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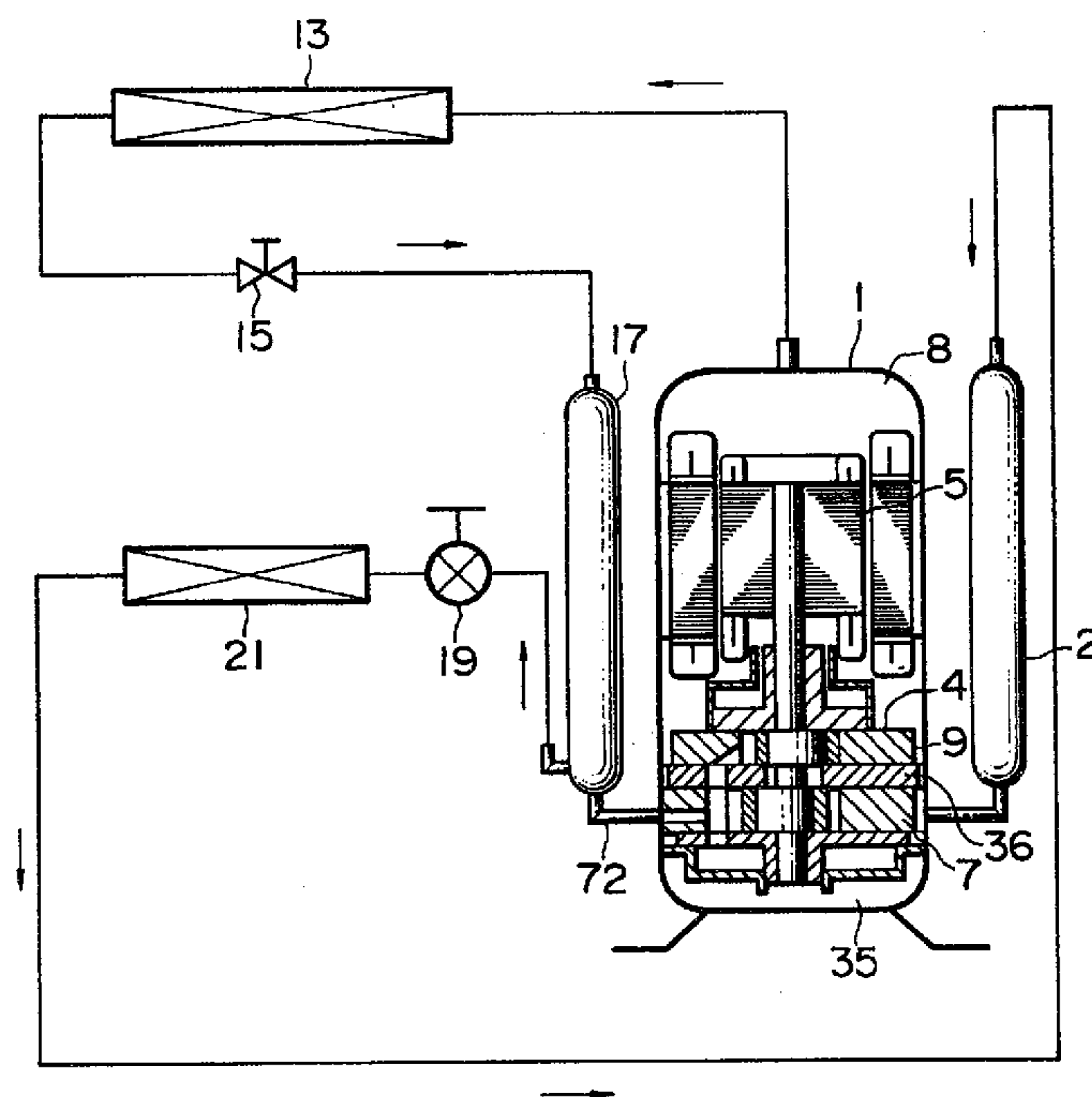
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(54) **COMPRESSEUR DE GAZ A PHASES MULTIPLES AVEC
ROBINET DE DERIVATION**

