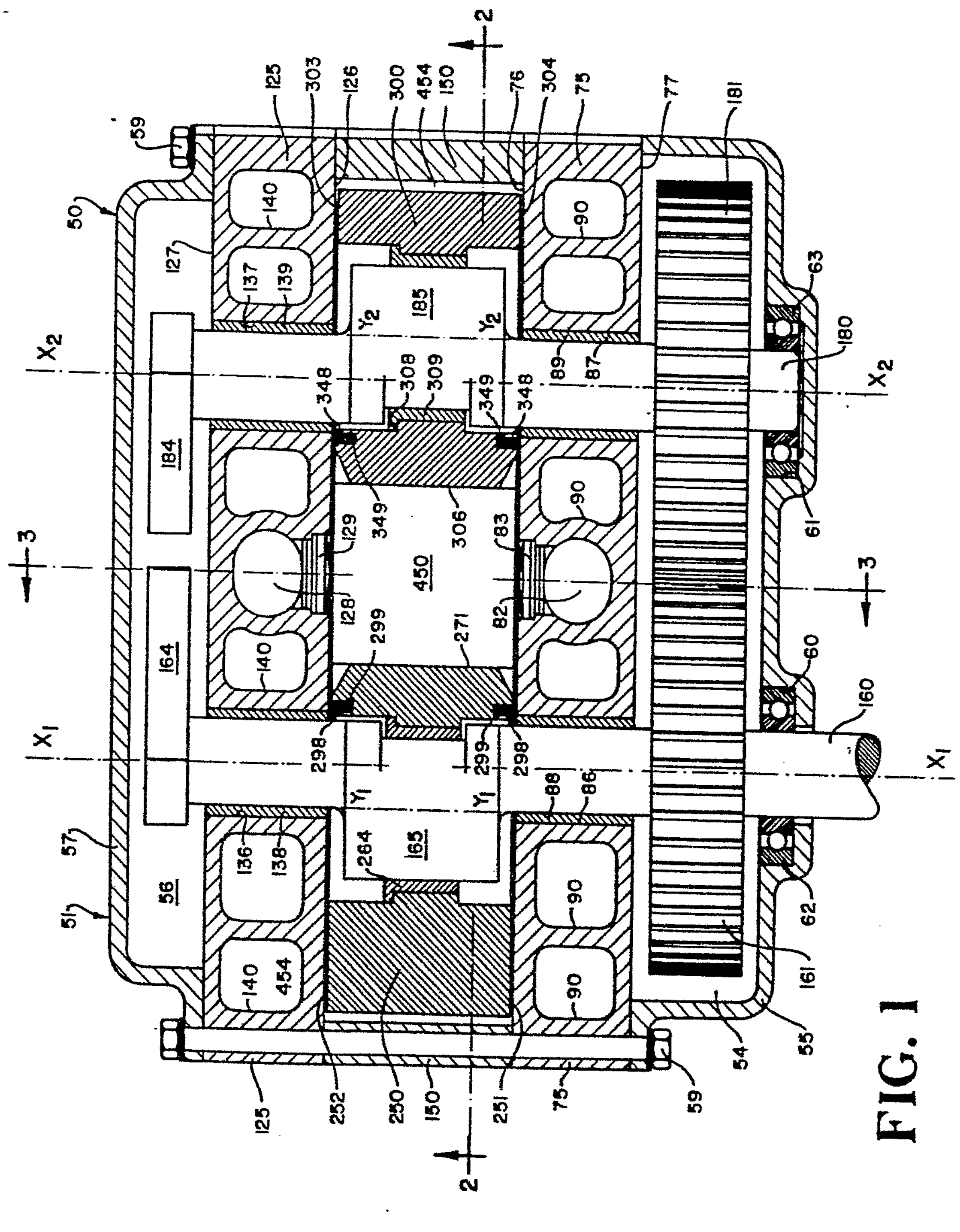

FIG. 1

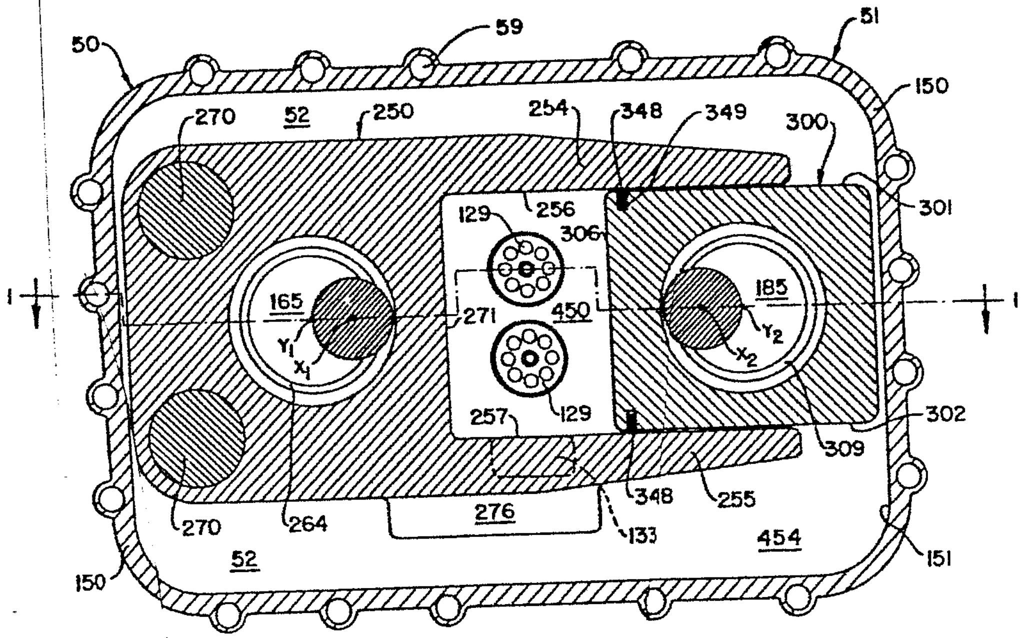

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FIG. 2

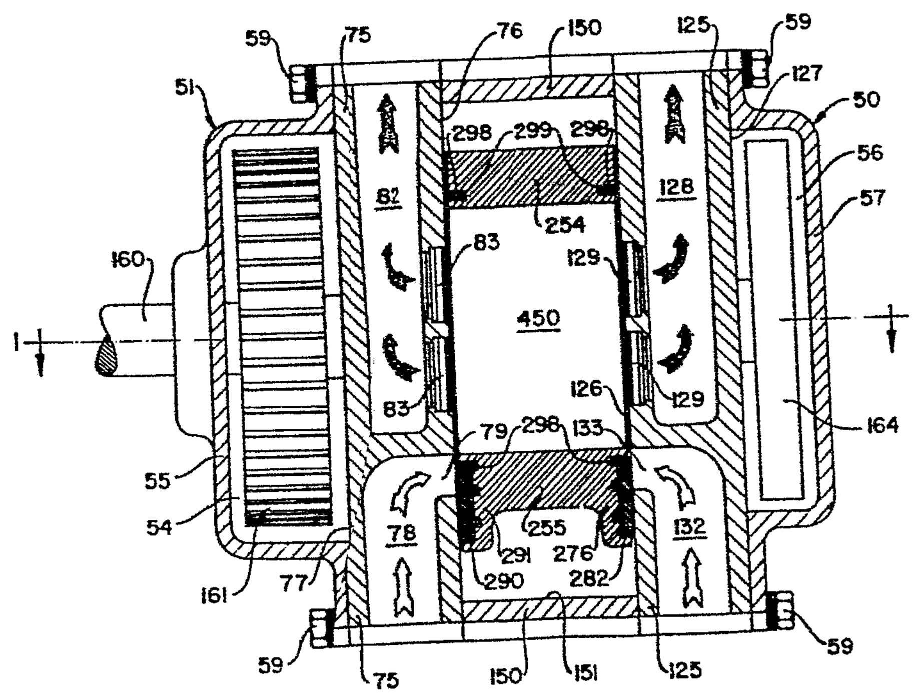

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FIG. 3

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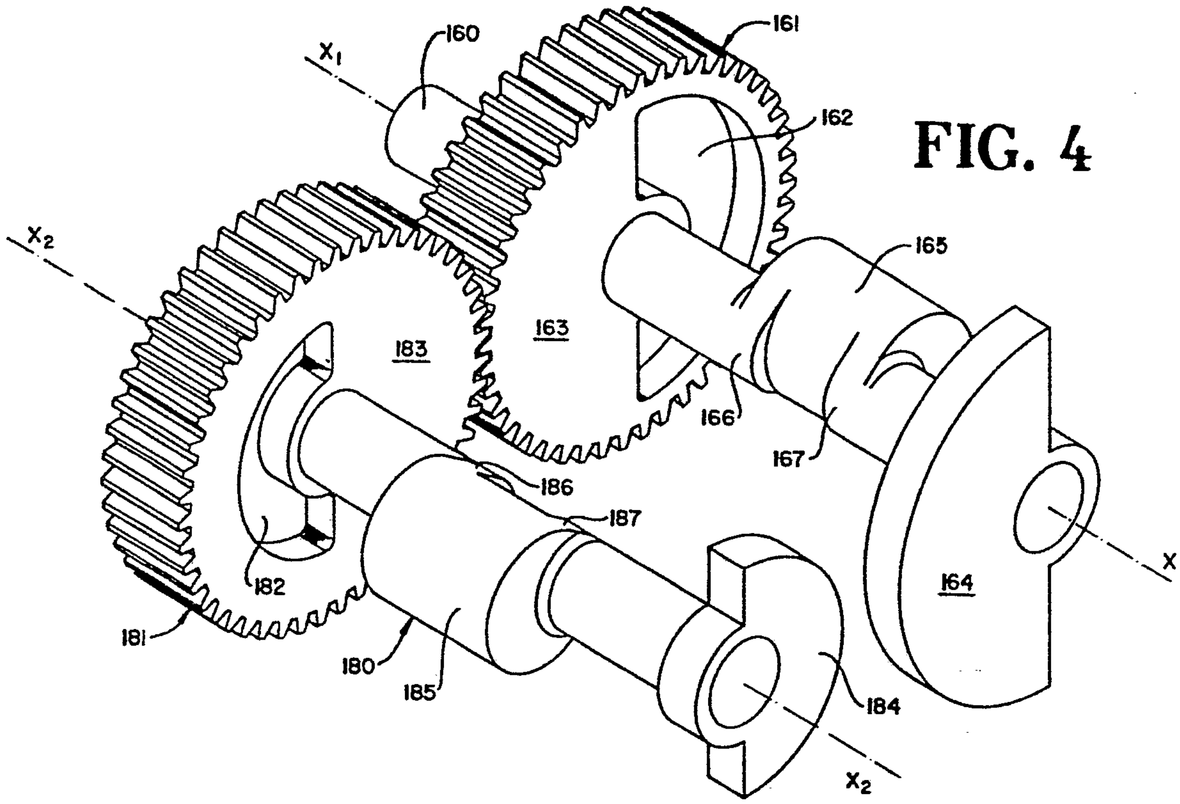


