FORM 1

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952 599033

APPLICATION FOR A STANDARD PATENT

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SANDEN CORPORATION

of 20 KOTOBUKI-CHO
ISESAKI-SHI
GUNMA-KEN
JAPAN

PATENT OFFICE $205 ...00561

hereby apply for the grant of a standard patent for an invention entitled:

SCROLL TYPE COMPRESSOR WITH VARIABLE DISPLACEMENT MECHANISM.

which is described in the accompanying complete specification

Details of basic application(s):

Number of basic application	Name of Convention country in which basic application was filed	Date of basic application
132487/85	JP	18 JUN 85

My/our address for service is care of CLEMENT HACK & CO., Patent Attorneys, 601 St. Kilda Road, Melbourne 3004, Victoria, Australia.

DATED this 18th day of June 1986

SANDEN CORPORATION

CLEMENT HACK & CO.

TO: The Commissioner of Patents.

APPLICATION ACCEPTED AND AMENDMENTS
...ED 4-5-90

LODGED AT SUB-OFFICE
18 JUN 1986
Melbourne

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Australian Patent Declaration Form

Forms 7 and 8

AUSTRALIA

Patents Act 1952

DECLARATION IN SUPPORT OF A CONVENTION OR NON-CONVENTION APPLICATION FOR A PATENT OR PATENT OF ADDITION

Name(s) of Applicant(s) — In support of the application made by SANDEN CORPORATION

Title — for a patent for an invention entitled SCROLL TYPE COMPRESSOR WITH VARIABLE DISPLACEMENT MECHANISM

Name(s) and address(es) of person(s) making declaration — I/We, Masayoshi Ushikubo of c/o Sanden Corporation, 20, Kotobuki-cho, Isesaki-shi, Gunme-ken, Japan

do solemnly and sincerely declare as follows:—

1. I am/we are the applicant(s) for the patent, or authorised by the abovementioned applicant to make this declaration on its behalf.

2. The basic application(~~s~~) as defined by Section 141 of the Act was/~~were~~ made in the following country ~~or countries~~ on the following date(~~s~~) by the following applicant(~~s~~) namely:-

Country, filing date and name of Applicant for the or each basic application

in JAPAN on 18 June 1985
by SANDEN CORPORATION
in on 19
by

3. The said basic application(~~s~~) was/~~were~~ the first application(~~s~~) made in a Convention country in respect of the invention the subject of the application.

4. The actual inventor(~~s~~) of the said invention ~~is~~/are

Name(s) and address(es) of the or each actual inventor

Kiyoshi Terauchi, 8-14, Heiwa-cho, Isesaki-shi, Gunma-ken, Japan

Atsushi Mabe, 4332-1, Mimoro-cho, Isesaki-shi, Gunma-ken, Japan

5. The facts upon which the applicant(s) is/are entitled to make this application are as follows:-

See reverse side of this form for guidance in completing this part

The applicant is the assignee of the actual inventors.

DECLARED at Tokyo Japan this 15th day of August 1988

Masayoshi Ushikubo (Executive Vice-President of SANDEN CORPORATION)

(12) PATENT ABRIDGMENT (11) Document No. AU-B-58830/86
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 599033

(54) Title
SCROLL TYPE COMPRESSOR WITH VARIABLE DISPLACEMENT MECHANISM

International Patent Classification(s)
(51)[4] F04C 018/02 F04C 029/10

(21) Application No. : 58830/86 (22) Application Date : 18.06.86

(30) Priority Data

(31) Number (32) Date (33) Country
60-132487 18.06.85 JP JAPAN

(43) Publication Date : 24.12.86

(44) Publication Date of Accepted Application : 12.07.90

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(56) Prior Art Documents
AU 577734 35175/84
AU 569921 35263/84
US 4642034

(57) Claim

1. A scroll type compressor including a housing having an inlet port and an outlet port, a fixed scroll fixedly disposed within said housing and having a circular end plate from which a first spiral element extends into the interior of said housing, an orbiting scroll having a circular end plate from which a second spiral element extends, said first and second spiral elements interfitting at an angular and radial offset to make a plurality of line contacts and define at least one pair of fluid pockets within the interior of said housing, a driving mechanism operatively connected to said orbiting scroll to effect the orbital motion of said orbiting scroll, a rotation preventing mechanism for preventing the rotation of said orbiting scroll

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during the orbital motion, said circular end plate of said fixed scroll dividing the interior of said housing into a suction chamber and a rear chamber, said suction chamber communicating with said inlet port, said rear chamber being divided into a discharge chamber which discharges to said outlet port a compressed gas discharged, as a discharge gas, from a central fluid pocket formed by both said scrolls and an intermediate pressure chamber, said circular end plate of said fixed scroll having at least one pair of holes to form a fluid channel between said fluid pockets and said intermediate pressure chamber, said circular end plate of said fixed scroll having a communication channel to form a fluid channel between said intermediate pressure chamber and said suction chamber, control means disposed on a portion of said intermediate pressure chamber for controlling fluid communication between said intermediate pressure chamber and said suction chamber, said control means comprising a cylinder communicating with said intermediate pressure chamber, said suction chamber and said discharge chamber, piston slidably disposed within said cylinder and operated by the discharge gas pressure from said discharge chamber to control the fluid communication between said suction chamber and said intermediate pressure chamber, and a control valve for controlling application of the discharge gas pressure onto said piston so as to control the compression ratio of the compressor, the improvement wherein said control valve comprises:

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an operating chamber communicating with said suction chamber;

means disposed in said operating chamber for sensing a gas pressure in said operating chamber as a sensed gas pressure; and

means coupled with said sensing means for controlling application of the discharge gas pressure onto said piston in response to said sensed gas pressure to operate said piston so as to close off the fluid communication between said suction chamber and said intermediate pressure chamber when said sensed gas pressure is above a predetermined gas pressure but to open the fluid communication between said suction chamber and said intermediate pressure chamber when said sensed gas pressure is below the predetermined gas pressure.

599033

AUSTRALIA

PATENTS ACT 1952

Form 10

COMPLETE SPECIFICATION

(ORIGINAL)

FOR OFFICE USE

Short Title:

Int. Cl:

Application Number: 58830/86.
Lodged:

Complete Specification-Lodged:
Accepted:
Lapsed:
Published:

This document contains the amendments made under Section 49.

and is correct for printing.

Priority:

Related Art:

TO BE COMPLETED BY APPLICANT

Name of Applicant:
SANDEN CORPORATION

Address of Applicant: 20 KOTOBUKI-CHO
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Actual Inventor:

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Australia.

Complete Specification for the invention entitled:
SCROLL TYPE COMPRESSOR WITH VARIABLE DISPLACEMENT MECHANISM.

The following statement is a full description of this invention including the best method of performing it known to me:-

SCROLL TYPE COMPRESSOR WITH VARIABLE DISPLACEMENT MECHANISM

Technical Field

The present invention relates to a scroll type compressor, and particularly, to a scroll type compressor with a variable displacement mechanism.