(54) **MULTI-STAGE GAS COMPRESSOR INCORPORATING
BYPASS VALVE DEVICE**



(57) A multi-stage gas compressor includes a plurality of compression elements which constitute a multi-stage compression mechanism, in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages so that a discharge side of each lower pressure stage compression element is communicated with a suction side of each higher pressure stage compression element through a communication passage so as to constitute a two-stage compression mechanism. A motor coupled to a drive shaft of the multi-stage compression mechanism is located in a motor chamber within a closed container containing the multi-stage compression mechanism, so as to discharge compressed gas from a final stage compression element of the multi-stage compression mechanism into the motor chamber. An oil sump is provided in a bottom part of the closed container, and a bypass passage connects an intermediate part of one of the communication passages with the motor chamber. A bypass valve device located in the bypass passage allows communication only from the one of the communication passages to the motor chamber, when the pressure of the one of the communication passages is higher than that of the motor chamber. The starting load of the compressor and vibration and noise are reduced.



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ABSTRACT

A multi-stage gas compressor includes a plurality of compression elements which constitute a multi-stage compression mechanism, in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages so that a discharge side of each lower pressure stage compression element is communicated with a suction side of each higher pressure stage compression element through a communication passage so as to constitute a two-stage compression mechanism. A motor coupled to a drive shaft of the multi-stage compression mechanism is located in a motor chamber within a closed container containing the multi-stage compression mechanism, so as to discharge compressed gas from a final stage compression element of the multi-stage compression mechanism into the motor chamber. An oil sump is provided in a bottom part of the closed container, and a bypass passage connects an intermediate part of one of the communication passages with the motor chamber. A bypass valve device located in the bypass passage allows communication only from the one of the communication passages to the motor chamber, when the pressure of the one of the communication passages is higher than that of the motor chamber. The starting load of the compressor and vibration and noise are reduced.

SPECIFICATION
MULTI-STAGE GAS COMPRESSOR INCORPORATING
BYPASS VALVE DEVICE

TECHNICAL FIELD

The present invention relates to a multi-stage compressor in which an abnormal rise of pressure in a communication passage between a low stage compression
5 element and a high stage compression element so as to enhance the compression efficiency and the durability and to reduce vibration and noise.

BACKGROUND OF THE INVENTION

These years, in the field of refrigerators,
10 studies for materializing a coolant compressor which is suitable for high compression ratio operation, as a part of insurance of a low temperature heat source and a high temperature heat source, have been prosperous.

Particularly, several kinds of multi-stage rotary
15 type compressors have been proposed in order to enhance the compression efficiency by decreasing the pressure differential between a compression chamber and a suction chamber so as to reduce the volume of leakage gas under compression.

20 Specifically, a rolling type rotary two stage compressor and a two stage compression refrigerating cycle system configuration connected thereto with the former compressor has been proposed as shown in Figs. 1 to 3

(Japanese Patent Unexamined Publication No. 50-72205). In these figures, a drive motor 1005 is disposed in the upper part of a closed container 1003 while a compression mechanism coupled to a rotary shaft 1005c of the drive motor 1005 and composed of two upper and lower stages (a low pressure stage compression mechanism 1007 as the upper stage and a high pressure stage compression mechanism 1009 as the lower stage) is disposed in the lower part of the closed container, and an oil sump is disposed in the bottom part thereof, the back surface of a vane 1007c (1009c) which partitions each of cylinders of the low pressure stage compression mechanism 1007 and the high pressure stage compression mechanism 1009 into a suction chamber and a compression chamber being communicated with the internal space of the closed container 1003, and a back pressure urging force applied to the vane 1007c (1009c) being given by a reaction force of a spring device and a pressure in the closed container 1003.

Coolant gas discharged from the lower pressure stage compression mechanism 1007 flows into an external gas-liquid separator 1017 through a discharge pipe 1007e, and then again flows into the internal space of the closed container 1003 through a communication pipe 1009d' so as to cool the motor 1005.

Discharged coolant gas having flown again into the closed container 1003 sucks up lubrication oil in the bottom part of the closed container 1003 when it flows through a suction pipe 1009d connected thereto with an oil suction

pipe 1023, and is then introduced into the high pressure stage compression element 1009 in order that the lubrication oil is used for cooling a slide surface and for sealing a gap in the compression chamber.

5 Discharged coolant gas recompressed by the high pressure stage compression mechanism 1009 is fed into an external condenser 1013 through a discharge pipe 1009e, and then returns again into the low pressure stage compression mechanism 1007 through a suction pipe 1007d by way of a first
10 expansion valve 1015, the gas-liquid separator 1017, a second expansion valve 1019 and an evaporator 1021.