FIG. 4

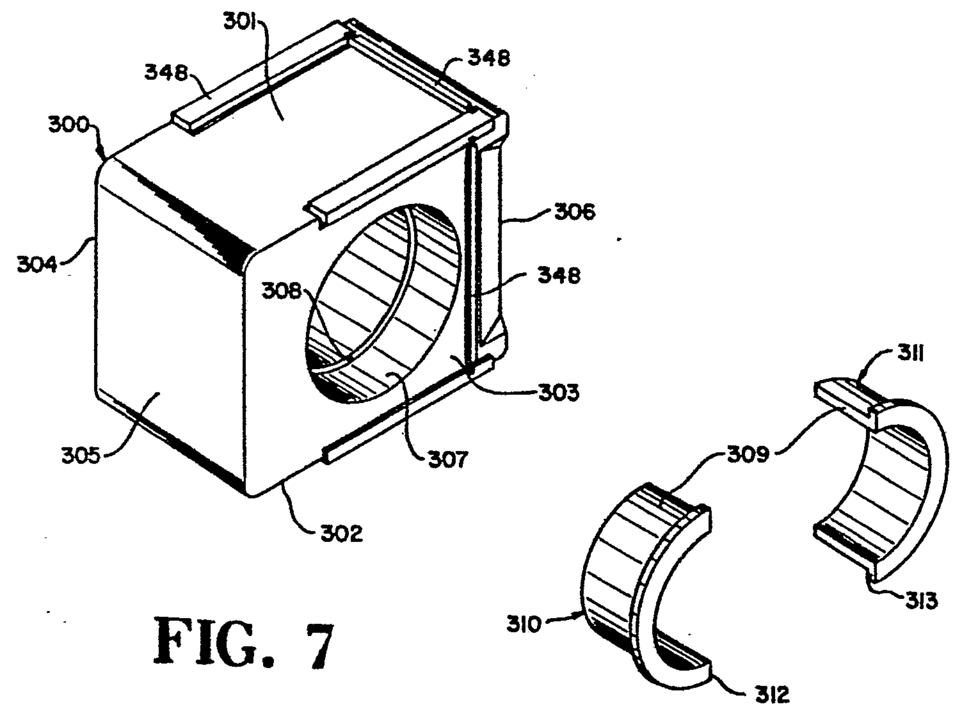
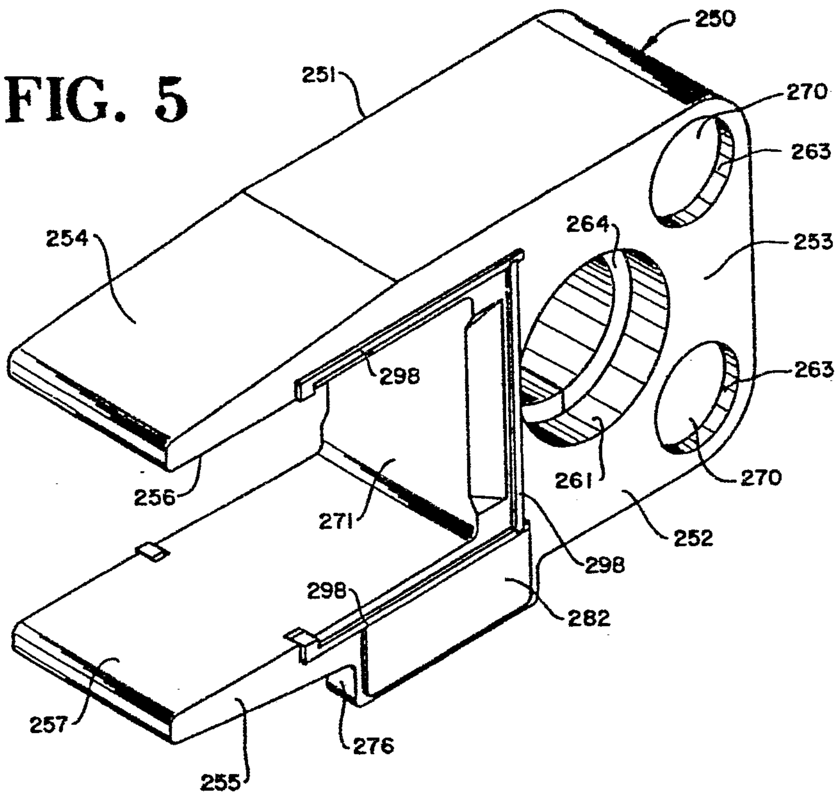


FIG. 7

FIG. 5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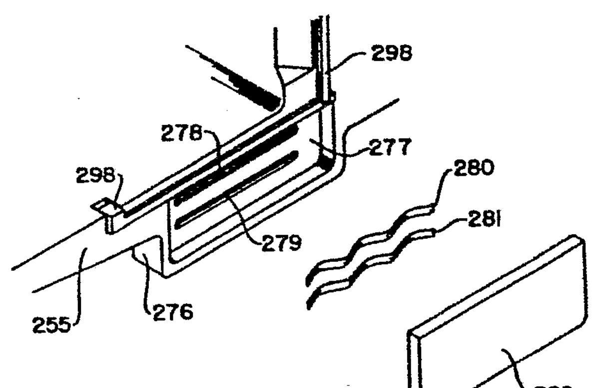
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FIG. 6

FIG. 8

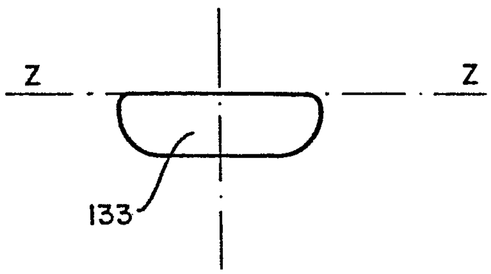
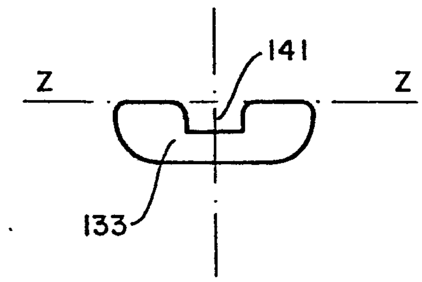