Background of the Invention

When the air conditioning load in the compartment of a car is decreased by an air conditioning system, or the temperature in the compartment of the car is below the predetermined temperature, the displacement of the compressor is not necessary to be as much as the displacement of the compressor before the air conditioning load in the compartment of the car is decreased. Accordingly, the compression ratio of the compressor can be decreased.

Conventionally, a scroll type compressor which can change compression ratio is well known. For example, U.S. Patent No. 4,505,651 and our Australian patent application 35175/84 filed on November 8, 1984 show the variable displacement control mechanism.

However, in U.S. Patent No. 4,505,651, the change of compression ratio which is made by the compressor is not sufficient.

In the mechanism shown in our Australian Patent application 35175/84, the temperature of discharge gas which is discharged from the compressor is abnormally increased while operating at a high speed. Further, It is necessary to control electric power supply to an electromagnetic valve so as to control the compression ratio. This means a necessity of an electric control device for the electromagnetic valve.

Summary of the Invention

It is a primary object of the present invention to provide a scroll type compressor with a variable displacement control mechanism which can continuously change compression volume in accordance with the load for a compressor or the variation of the rotational speed of the compressor without use of the electromagnetic valve.

It is another object of the present invention to provide a scroll type compressor with a variable displacement control mechanism which can continuously change compression volume in accordance with variation of the suction pressure.

It is still another object of the present invention to provide a scroll type compressor with a variable displacement control mechanism which can change compression volume in large range.

It is a further object of the present invention to provide a scroll type compressor with a variable displacement control mechanism which can avoid suction pressure loss and increasing a temperature of discharged gas.

According to the present invention, there is provided with a scroll type compressor including a housing having an inlet port and an outlet port, a fixed scroll fixedly disposed within the housing and having a circular end plate from which a first spiral element extends into the interior of the housing, an orbiting scroll having a circular end plate from which a second spiral element extends, the first and second spiral elements interfitting at an angular and radial offset to make a plurality of line contacts and define at at least one pair of fluid pockets within the interior of the housing, a driving mechanism operatively connected to the orbiting scroll to effect the orbital motion of the orbiting scroll, a rotation preventing mechanism for preventing the rotation of the orbiting scroll during the orbital motion, the circular end plate of the fixed scroll dividing the interior of the housing into a suction chamber and a rear chamber, the suction chamber communicating with the inlet port, the rear chamber being divided into a discharge chamber which discharges to the outlet port a compressed gas discharged, as a discharge gas, from a central fluid pocket formed by both the scrolls and an intermediate pressure chamber, the circular end plate of the fixed scroll having at least one pair of holes to form a fluid channel between the fluid pockets and the intermediate pressure chamber, the circular end plate of the fixed scroll having a communication channel to form a fluid channel between the intermediate pressure chamber and the suction chamber, control means disposed on a portion of the intermediate pressure chamber for controlling fluid communication between the intermediate pressure chamber and the suction chamber, the control means comprising a cylinder communicating with the intermediate pressure chamber, the suction chamber and the discharge chamber, piston slidably disposed within the cylinder and operated by the discharge gas pressure from the discharge chamber to control communication between the suction chamber and the intermediate pressure chamber, and a control valve for controlling application of the discharge gas pressure onto the piston so as to control the compression ratio of the compressor, which is characterized in that the control valve comprises: an operating chamber communicating with the suction chamber; means disposed in the operating chamber for sensing a gas pressure in the operating chamber as a sensed gas pressure; and means coupled with the sensing means for controlling application of the discharge gas onto the piston in response to the sensed gas pressure to operate the piston so as to close off the communication between the suction chamber and the intermediate pressure chamber when the sensed gas pressure is above a predetermined gas pressure but to open the communication between the suction chamber and the intermediate pressure chamber when the sensed gas pressure is below the predetermined gas pressure.

Further objects, feature, and aspects of this invention will be understood from the following detailed description of preferred embodiments of this invention, referring to the annexed drawings.

Figure 1 is a vertical cross-sectional view of a scroll type compressor with a variable displacement control mechanism using an electromagnetic valve of a type as shown in our Australian Patent application 35175/84.

Figure 2 is a sectional view of the compressor in Figure 1 for illustrating the position of holes formed in an end plate of a fixed scroll.

Figure 3 is a cross sectional view of a variable displacement control mechanism according to a first embodiment of this invention.

Figure 4 is a cross sectional view of a variable displacement control mechanism according to a second embodiment of this invention.

Figure 5 is a cross sectional view of a variable displacement control mechanism according to a third embodiment of this invention.

Figure 6 is a cross sectional view of a variable displacement control mechanism according to a fourth embodiment of this invention.

Detailed Description of the preferred Embodiments

Prior to description of preferred embodiments of this invention, a scroll type compressor with a variable displacement mechanism of a type shown in our Australian patent application No. 35175/84 will be described with reference to Figures 1 and 2 so as to assist the better understanding of this invention.

Referring to Figure 1, the scroll type compressor 1 includes a compressor housing 10 having a front end plate 11 and a cup-shaped casing 12 which is attached to an end surface of front end plate 11. A hole 111 is formed in the center of front end plate 11 for penetration of a drive shaft 13. An annular projection 112 is formed in a rear surface of front end plate 11. Annular projection 112 faces cup shaped casing 12 and is concentric with hole 111. An outer peripheral surface of projection 112 extends into an inner wall of the opening of cup-shaped casing 12. Thus, an opening 121 of cup-shaped casing 12 is covered with front end plate 11. An O-ring 14 is placed between the outer peripheral surface of annular projection 112 and the inner wall of the opening of cup-shaped casing 12 to seal the mating surface of front end plate 11 and cup-shaped casing 12.

An annular sleeve 16 projects from the front end surface of front end plate 11 to surround drive shaft 13 and to define a shaft seal cavity. In the embodiment shown in Figure 1, sleeve 16 is formed separately from front end plate 11. Therefore, sleeve 16 is fixed to the front end surface of front end plate 11 by screws (not shown). Alternatively, sleeve 15 may be formed integral with front end plate 11.

Drive shaft 13 is rotatably supported in sleeve 16 by a bearing 17 located within the front end of sleeve 16. Drive shaft 13 has a disk-shaped rotor 131 at its inner end which is rotatably supported in front end plate 11 by a bearing 15 located within opening 111 of front end plate 11. A shaft seal assembly 18 is coupled to drive shaft 13 within the shaft seal cavity of sleeve 16.

A pulley 201 is rotatably supported by a ball bearing 19 which is carried on the outer surface of sleeve 16. An electromagnetic coil 202 is fixed about the outer surface of sleeve 16 by a support plate. An armature plate 203 is elastically supported on the outer end of drive shaft 13. Pulley 201, electromagnetic coil 202 and armature plate 203 form a magnetic clutch 20.

In operation, drive shaft 13 is driven by an external power source, for example, an engine of an automobile, through a rotation transmitting device such as the above explained magnetic clutch.

A fixed scroll 21, an orbiting scroll 22, a driving mechanism for orbiting scroll 22 and a rotation preventing/thrust bearing mechanism 24 for orbiting scroll 22 are disposed in the interior of housing 10.