 Further, in order to improve torque variation which is large during compression and which is one of disadvantages inherent to the rolling piston type rotary
15 compressor, the directions of eccentricity of crank parts of the rotary shaft 1005c are shifted from each other by an angle of 180 deg., and the directions of attachment of the vanes (1007c, 1009c) of both compression mechanisms (low pressure stage compression mechanism 1007 and high pressure
20 stage compression mechanism 1009) are shifted between the high and low pressure stage sides by an angle of 75 to 80 deg. That is, a countermeasure for reducing the torque variation in comparison with a rotary type first stage compressor has been proposed.

25 The two stage compression refrigerating cycle is constituted by the arrangement of the above-mentioned components so as to devise a measure for holding the pressure of the internal space of the closed container 1003 at a value

intermediate of between the condensation pressure and evaporation pressure of the coolant.

However, in the above-mentioned arrangement as shown in Figs. 1 to 3, coolant gas flowing into the suction side of the high pressure stage compression mechanism 1009 is heated when it passes around the drive motor 1005, and accordingly, there has been raised such problems that the suction efficiency of the coolant gas is lowered in the high pressure stage compression mechanism 1009, and the compression efficiency is remarkably lowered due to an abnormal rise in pressure of the coolant gas during compression.

Further, as well-known, the suction cylinder volume of the high pressure stage compression element 1009 in the two stage compressor is set to correspond to the volume of coolant gas discharged from the low pressure stage compression element 1007, but excess or insufficiency occurs between the volume of gas discharged from the low pressure stage compression element 1007 and the suction cylinder volume of the high pressure stage compression element 1009 during the transition period between the suction and discharge strokes of both compression elements. As a result, pressure pulsation is caused in the intermediate passage communicating between both compression elements, and accordingly, the discharge pressure of the low pressure stage compression element 1007 instantly increases while the suction pressure of the high pressure stage compression element 1009 instantly decreases, that is, the compression

ratio remarkably varies so as to incur an input loss.

Thus, in such an arrangement that an intermediate passage communicating between both compression elements is remarkably long since it is laid detouring externally around a closed container, there is raised a problem in that the size of the compression mechanism becomes large while a delay in follow-up of suction gas in the high pressure stage compression element 1009 occurs so as to increase the input loss.

Measures are taken to improve the above-mentioned problem relating to the two stage compressor, as shown in Figs. 4 and 5 (Japanese Patent Unexamined Publication No. 1-247785).

In this compressor, a low pressure stage compression mechanism 2005 and a high pressure stage compression mechanism 2006 are directly communicated together so as to cool a motor with discharge gas discharged into a motor chamber from the high pressure stage compression element 2005 while the rear surface of a vane dividing the inside of each cylinder into a suction chamber and a compression chamber is urged mainly by lubrication oil under action of the discharge pressure, thereby the rolling piston type two-stage compressor is miniaturized.

Fig. 4 is an explanatory view for the compression timings of the low pressure stage compression element 1007 and the high pressure stage compression element 1009 of the above-mentioned compressor, and Fig. 5 is a partial sectional view illustrating the compressor comprising the

low pressure stage compression mechanism 2005 disposed in a vertical type closed casing 2001 and a valve cover 2027 therefor, a high pressure stage compression mechanism 2006 disposed below the low pressure stage compression mechanism 2005 and a valve cover 2028 therefor, an intermediate frame 2020 connecting between both compression mechanisms (2005, 2006), a crank shaft 2004 for driving both compression mechanisms (2005, 2006), a passage 2032 connecting the discharge side of the low pressure stage compression mechanism 2005 with the suction side of the high pressure stage compression mechanism 2006, and the like with vanes 2011 and 2012 being arranged so as to be spaced from each other by an angle of 90 deg. in order to delay the compression timing of the high pressure stage compression mechanism 2006 from that of the low pressure stage compression mechanism 2005 by an angle of 90 deg. and pressure gas discharged from the high pressure stage compression mechanism 2006 is filled in the vertical closed casing 2001.

It is noted that coolant gas compressed by the low pressure stage compression element 2005 flows into a low stage discharge chamber defined in the valve cover 2027, and then flows into the suction side of the high pressure stage compression element 2006 by way of the passage 2023 (which is not shown in Fig. 5). After compression, the coolant gas is discharged into a high stage discharge chamber surrounded by the valve cover 2023, and then it flows into the motor chamber disposed thereabove.