FIG. 9



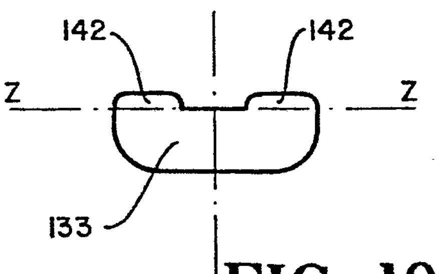


FIG. 10

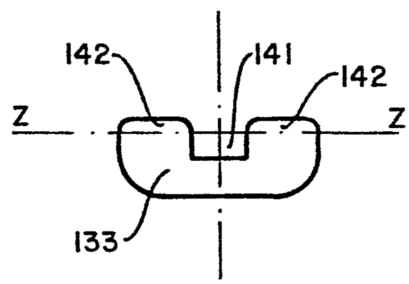


FIG. 11

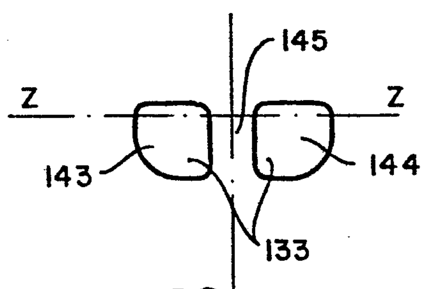


FIG. 12

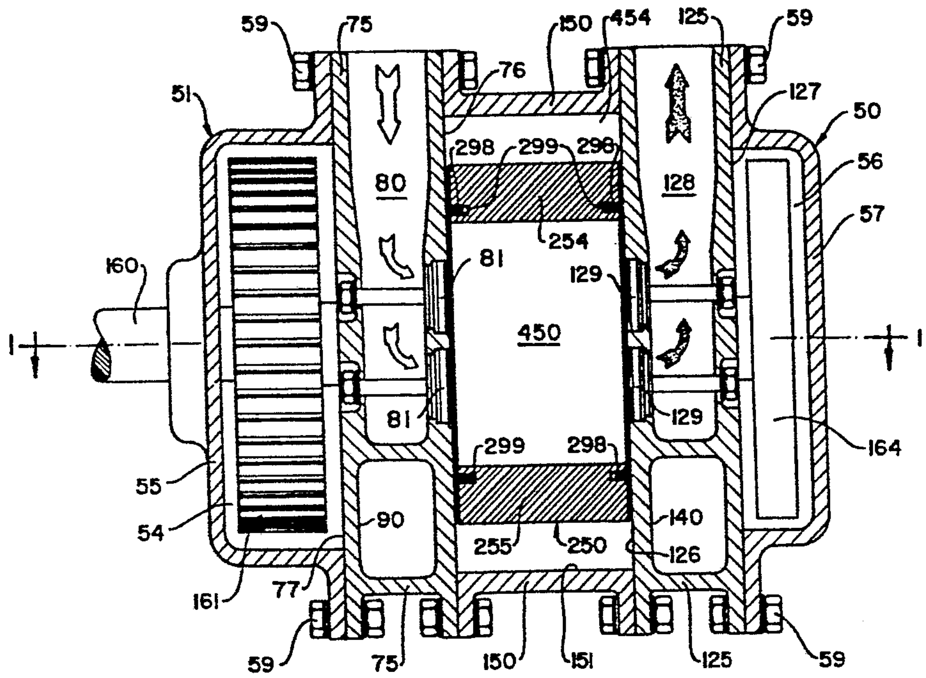

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FIG. 13

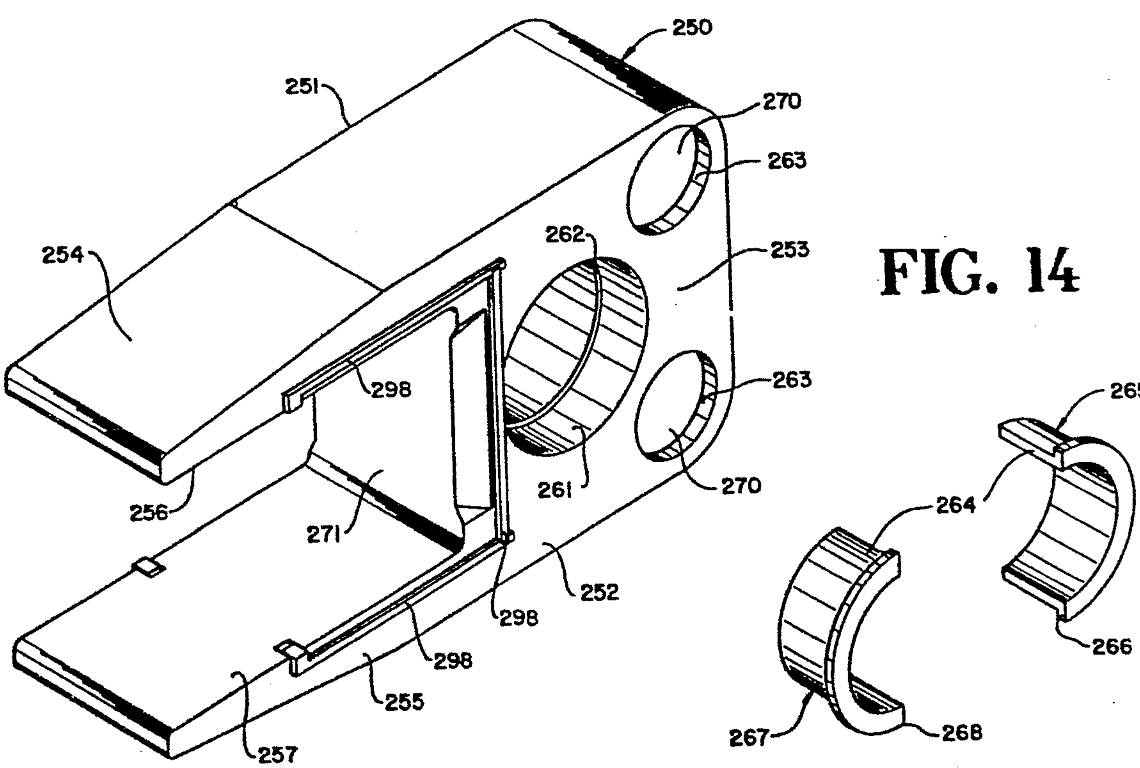
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FIG. 14

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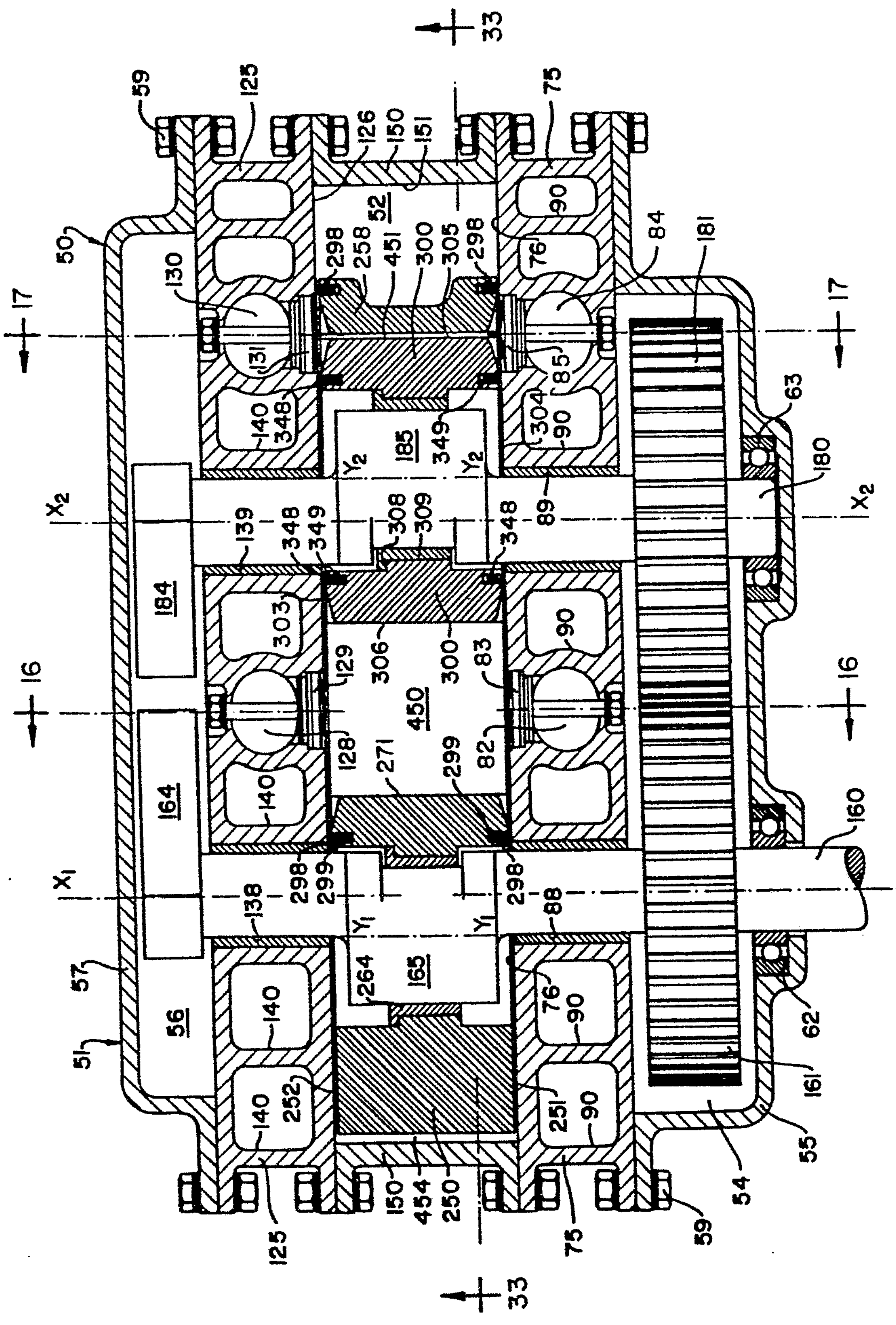