Fixed scroll 21 includes a circular end plate 221 and a spiral element 212 affixed onto or extending from one end surface of circular end plate 211. Fixed scroll 121 is fixed within the inner chamber of cup-shaped casing 12 by screws 25 screwed into circular end plate 211 from outside of cup-shaped casing 12. Circular end plate of fixed scroll 21 partitions the inner chamber of cup-shaped casing 12 into two chambers, such as a front chamber 27 and a rear chamber 28. Spiral element 212 is located within front chamber 27.

A partition wall 122 axially projects from the inner end surface of cup-shaped casing 12. The end surface of partition wall 122 contacts against the end surface of circular end plate 211. Thus, partition wall 122 divides rear chamber 28 into a discharge chamber 281 formed at the center portion of rear chamber 28 and an intermediate chamber 282. A gasket 26 may be disposed between the end surface of partition wall 122 and circular end plate 211 to secure the sealing.

Orbiting scroll 22 is located in front chamber 27 and includes a spiral element 222 affixed onto or extending from one end surface of a circular end plate 221. Spiral element 222 of orbiting scroll 22 and spiral element 212 of fixed scroll 21 interfit at angular offset of 180° and predetermined radial offset. Sealed spaces are thus formed between both spiral elements 212 and 222. Orbiting scroll 22 is rotatably supported by a bushing 23, which is connected with the inner end of a disk-shaped rotor 131 at eccentricity of the axis of drive shaft 13, through a radial needle bearing 30.

While orbiting scroll 22 orbits, the rotation of orbiting scroll 22 is prevented by rotation preventing/thrust bearing mechanism 24 which is placed between the inner end surface of front end plate 11 and circular end plate 221 of orbiting scroll 22. Rotation preventing/thrust bearing mechanism 24 includes a fixed ring 241, a fixed race 242, an orbiting ring 243, an orbiting race 244 and balls 245. Fixed ring 241 is attached on the inner end surface of front end plate 11 through fixed race 242 and has a plurality of circular holes 241a. Orbiting ring 243 is attached on the back surface of orbiting scroll 22 through orbiting race 244 and has a plurality of circular holes 243a. Each ball 245 is placed between hole 241a of fixed ring 241 and circular hole 243a of orbiting ring 243, and moves along the edges of both circular holes 241a and 243a. Also, axial thrust load from orbiting scroll 22 is supported on front end plate 11 through balls 245.

Compressor housing 10 is provided with an inlet port 31 and an outlet port 32 for connecting the compressor to an external refrigerating circuit. Refrigerant gas from the external circuit is introduced into a suction chamber 271 through inlet port 31 and is taken into spaces which are formed between both spiral elements 212 and 222, through openings between the spiral elements. That is, the shape of each opening is formed by the outer terminal end of one spiral element and the outer side surface of the other spiral element. The openings sequentially open and close during the orbital motion of orbiting scroll 22. When the openings are open, fluid to be compressed flows into these spaces but no compression occurs. When the openings are closed, thereby sealing off the spaces, no additional fluid flows into the spaces and compression begins. Since the location of the outer terminal ends of each spiral elements 212 and 222 is at the final involute angle, location of the opening is directly related to the final involute angle. Furthermore, refrigerant gas in the sealed space is radially inwardly moved and compressed in accordance with the orbital motion of orbiting scroll 22. Compressed refrigerant gas at the center sealed space is discharged to discharge chamber 281 through a discharge port 213, which is formed at the center of circular end plate 211.

Referring to Figures 1 and 2, a pair of holes 214 and 215 are formed in end plate 211 of fixed scroll 21 and are placed symmetrical positions so that an axial end surface of spiral element 222 of orbiting scroll 22 simultaneously crosses over holes 214 and 215. Holes 214 and 215 communicate between the sealed space and intermediate pressure chamber 282. Hole 214 is placed at a position defined by an involute angle ϕ_1, and opens along the inner side wall of spiral element 212. The other hole 215 is placed at a position defined by an involute angle $(\phi_1 - \pi)$ and opens along the outer side wall of spiral element 212. A control device, such as valve member 34 having valve leaf 341, 342 is attached by fastening 351 and 352 to end surface of end plate 211 to oppose each hole 214, 215. Each valve leaf 341, 342 is made of a spring type material so that the inherent spring of each valve leaf 341, 342 pushes it against the opening of each hole 214, 215 to close each hole.

End plate 211 of fixed scroll 21 has a communicate hole 29 at the outer side portion of the terminal end of spiral elements 212. Communicate hole 29 communicates suction chamber 271 with intermediate pressure chamber 282 through a communication chamber 283.

A variable displacement control mechanism 36 controls the communication between communication chamber 283 and intermediate pressure chamber 282. Variable displacement control mechanism 36 includes a cylinder 361, an I-shaped piston 362 slidably disposed within cylinder 361 and a coil spring 363 disposed between the lower end portion of piston 362 and the bottom portion of cylinder 361 to support piston 362. A first hole 361a is formed in the side surface of cylinder 362 to communicate with communication chamber 283, and a second hole 361b is formed on the bottom portion of cylinder 361 to communicate with intermediate pressure chamber 282. The upper portion of cylinder 361 is covered with plate 365 provided with an aperture 366 at its center portion and connected with discharge chamber 281 through a capillary tube 368. The communication between cylinder 361 and discharge chamber 281 may be controlled by electromagnetic valve 364 disposed on the housing 10. A piston ring 362c is fitted around the upper portion of piston 362 to prevent the leakage of high pressure gas through a gap between cylinder 361 and piston 362.

The operation of the variable displacement control mechanism 36 will now be described below. When orbiting scroll 22 is operated by the rotation of drive shaft 13, refrigerant gas which flows into suction chamber 271 through inlet portion 31 is taken into sealed spaces defined by both spiral elements 212 and 222. The refrigerant gas in the sealed spaces moves toward the center of both spiral elements 212 and 222 with a resultant volume reduction and compression, and is discharged from discharge port 213 to discharge chamber 281.

In this condition, if electromagnetic valve 364 is not energized, the communication between discharge chamber 281 and cylinder 361 is prevented. Thus, piston 362 is urged upwardly by recoil strength of spring 363, and the bottom portion 362b of cylinder 362 is placed at the portion over the first hole 361a. As a result, intermediate pressure chamber 282 communicates with communication chamber 283 through cylinder 361. Therefore, intermediate pressure chamber 282 is maintained at the suction pressure level, thereby, refrigerant gas in fluid pockets flows into intermediate pressure chamber 282 through holes 214 and 215 and finally flows into suction chamber 271. That is, actual compression stroke of compressor is started after the holes 214 and 215 are crossed over by spiral element 222. Thus, compression ratio of the compressor is greatly reduced by operation of variable displacement control mechanism 36.