However, for a while after a start of the compressor, coolant liquid or gas-liquid mixture coolant having flown into and staying in the suction side of the low pressure stage compression element 2005 is heated and expanded within the cylinder of the low pressure stage compression element 2005 so as to produce a volume of coolant gas which is much greater than that of the cylinder suction volume of the high pressure stage compression element 2006 and which is discharged into the valve cover 2027. Thus, a rise in pressure in the passage 2023 is fast, and as a result, the compression torque of the low pressure stage compression element 2005 becomes larger so that vibration just after the start is excessive, thereby there have been raised problems such as an increase in cost due to a large size motor and a limitation to a supply power source facility due to an increase in start current.

Further, since the temperature of the discharge side is low, in particular, for a while after a cold start of the compressor, a rise in pressure in the vertical closed casing 2001 is slow, and accordingly, the urging force acting upon the rear surface of the vane 2012 in the high pressure stage compression element 2006 is insufficient until the pressure reaches a predetermined value.

Since a rise in pressure in the passage 2023 is fast in this condition, the suction pressure (pressure in the passage 2023) becomes higher than the pressure urging the rear surface of the vane 2012 in the high pressure stage compression element 2006, subjecting the vane 2012 to an

excessive jumping phenomenon. As a result, excessive bumping sound produced between the tip end of the vane 2012 and the roller 2008 and vibration accompanied therewith cause high noise and vibration, and accordingly, there has been raised
5 a problem of lowering the durability of the vane 2012 and the roller 2008.

Further, due to the high jumping phenomenon of the vane 2012, leakage of coolant gas from the compression chamber to the suction chamber becomes large, there has been
10 raised a problem of incurring a remarkable lowering of the compression efficiency at the initial stage of a cold start.

It is noted that a large volume of high pressure liquefied coolant on the heat radiation side flows into the suction side of the two stage compressor so that liquid
15 compression occurs in the low pressure stage compression element 2005, resulting in an abnormal rise in pressure in the passage 2023, just after defrosting operation is started by changing over between a pipe line to the heat sink side and a pipe line to the heat radiator side with the use of a
20 solenoid valve or the like in such a case that the outer surface of a heat sink side heat-exchanger frosts over during hot water supply operation or during air-conditioning heating operation by a two stage compression and two stage expansion refrigerating cycle in the winter season.
25 Meanwhile due to change-over to the defrosting operation, the pressure on the discharge side of the high pressure stage compression element 2006 abruptly lowers so that the pressure in the passage 2023 becomes higher than that on the

discharge side of the high pressure stage compression
element 2006, and accordingly, the vanes 2011, 2012 are
subjected to a jumping phenomenon which is more excessive
than that mentioned above. Thus, there has been raised a
5 serious problem, peculiar to the two stage compression
mechanism, in that the compressor is broken.

Further, although explanation has been made of the
problems relating to a rolling piston type rotary two stage
compressor, it is clear that problems such as large
10 vibration, a rise in cost caused by a large size motor and a
limitation to a supply power source facility caused by an
increase in starting current would be presented by a slide
vane type rotary two stage compressor in which vanes are
rotated together with a drive shaft, a reciprocation type
15 two stage compressor, a scroll type two stage compressor or
the like, similar to the above-mentioned problems.

DISCLOSURE OF THE INVENTION

The present invention is devised in view of the
above-mentioned problems, and accordingly, one object of the
20 present invention is to aim at reducing a start load to a
compressor, vibration and noise.

Specifically, among a plurality of compression
elements, the discharge sides of low pressure stage
compression elements are coupled in series with the suction
25 sides of high pressure stage compression elements through
the intermediary of communication passages, respectively,
and compressed gas is discharged into a discharge gas

discharging space from the final stage compression element while an oil sump is arranged in the bottom part of the space. Further a bypass passage is provided between the communication passage and the discharge gas discharging
5 space or a space communicated therewith, and a bypass valve device which allows communication only from the communication passage to the discharge gas discharging space or the space communicated therewith when the pressure in the communication passage is higher than that in the discharge
10 gas discharging space, is disposed in the bypass passage.