FIG. 15

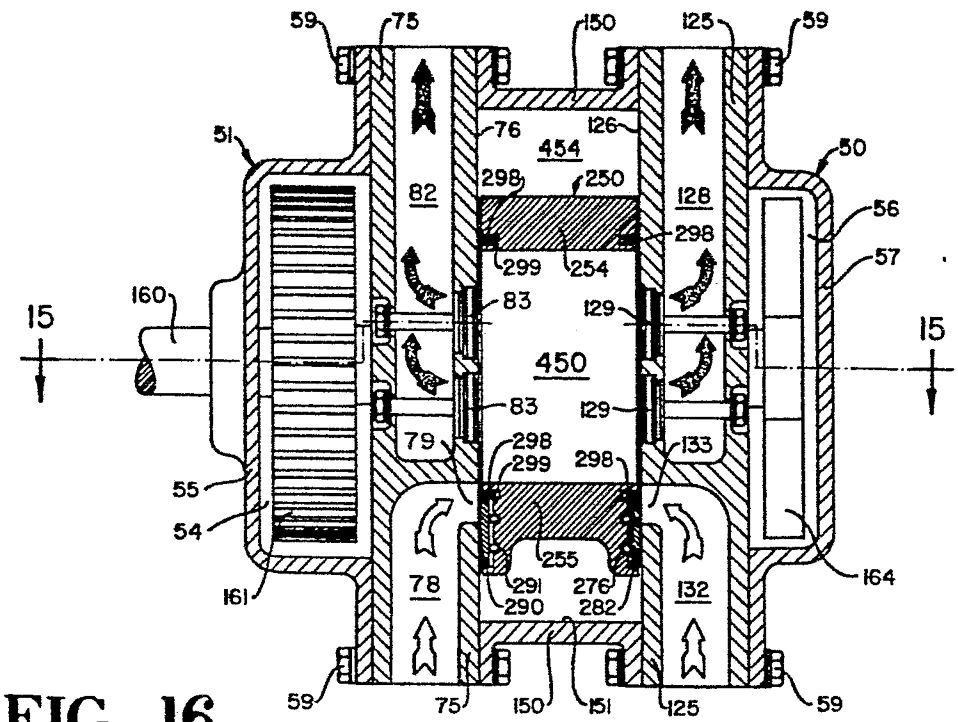

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FIG. 16

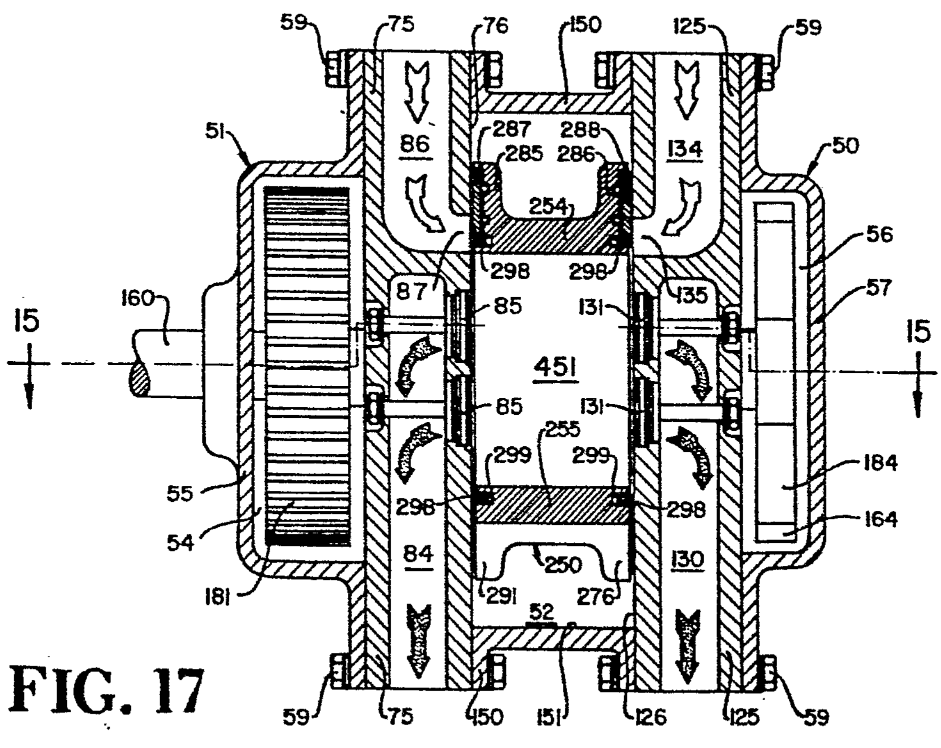

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FIG. 17

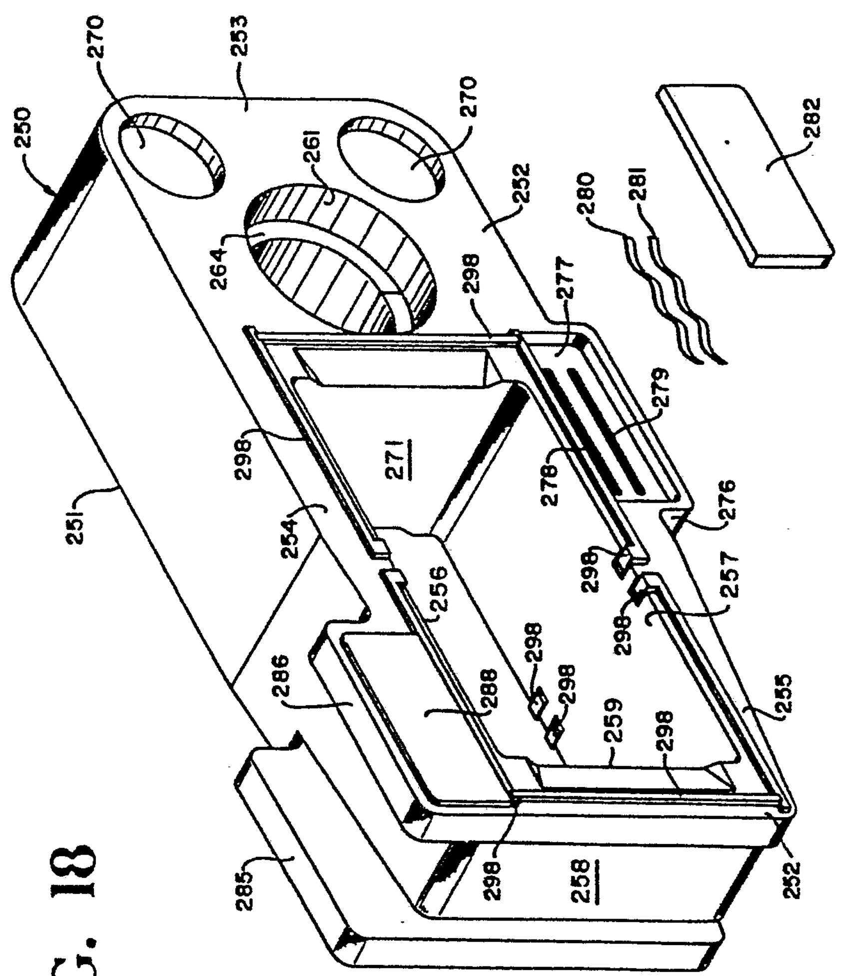

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FIG. 18

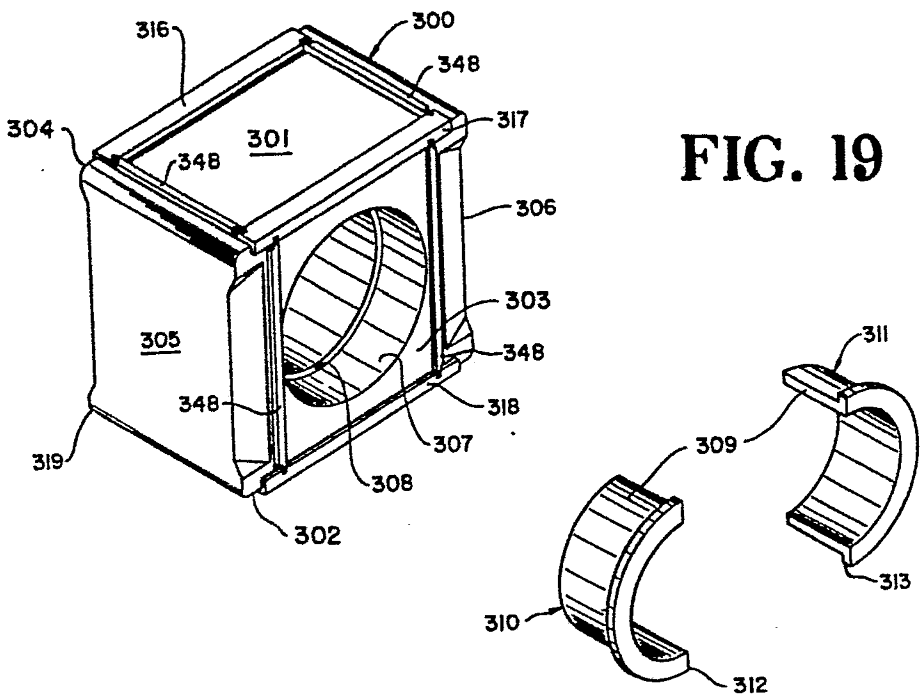