On the other hand, when electromagnetic valve 364 is energized, the discharge gas flows from discharge chamber 281 into cylinder 361 through capillary tube 368. At that time, recoil strength of spring 363 is selected to be less than pressure force of the discharge gas, piston 362 will be pushed downwardly by pressure force of the discharge gas. In this situation, second hole 361b is closed by piston 362 and communication is prevented between the communication chamber 283 and intermediate pressure chamber 282. Therefore, pressure in intermediate pressure chamber 282 is gradually increased due to leakage gas from sealed spaces or fluid pockets through holes 214 and 215. This leakage of compressed gas continues until pressure in intermediate pressure chamber 282 is equal to the pressure in the sealed spaces or fluid pockets. When the pressure equalization occurs, holes 214 and 215 are closed by the spring tension of valve leaves 341 and 342 so that normal compression is carried out and the displacement volume of the sealed off fluid pockets is equal to the displacement volume when the terminal end of each one of spiral elements 212 and 222 firstly contacts with the outer spiral surface of the other one.

In the compressor shown in Figure 1, the temperature of the discharge gas is abnormally increased while operating at a high speed. Further, It is necessary to control electric power supply to an electromagnetic valve so as to control the compression ratio. This means a necessity of an electric control device for the electromagnetic valve.

Referring to Figure 3, a variable displacement control mechanism 36 according to a first embodiment of the present invention includes cylinder 361, I-shaped piston 362 slidably disposed within cylinder 361, spring 363 disposed between the lower end surface of piston 362 and the bottom portion of cylinder 361 to support piston 362 and a control valve 37. Intermediate pressure chamber 282, cylinder 361 and communication chamber 283 are communicated with one another through first and second holes 361a and 361b as mentioned above with reference to Figure 1. The upper opening of cylinder 361 is covered with control valve 37 which is provided with a valve housing defining an operating chamber 371. An interior of operating chamber 371 is communicated with cylinder 361 through an aperture 372 and is also communicated with communication chamber 283 through another aperture 373 as a fluid communication passage. An intermediate portion of aperture 372 is communicated, at an opening, with discharge chamber 281 through a capillary tube 368 and a connecting way 374 which form a communication passageway. The capillary tube 368 is provided with an orifice (381 in Figure 4). A bellows valve 375 is disposed in operating chamber 371 and comprises a bellows portion 375a and a valve portion or a rod-like member 375b attached on the lower end surface of bellows portion 375a. Valve portion 375b is slidably disposed in aperture 372 to control the communication between cylinder 361 and discharge chamber 281.

During operation of the compressor, if the suction pressure is decreased and the gas pressure in communication chamber 283 is, therefore, decreased, the gas pressure in operating chamber 371 is also decreased. At this time, if the gas pressure in bellows portion 375a becomes larger than the gas pressure in operating chamber 371, bellows portion 375a expands. Thus, valve portion 375b moves downwardly and closes the opening of aperture 372 and connecting way 374. As a result, communication between discharge chamber 281 and cylinder 361 is prevented. In this situation, piston 362 is pushed upwardly by recoil strength of spring 363, and the communication is established between intermediate pressure chamber 282 and communication chamber 283 through cylinder 361. Therefore, compression ratio of the compressor is decreased as mentioned above.

On the other hand, if the suction pressure increases and the gas pressure in operating chamber 371 is increased and the gas pressure in bellows portion 375a exceeds the gas pressure in operating chamber 371, bellows portion 375a shrinks, and in accordance with the shrink of bellows portion 375a, valve portion 375b moves upwardly to open the opening of aperture 372 and connecting way 374. Therefore, cylinder 361 is communicated with discharge chamber 281 through aperture and capillary tube 368. In this situation, the discharge gas flows from discharge chamber 281 into cylinder 361 through aperture and capillary tube 368. Since pressure of the discharge gas is stronger than the recoil strength of spring 363, piston 362 is pushed downwardly by pressure of the discharge gas. As a result, communication is blocked between intermediate pressure chamber 282 and communication chamber 283 through cylinder 361. Therefore, compression ratio of the compressor is increased as mentioned above.

The moving distance of bellows portion 375a is determined by the gas pressure in operating chamber 371. Accordingly, the operation of valve portion 375b is determined in accordance with the gas pressure in operating chamber 371.

When the air conditioning load is small, or the gas pressure in operating chamber 371 is decreased below a predetermined value by increasing of the rotational speed of the compressor, bellows portion 375a expands and valve portion 375b moves down. Therefore, the opening of aperture 372 and connecting way 374 is made small and volume of the discharge gas supplied into cylinder 361 is decreased. Therefore, piston 362 is pushed upwardly by recoil strength of spring 363. Thus, opening area of first hole 361a is increased due to moving up of piston 362. Therefore, the communication chamber 283 communicates with intermediate chamber 282 through the increased opening area of first hole 361a, cylinder 361 and second hole 361b, so that the pressure loss for compressed gas flowing out through holes 214 and 215 is decreased. As a result, compression ratio is decreased. Thus, the suction gas pressure is gradually increased so that the gas pressure in communication chamber 283 is again gradually increased.

When the gas pressure in communication chamber 283 is increased, and becomes larger than the predetermined value, bellows portion 375a shrinks, and moving distance of valve portion 375b is gradually decreased. The volume of the discharge gas supplied into cylinder 361 is increased. Piston 362 is thus pushed downwardly by the pressure of the discharge gas against the recoil strength of spring 363. The opening area of first hole 361a of cylinder 361 is gradually decreased.

Thereafter, the similar operation is repeated in accordance with variation of the suction gas pressure.

Referring to Figure 4, a variable displacement control mechanism of a second embodiment shown therein is a modification of the mechanism shown in Figure 3. That is, a control valve 39 is slightly different from the control valve 37 in Figure 3. Control valve 39 comprises a bellows valve 391 which comprises a bellows portion 391a and a needle or pin-like portion 391b attached on the bottom surface of bellow portion 391a. The bellows valve 391 is disposed in a first operating chamber 393 which is communicated with communication chamber 283 through an aperture 397 as a fluid communication passage. Needle portion 391b is slidably inserted into an aperture 392 and extends to a second operating chamber 394. Aperture 392 communicates between first and second operating chambers 393 and 394. The second operating chamber 394 communicates, as a communication passageway, with cylinder 361 and with discharge chamber 281 through capillary tube 368. A ball 395 is disposed on the top end of a spring 396 which is disposed in second operating chamber 394 and contacts with an extended end portion of needle portion 392. Thus, ball 395 controls opening and closing of aperture 392 due to recoil strength of spring 396 and operation of bellows portion 391.

During operation of the compressor, a small amount of the discharge gas is always supplied to second operating chamber 394 from discharge chamber 281 through an orifice 381. When the suction gas pressure is increased and the gas pressure in first operating chamber 393 is, therefore, larger than that in bellows portion 391a, bellows portion 391a shrinks. Ball 395 is moved up by the recoil strength of spring 396 together with needle portion 391b and closes the opening of aperture 392 between first operating chamber 393 and second operating chamber 394. Then, the discharge gas pressure acts on the top surface of piston 362. Thus, piston 362 is pushed downwardly to against the recoil strength of spring 363 by the discharge gas pressure and closes second hole 361b. Communication chamber 283 is blocked from communication with intermediate pressure chamber 282. Therefore, compression volume is increased. Then, the suction gas pressure is gradually decreased.