Further, another object of the present invention is to prevent the vanes from jumping during defrosting operation in a heating operation mode at the initial stage of a cold start or in the winter season so as to aim at
15 reducing noise and vibration and at enhancing the durability.

Specifically, among a plurality of compression elements, the discharge sides of low pressure stage compression elements are coupled in series with the suction
20 sides of high pressure stage compression elements through the intermediary of communication passages, respectively, so as to constitute a multi-stage compression mechanism, and compressed gas is discharged into a discharge gas discharging space from the final stage compression element
25 while an oil sump is arranged in the bottom part of the space. Further a bypass passage is provided between each of the communication passage and the discharge gas discharging

space or a space communicated therewith, and a bypass valve device which allows communication only from the communication passage to the discharge gas discharging space or the space communicated therewith when the pressure in the communication passage is higher than that in the discharge gas discharging space, is disposed in the bypass passage. In addition, lubrication oil discharged from the final stage compression element and separated from discharge gas therefrom is introduced into a rear chamber for a vane which defines a suction chamber and compression chamber in a cylinder of each of the compression elements while the vane is extended and retracted in the cylinder, thereby the vane is urged under back pressure.

Further, another object of the present invention is to prevent lubrication oil from flowing outside of the compressor when gas in the communication passage between the low pressure stage compression element and the high pressure stage compression element is temporarily bypassed so as to flow into the discharge side of the high pressure stage compression element in order to temporarily reduce the compression load.

Specifically, among a plurality of compression elements, the discharge sides of low pressure stage compression elements are coupled in series with the suction sides of high pressure stage compression elements through the intermediary of communication passages, respectively, so as to form a multi-stage compression mechanism, and

compressed gas is discharged into a discharge gas discharging space from the final stage compression element while an oil sump is arranged in the bottom part of the space. Further a bypass passage is provided between each of the communication passages and the discharge gas discharging space or a space communicated therewith, and a bypass valve device which allows communication only from the communication passage to the discharge gas discharging space or the space communicated therewith when the pressure in the communication passage is higher than that in the discharge gas discharging space, is disposed in the bypass passage. In addition, the bypass passage is communicated with a discharge chamber in the high pressure stage compression element.

Further, another object of the present invention is to prevent a multi-stage compression function from deteriorating due to useless bypass action during stable operation in such an arrangement that gas in the communication passage between the low pressure stage compression element and the high pressure stage compression element is temporarily bypassed so as to flow into the discharge side of the high pressure stage compression element in order to temporarily reduce the compression load.

Specifically, among a plurality of compression elements, the discharge sides of low pressure stage compression elements are coupled in series with the suction sides of high pressure stage compression elements through the intermediary of communication passages, respectively,

so as to form a multi-stage compression mechanism, and compressed gas is discharged into a discharge gas discharging space from the final stage compression element while an oil sump is arranged in the bottom part of the space. Further a bypass passage is provided between each of the communication passages and the discharge gas discharging space or a space communicated therewith, and a bypass valve device which allows communication only from the communication passage to the discharge gas discharging space or the space communicated therewith when the pressure in the communication passage is higher than that in the discharge gas discharging space, is disposed in the bypass passage. In addition, an urging force for pressing a valve element in the bypass valve device, toward a valve seat is given by a spring device.

Further, another object of the present invention is to reduce the load during a cold start of the compressor and to improve unnecessary gas leakage from the discharge side to the communication passage during stable operation so as to aim at enhancing the compression efficiency in such an arrangement that gas in the communication passage between the low pressure stage compression element and the high pressure stage compression element is temporarily bypassed so as to flow into the discharge side of the high pressure stage compression element in order to temporarily reduce the compression load.

Specifically, among a plurality of compression elements, the discharge sides of low pressure stage

compression elements are coupled in series with the suction sides of high pressure stage compression elements through the intermediary of communication passages, respectively, so as to form a multi-stage compression mechanism, and
5 compressed gas is discharged into a discharge gas discharging space from the final stage compression element while an oil sump is arranged in the bottom part of the space. Further a bypass passage is provided between each of the communication passages and the discharge gas discharging
10 space or a space communicated therewith, and a bypass valve device which allows communication only from the communication passage to the discharge gas discharging space or the space communicated therewith when the pressure in the communication passage is higher than that in the discharge
15 gas discharging space, is disposed in the bypass passage. In addition, an urging force for pressing a valve element in the bypass valve device, toward a valve seat is given by a spring device which incorporates a shape memory function such that the urging force of the spring is increased as the
20 temperature thereof increases while the urging force is decreased as the temperature decreases.