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FIG. 19

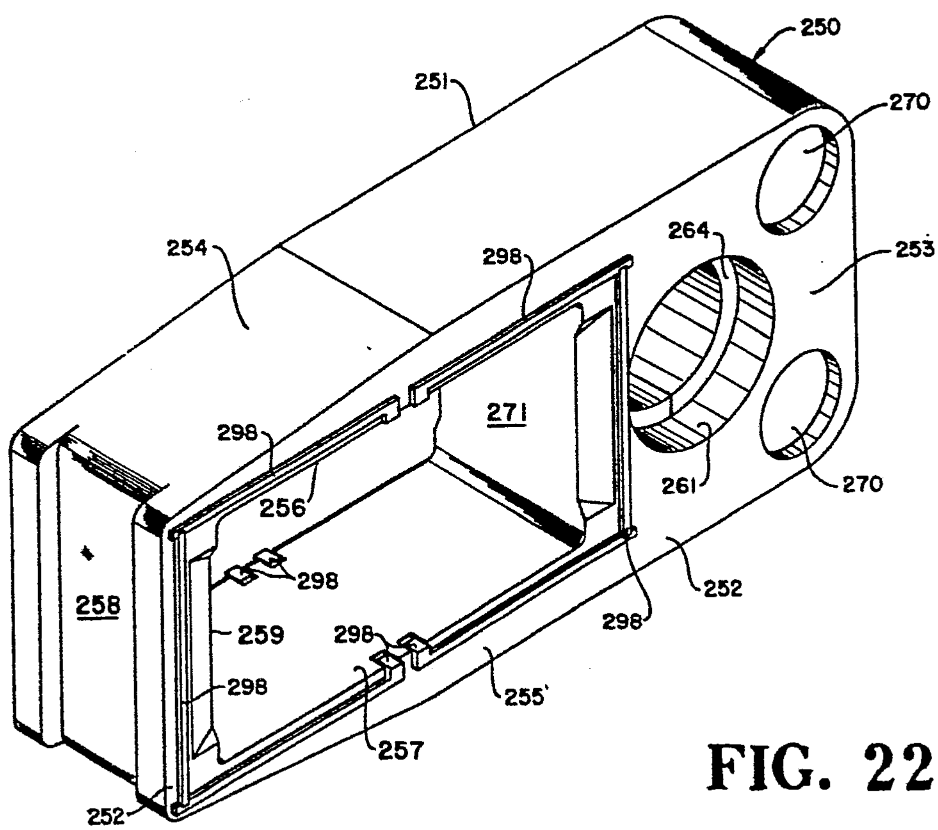

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FIG. 22

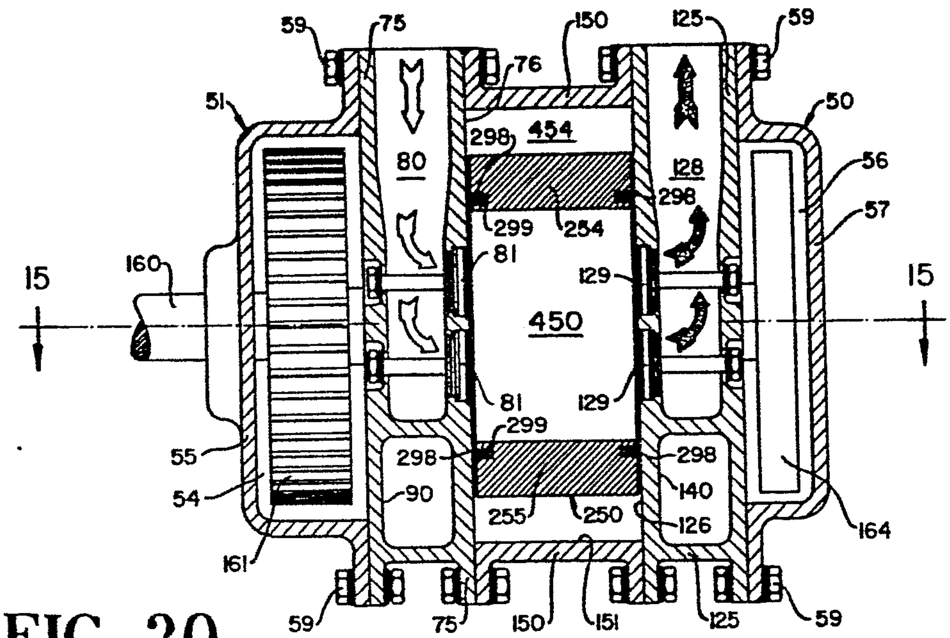
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FIG. 20

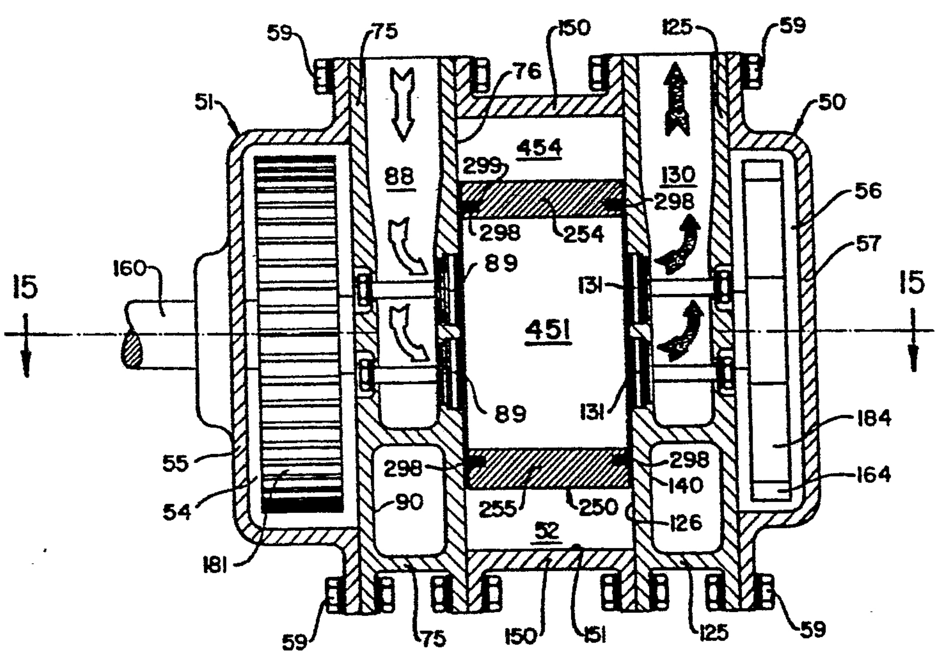
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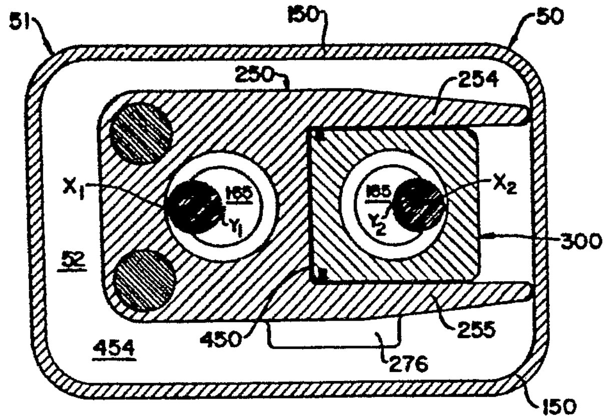
FIG. 21