When the suction gas pressure is decreased and the gas pressure in first operating chamber 393 is, therefore, decreased below the gas pressure in bellows portion 391a, bellows portion 391a expands. Accordingly, needle portion 391b moves down and pushes ball 395 downwardly to against recoil strength of spring 396. The discharge gas in second operating chamber 394 flows to first operating chamber 393 through aperture 392. Since the pressure in second operating chamber 394 is decreased, piston 362 is moved up by the elastic force of spring 363. Accordingly, communication chamber 283 is communicated with intermediate pressure chamber 282 through cylinder 361 and holes 361a and 361b. Therefore, compression volume is decreased. Then, the suction gas pressure is gradually increased.

Thereafter, the similar operation is repeated in accordance with variation of the suction gas pressure.

Referring to Figure 5, a variable displacement control valve mechanism 40 according to a third embodiment shown therein comprises a cylinder 401, a piston valve 402, a bellows 403 and a spring 404.

Piston valve 402 is slidably disposed within cylinder 401 and has a hollow portion with openings 402a and 402b. Also, piston 402 is pushed upwardly by spring 404 disposed between the bottom portion of cylinder 401 and the lower end of piston valve 402. Bellows 403 is disposed in the hollow portion of piston valve 402, and comprises a valve portion 403a and a bellows portion 403b. Valve portion 403a extends to the outside of piston valve 402 through opening 402a which is formed on upper portion of piston 402. Cylinder 401 communicates with discharge chamber 281 through conduits 404 and 405 in which orifice 406 is disposed.

Since the hollow portion of piston valve 402 is communicated with communication chamber 283 through opening 402b, cylinder 401 and first hole 361a, if the gas pressure in communication chamber 283 is decreased below the pressure of gas enclosed in bellows portion 403b by decrease of the suction gas pressure, bellows portion 403b is expanded or straightened. In this situation, valve portion 403a opens opening 402a of piston valve 402, therefore, a small amount of the discharge gas which is introduced in the top space of cylinder 401 through orifice 406 flows into communication chamber 283 through the interior of piston valve 402, opening 402b and cylinder 401. Therefore, the discharge gas pressure is not applied to the piston valve 402. At this time, piston valve 402 is pushed upwardly by the recoil strength of spring 404 from a position closing second hole 361b and communication is accomplished between communication chamber 283 and intermediate pressure chamber 282. Therefore, compression ratio is decreased.

On the other hand, if suction gas pressure is increased and the gas pressure in communication chamber 283 is, therefore, increased above the pressure of gas in bellows portion 403b, the bellows portion 403b shrinks. Since valve portion 403a is drawn due to operation of bellows portion 403b, opening 402a is closed by valve portion 403a. In this situation, by the pressure of the discharge gas from discharge chamber 281 into the top space of cylinder 401, piston valve 402 is pushed downwardly against the recoil strength of spring 404. Second hole 361b is thus closed by piston valve 402, and compression ratio is increased.

Thus, the compressor is variable in the compression volume in accordance with the variation of the suction gas pressure.

In the embodiment shown in Figure 5, construction of valve portion 403a is a simple structure, however, needle-ball type valve mechanism 41 can be used as shown in Figure 6. Also, strength of pushing force by bellows portion can be controlled by position of bellows 403. The position of bellows 403 can be determined by a screw 42 in the bottom portion of piston valve 402, as shown in Figure 6.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A scroll type compressor including a housing having an inlet port and an outlet port, a fixed scroll fixedly disposed within said housing and having a circular end plate from which a first spiral element extends into the interior of said housing, an orbiting scroll having a circular end plate from which a second spiral element extends, said first and second spiral elements interfitting at an angular and radial offset to make a plurality of line contacts and define at least one pair of fluid pockets within the interior of said housing, a driving mechanism operatively connected to said orbiting scroll to effect the orbital motion of said orbiting scroll, a rotation preventing mechanism for preventing the rotation of said orbiting scroll during the orbital motion, said circular end plate of said fixed scroll dividing the interior of said housing into a suction chamber and a rear chamber, said suction chamber communicating with said inlet port, said rear chamber being divided into a discharge chamber which discharges to said outlet port a compressed gas discharged, as a discharge gas, from a central fluid pocket formed by both said scrolls and an intermediate pressure chamber, said circular end plate of said fixed scroll having at least one pair of holes to form a fluid channel between said fluid pockets and said intermediate

pressure chamber, said circular end plate of said fixed scroll having a communication channel to form a fluid channel between said intermediate pressure chamber and said suction chamber, control means disposed on a portion of said intermediate pressure chamber for controlling fluid communication between said intermediate pressure chamber and said suction chamber, said control means comprising a cylinder communicating with said intermediate pressure chamber, said suction chamber and said discharge chamber, piston slidably disposed within said cylinder and operated by the discharge gas pressure from said discharge chamber to control the fluid communication between said suction chamber and said intermediate pressure chamber, and a control valve for controlling application of the discharge gas pressure onto said piston so as to control the compression ratio of the compressor, the improvement wherein said control valve comprises:

an operating chamber communicating with said suction chamber;

means disposed in said operating chamber for sensing a gas pressure in said operating chamber as a sensed gas pressure; and

means coupled with said sensing means for controlling application of the discharge gas pressure onto said piston in response to said sensed gas pressure to operate said piston so as to close off the fluid communication between said suction chamber and said intermediate pressure chamber when said sensed gas pressure is above a predetermined gas pressure but to open the fluid communication between said suction chamber and said intermediate pressure chamber when said sensed gas pressure is below the predetermined gas pressure.

2. A scroll type compressor according to Claim 1, wherein said sensing means is a bellows, said bellows expanding according to decrease of said sensed gas pressure and shrinking according to increase of said sensed gas pressure, and said controlling means is a valve element coupled to and controlled by said bellows.

3. A scroll type compressor according to Claim 2, a lower portion of said cylinder communicates with said intermediate pressure chamber and said suction chamber, a top portion of said cylinder communicating with said discharge chamber, a spring being disposed in said lower portion of said cylinder to urge said piston upwardly, wherein said control valve is mounted on said cylinder and comprises a valve housing defining said operating chamber and a fluid communication passage communicating said operating chamber with said suction chamber.

4. A scroll type compressor according to claim 3, said control means comprising a communication passageway communicating said cylinder and said discharge chamber, wherein said valve element is disposed to control opening and closing of said

communication passageway so that the discharge gas pressure is applied to move said piston downwardly against said spring urging force to close off the fluid communication between said suction chamber and said intermediate pressure chamber when said valve element opens said communication passageway, while the discharge gas pressure is not applied to said piston to allow said piston move upwardly by said spring urging force to open the fluid communication between said suction chamber and said intermediate pressure chamber when said valve element close said communication passageway.

5. A scroll type compressor according to claim 4, wherein said valve element comprises a rod member coupled to said bellows, said rod member extending to cross and close said communication passageway when said bellows expands, said rod member being drawn back to open said communication passageway when said bellows shrinks.