FIG. 23



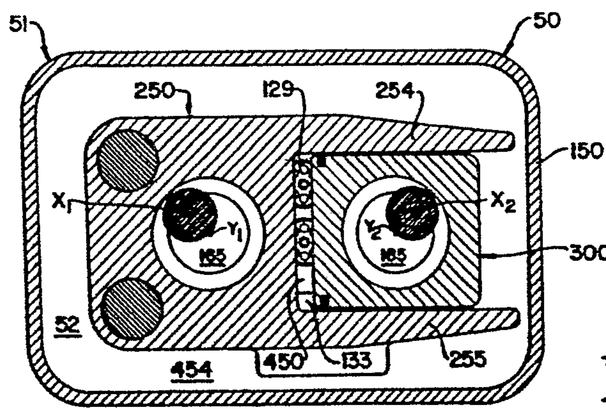


FIG. 24

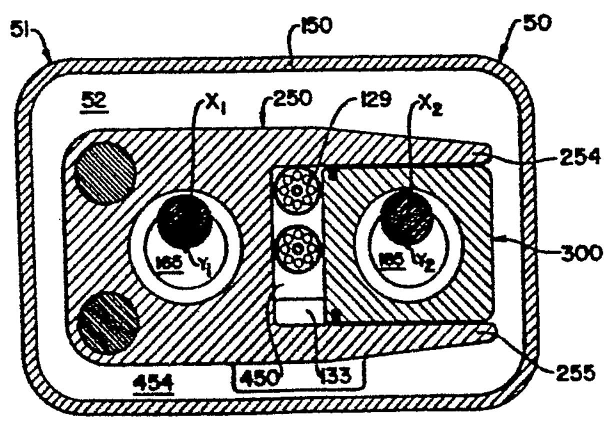
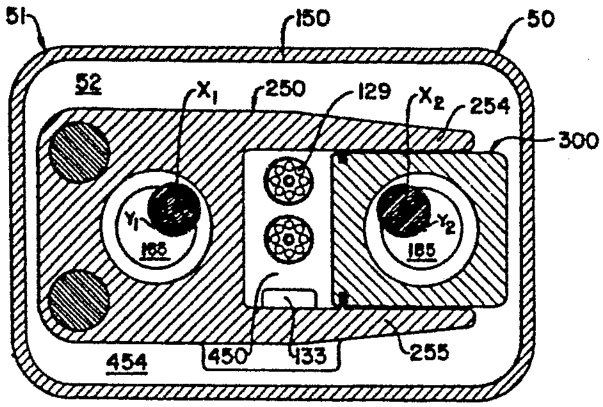


FIG. 25

FIG. 26



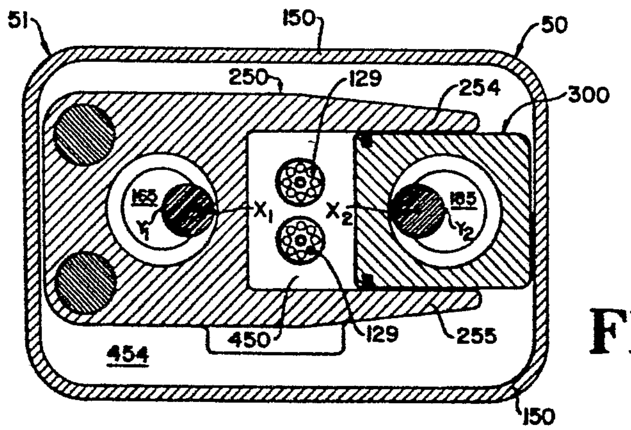


FIG. 27

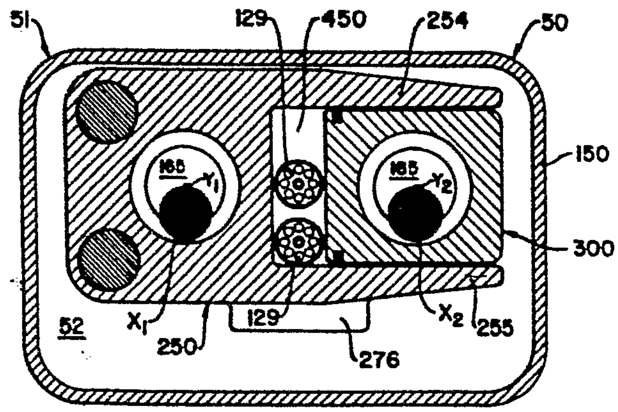


FIG. 28

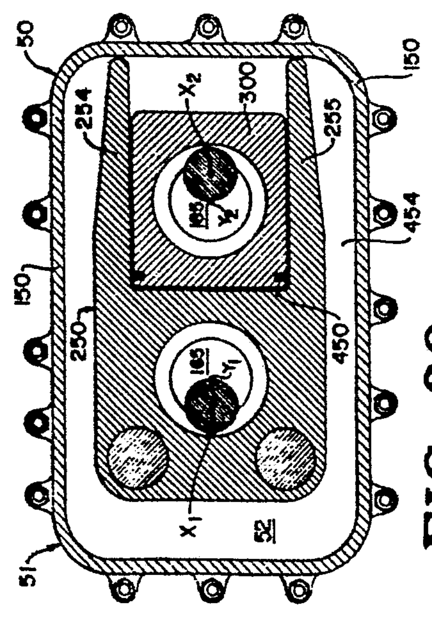


FIG. 29

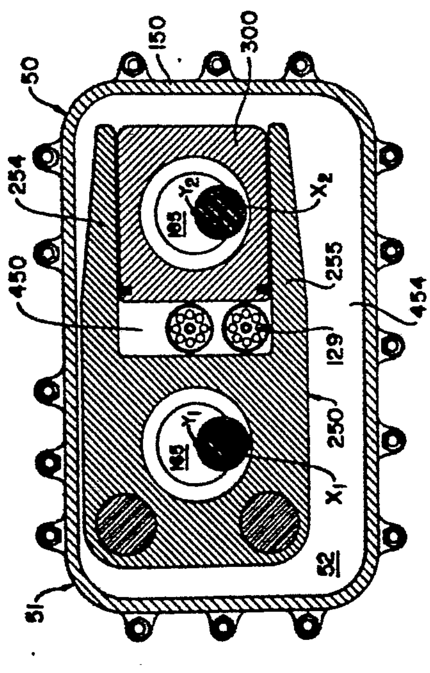


FIG. 30

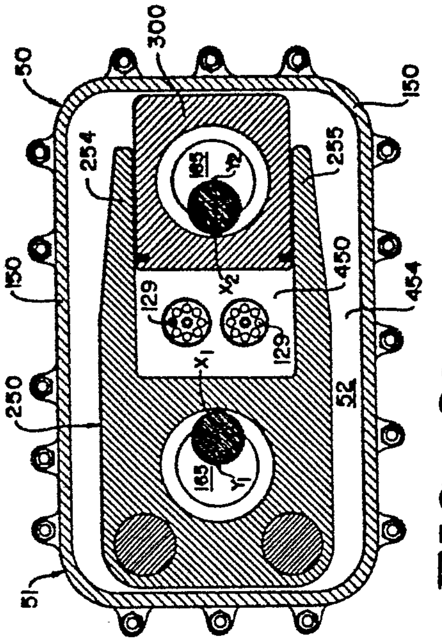


FIG. 31

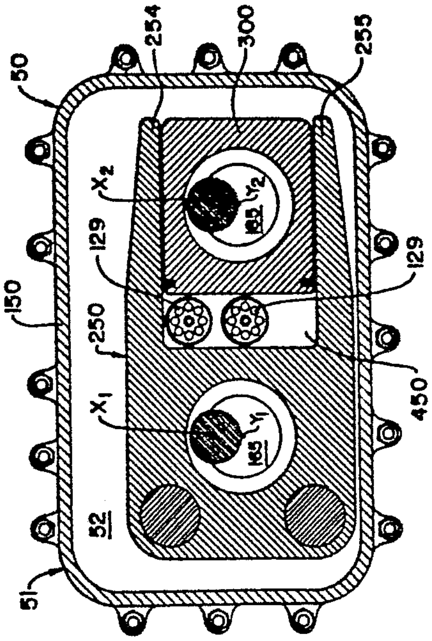


FIG. 32

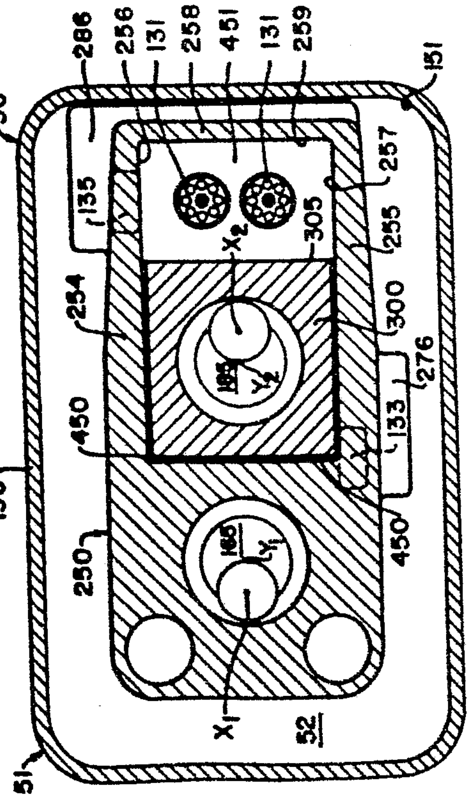


FIG. 33

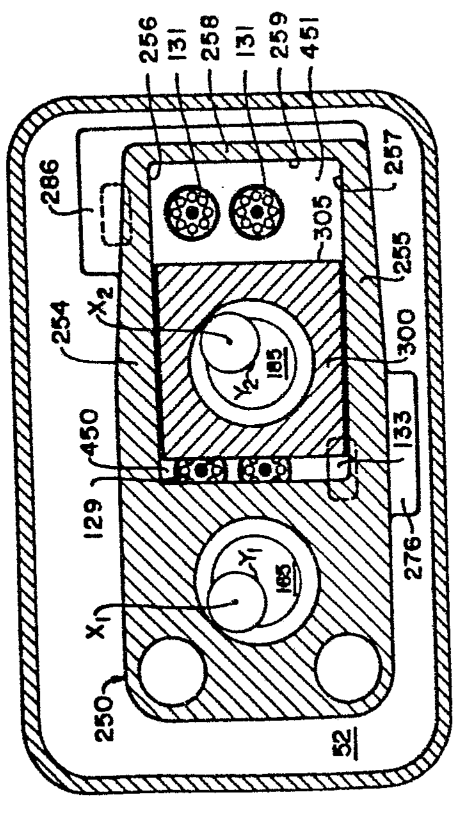


FIG. 34

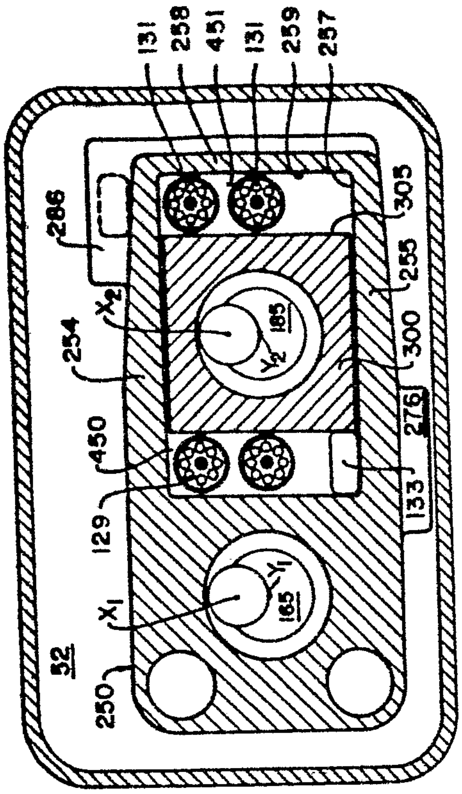


FIG. 35

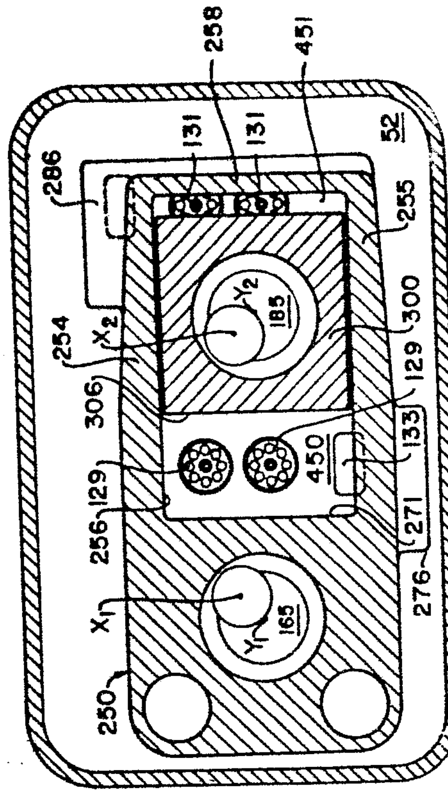


FIG. 36

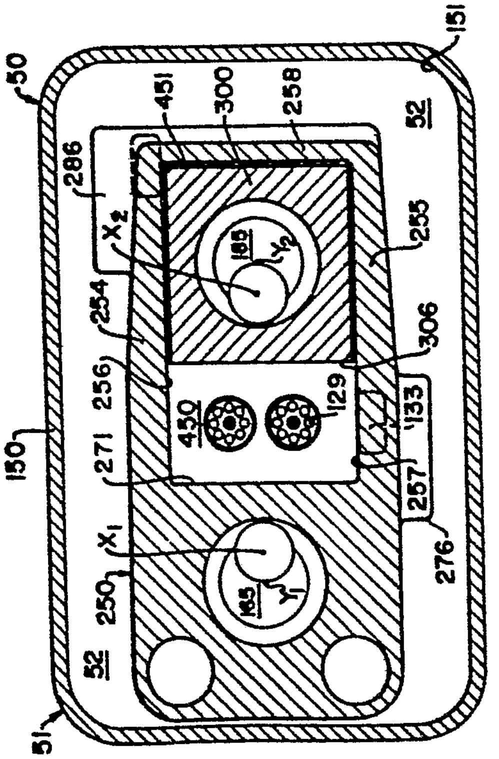


FIG. 37

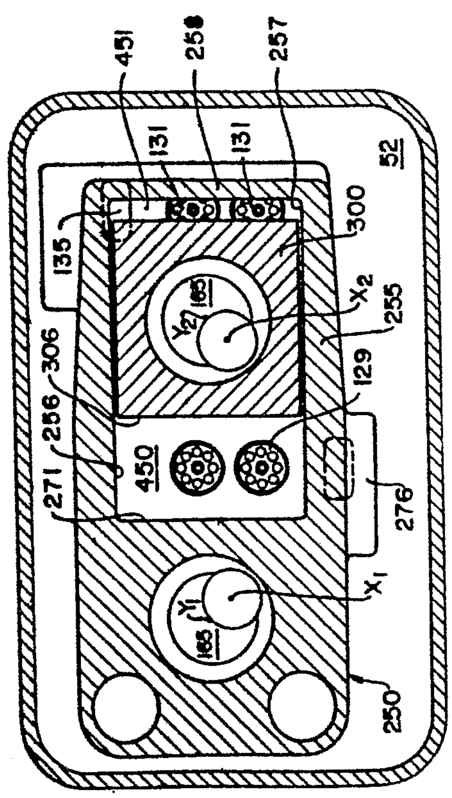


FIG. 38

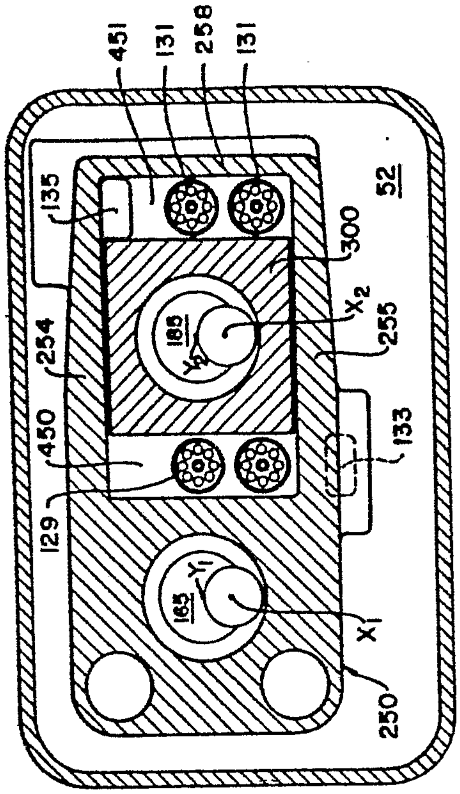


FIG. 39

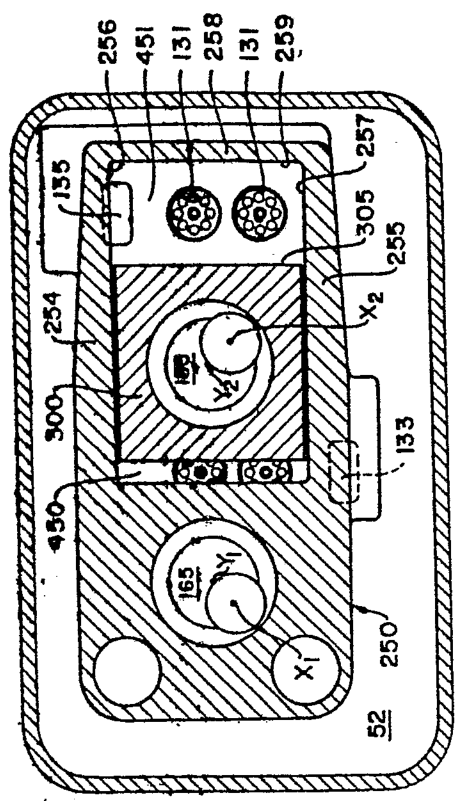


FIG. 40

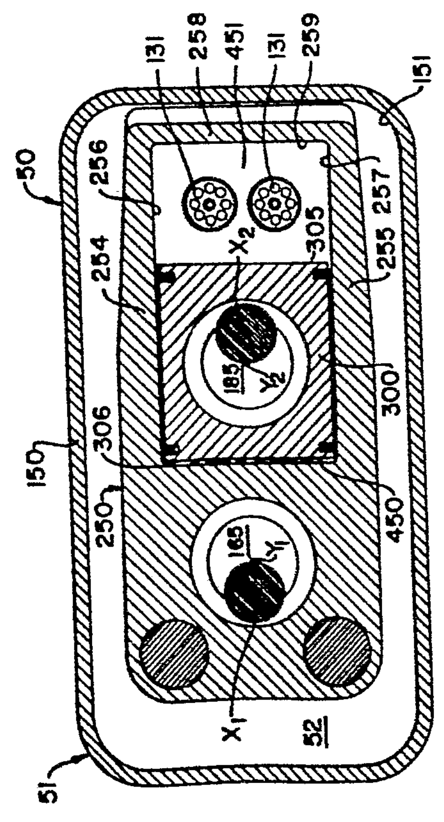


FIG. 41

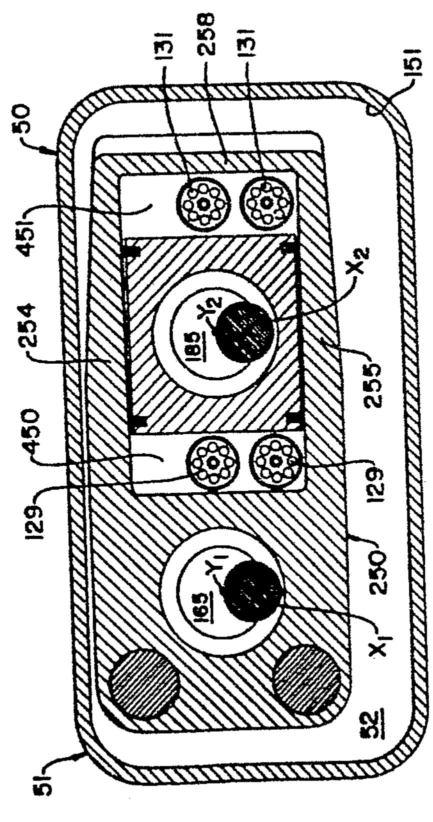


FIG. 42

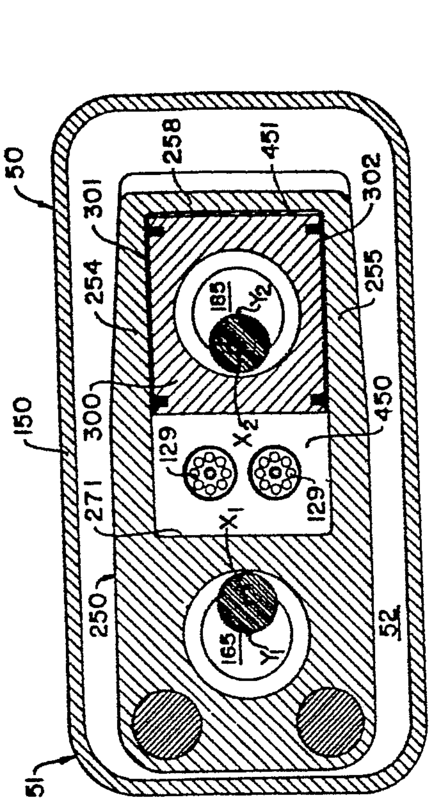


FIG. 43

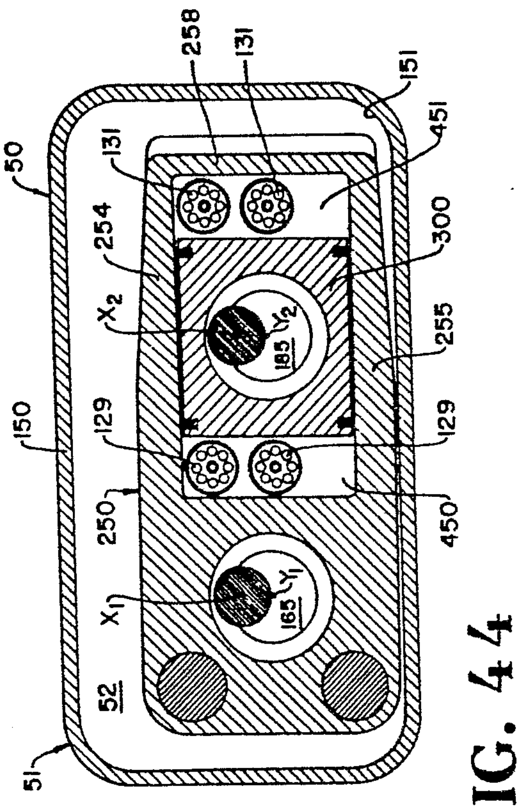


FIG. 44

European Patent Office

EUROPEAN SEARCH REPORT

0014723

Application number
EP 78 30 0705