6. A scroll type compressor according to Claim 3, said control means comprising a communication passageway communicating said cylinder and said discharge chamber, wherein said valve housing having an aperture communicating said operating chamber with said communication passageway, said valve element controlling opening and closing said aperture so that the discharge gas pressure is applied to move said piston downwardly to close off the fluid communication between said suction chamber and said intermediate pressure chamber

when said valve element opens said aperture, while the discharge gas pressure is not applied to said piston to allow said piston upwardly by said spring urging force to open the fluid communication between said suction chamber and said intermediate pressure chamber when said valve element close said aperture.

7. A scroll type compressor according to Claim 6, wherein said valve element comprises a valve ball element urged by a spring to close said aperture, and a pin coupled with said bellows to push said valve ball element against the urging force by said spring to open said aperture when said bellows expands, to thereby make said discharge gas flow into said operating chamber through said aperture so that said discharge gas pressure does not act onto said piston.

8. A scroll type compressor according to Claim 1, a lower portion of said cylinder communicates with said intermediate pressure chamber and said suction chamber, a top portion of said cylinder communicating with said discharge chamber, a spring being disposed in said lower portion of said cylinder to urge said piston upwardly, wherein said control valve is disposed in said piston.

9. A scroll type compressor according to Claim 8, wherein said piston comprises a hollow portion as said operating chamber and two openings a first one of which communicates with said suction chamber through said cylinder, the other second one communicating with

said discharge chamber, said sensing means being a bellows disposed in said hollow portion, said bellows expanding according to decrease of said sensed gas pressure and shrinking according to increase of said sensed gas pressure, and said valve element controlling opening and closing said second opening so that the discharge gas pressure is applied to move downwardly said piston to close off the fluid communication between said suction chamber and said intermediate pressure chamber when said valve element closes ~~opens~~ said second opening, while the discharge gas pressure is not applied to said piston to allow said piston upwardly by said spring urging force to open the fluid communication between said suction chamber and said intermediate pressure chamber when said valve element opens ~~close~~ said second opening.

10. A scroll type compressor according to Claim 9, wherein said valve element comprises a rod-like member extending into said second opening, said rod-like member moving to close said second opening when said bellows shrink, said rod-like member moving to open said second opening when said bellows expands.

11. A scroll type compressor according to Claim 9, wherein said valve element comprises a pin-like member extending into said second opening and a valve ball element disposed to be urged by said discharge gas pressure to close said second opening, said pin-like member moving to push said valve ball element against

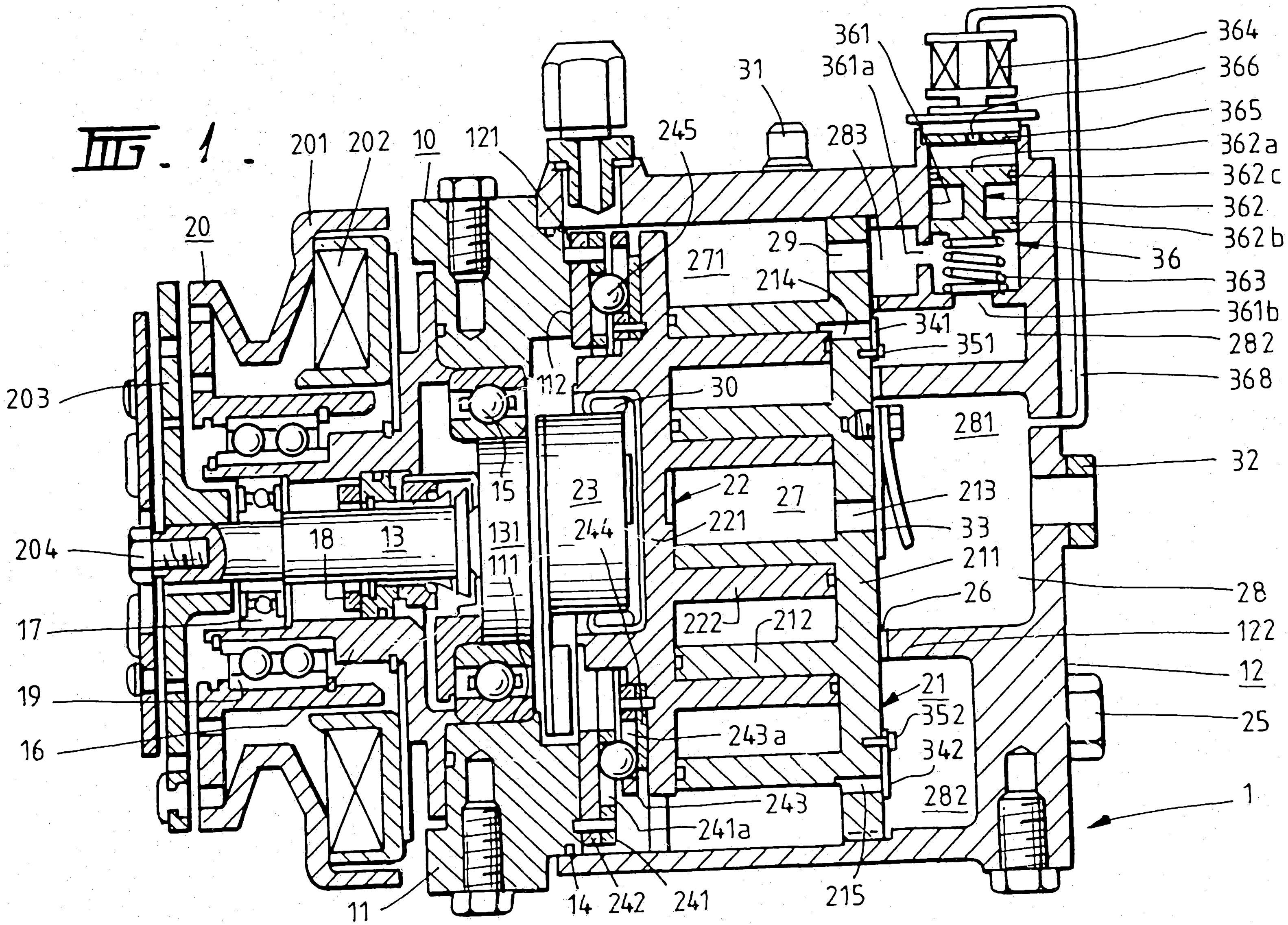
said discharge gas pressure to open said second opening when said bellows expands, said pin-like member drawing back to allow said valve ball element to move to close said second opening under the discharge gas pressure when said bellows shrink.

Dated this 30th day of April, 1990

SANDEN CORPORATION
By Its Patent Attorneys

GRIFFITH HACK & CO.
Fellows Institute of
Patent Attorneys of Australia

FIG. 1.



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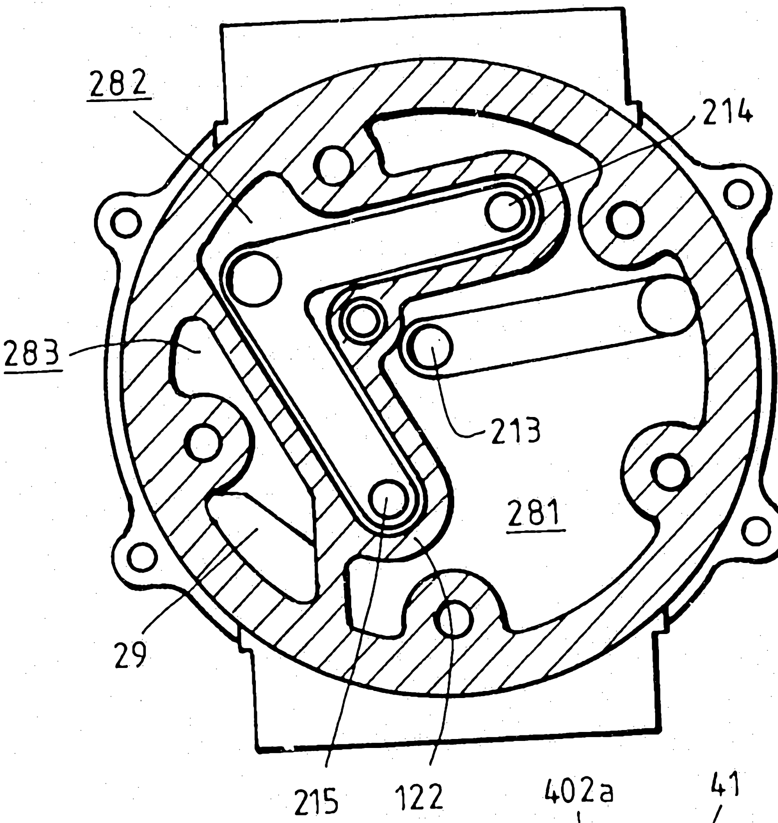
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FIG. 2.

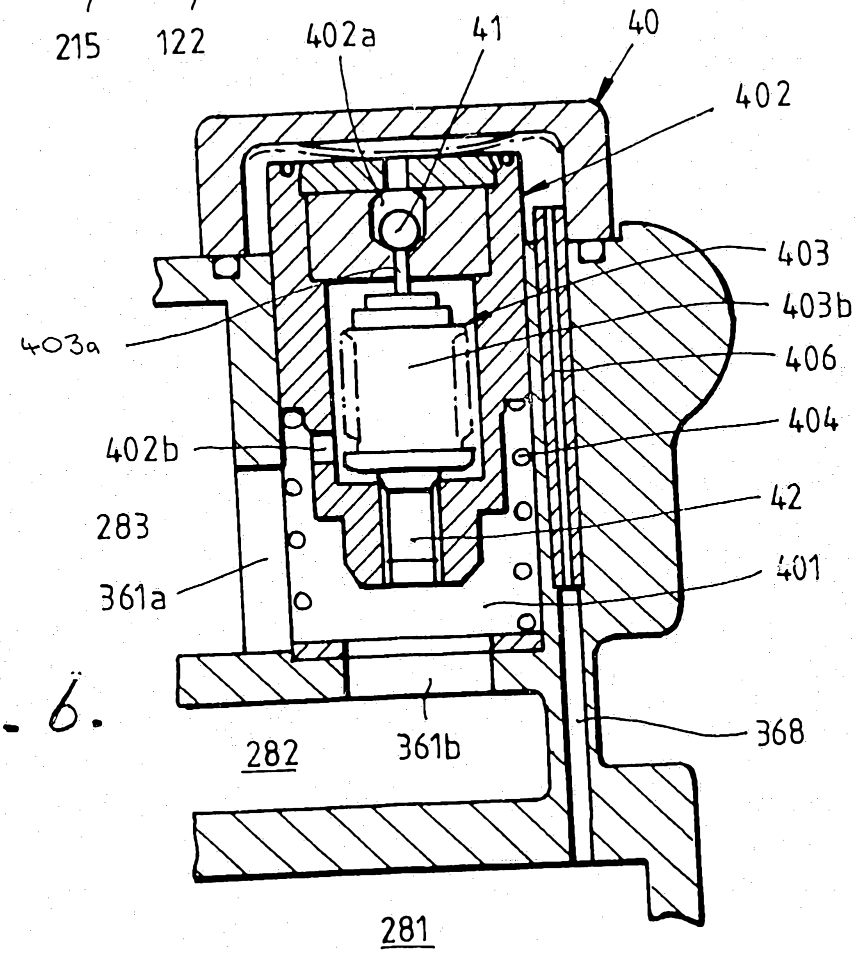
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FIG. 6.

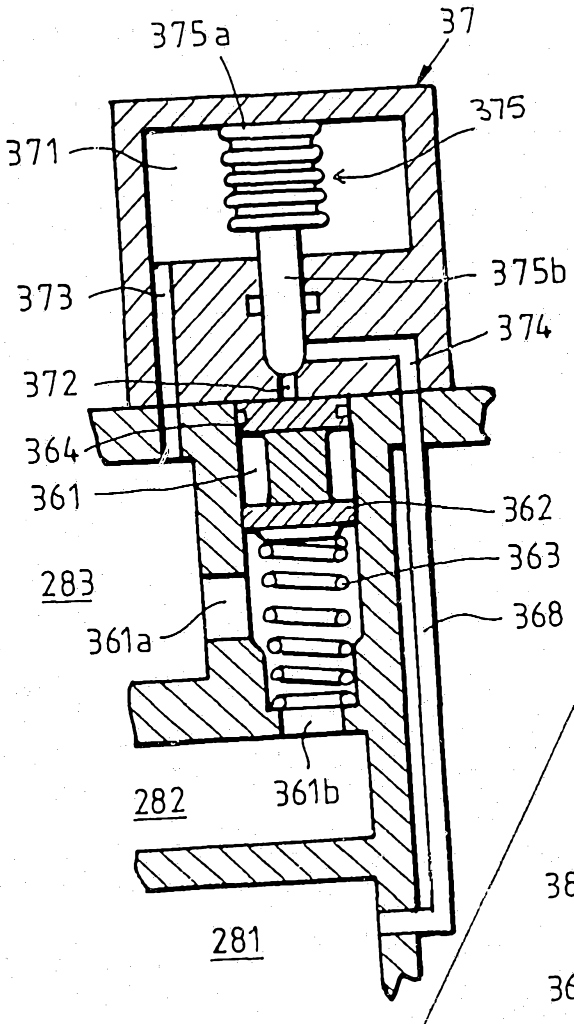
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FIG. 3.