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	US - A - 4 010 675 (LASSOTA) * Column 1, lines 35-39; column 3, lines 49-68; column 4, lines 1-68; column 5, lines 1-68; column 6, lines 1-68; column 7, lines 1-68; column 8, lines 1-68; column 9, lines 1-44; figures 1-3,11 * --	1-4,6-9,11,17,18,20,21	F 04 B 29/00 F 16 J 10/02
X	US - A - 3 974 803 (LASSOTA) * Column 1, lines 56-65; column 2, lines 1-5; column 4, lines 34-68; column 5, lines 1-65; column 7, lines 46-55; figures 1,2 * --	1,3,5,8,10,11,15,16,18,20,22	TECHNICAL FIELDS SEARCHED (Int.Cl.
	US - A - 1 758 601 (HAYART) * Page 1, lines 30-75; figures 1,2 * --	1,2,6,8,10,11,16,18,20,22	F 04 B F 01 B
	US - A - 2 013 862 (SCHULZ) * Page 1, right-hand column, lines 11-55; page 2, left-hand column, lines 1-75; right-hand column, lines 1-19; figures 1-6 * --	1,2,4,6-9,11,15,16,18,20,21,23-25	CATEGORY OF CITED DOCUMENTS
A	DE - A - 1 401 414 (HERING) * In its entirety * ----	1	X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
K	The present search report has been drawn up for all claims		&: member of the same patent family, corresponding document

Place of search	Date of completion of the search	Examiner
The Hague	03-06-1980	HEINLEIN