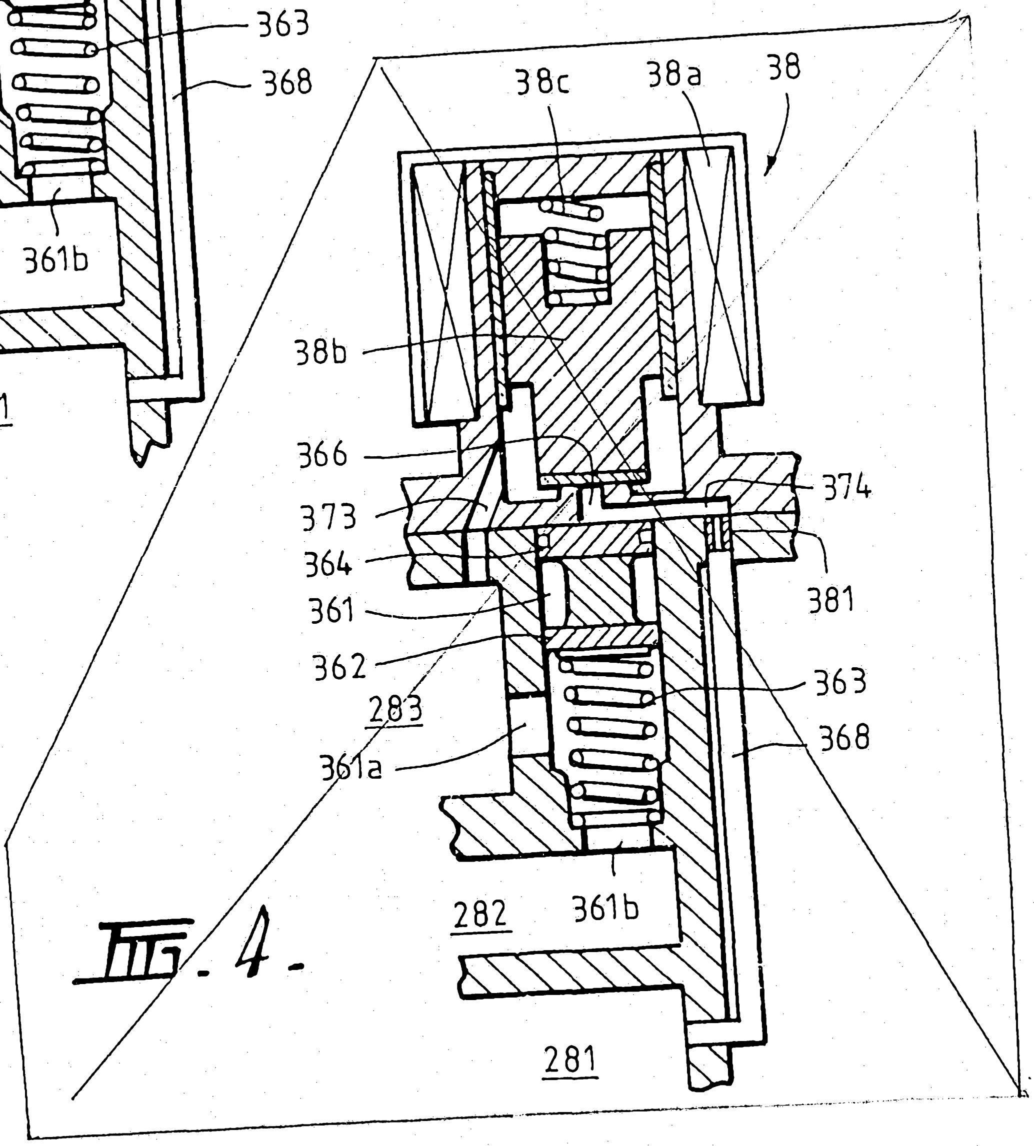
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FIG. 4.

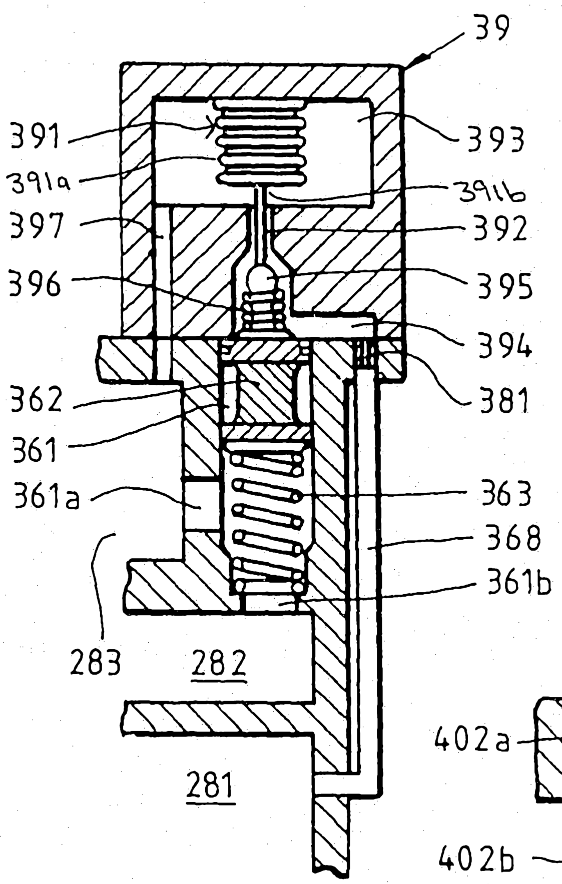
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FIG. 4.

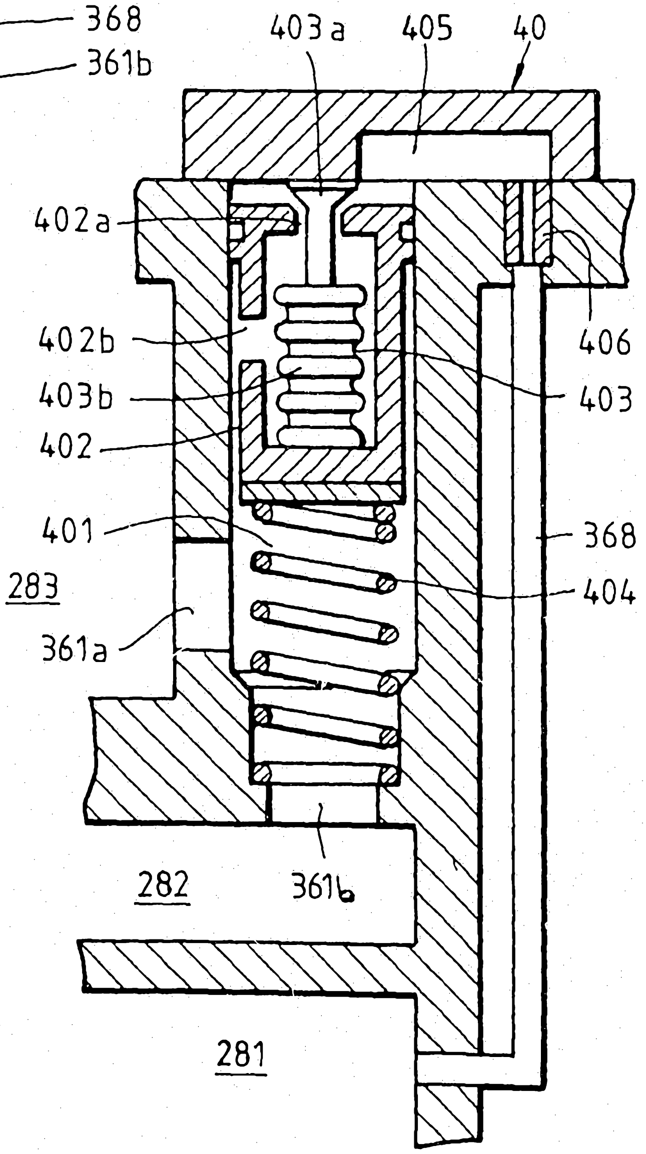
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FIG. 5.