Further, another object of the present invention is to reduce the compression load in follow-up with an increase in the discharge pressure of the high pressure side
25 so as to carry out smooth control in a range of start to smooth operation in order to enhance the durability of the compressor in such an arrangement that gas in the communication passage between the low pressure stage compression

element and the high pressure stage compression element is temporarily bypassed to the discharge side of the high pressure compression element so as to temporarily reduce the compression load.

5 Specifically, among a plurality of compression elements, the discharge sides of low pressure stage compression elements are coupled in series with the suction sides of high pressure stage compression elements through the intermediary of communication passages, respectively,
10 so as to constitute multi-stage compression mechanism, and compressed gas is discharged into a discharge gas discharging space from the final stage compression element while an oil sump is arranged in the bottom part of the space. Further a bypass passage is provided between each of
15 the communication passage and the discharge gas discharging space or a space communicated therewith, and a bypass valve device which allows communication only from the communication passage to the discharge gas discharging space or the space communicated therewith when the pressure in the
20 communication passage is higher than that in the discharge gas discharging space, is disposed in the bypass passage. In addition, pressure in the discharge gas discharging space or the space communicated therewith is allowed to act upon the rear surface of a valve element in the bypass valve device so
25 as to press the valve element toward a valve seat.

Further, another object of the present invention is to reduce expansion sound when gas is bypassed, and to

prevent lubrication oil from flowing out from the discharge side in such an arrangement that gas in the communication passage between the low pressure stage compression element and the high pressure stage compression element is
5 temporarily bypassed so as to flow into the discharge side of the high pressure stage compression element in order to temporarily reduce the compression load.

Specifically, among a plurality of compression elements, the discharge sides of low pressure stage
10 compression elements are coupled in series with the suction sides of high pressure stage compression elements through the intermediary of communication passages, respectively, so as to form a multi-stage compression mechanism, and compressed gas is discharged into a discharge gas
15 discharging space from the final stage compression element while an oil sump is arranged in the bottom part of the space. Further a bypass passage is provided between each of the communication passage and the discharge gas discharging space or a space communicated therewith, and a bypass valve
20 device which allows communication only from the communication passage to the discharge gas discharging space or the space communicated therewith when the pressure in the communication passage is higher than that in the discharge gas discharging space, is disposed in the bypass passage. In
25 addition, a discharge chamber in the high pressure stage compression element is disposed just downstream of the bypass valve device.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view illustrating a pipe line system of a two-stage compression refrigerating cycle in which a conventional two stage coolant compressor is used;

Fig. 2 is an explanatory plan view illustrating a compression mechanism in the compressor;

Fig. 3 is a detailed sectional view illustrating a lubricating device in the compressor;

Fig. 4 is an explanatory view showing the
10 compression timing of another two stage compressor;

Fig. 5 is a sectional view illustrating an essential part of a compression mechanism in the compressor;

Fig. 6 is a view illustrating pile line system of a two-stage compression refrigerating cycle in which a two stage compressor in a first embodiment of the present invention is used;

Fig. 7 is a sectional view illustrating the compressor;

Fig. 8 is a sectional view illustrating an
20 essential part of a compression mechanism in the compressor;

Fig. 9 is a perspective view illustrating a bypass valve used in the compressor;

Fig. 10 is a partial sectional view along the line X-X in Fig. 8;

Fig. 11 is a sectional view illustrating an essential part of the compression mechanism in the compressor in a condition such that the bypass valve device and a check valve device are operated;

Fig. 12 is a sectional view illustrating an essential part of a compression mechanism in a two stage coolant compressor in a second embodiment of the present invention;

Fig. 13 is a transverse sectional view illustrating a two stage coolant compressor in a third embodiment of the present invention;

Fig. 14 is a partial sectional view along the line XIV-XIV in Fig. 13; and

10 Fig. 15 is a transverse sectional view illustrating a two stage coolant compressor in a fourth embodiment of the present invention.

BEST MODE OF THE INVENTION

Explanation will be made hereinbelow of a rolling piston type rotary two stage coolant compressor in a first embodiment of the present invention with reference to Figs. 6 to 11.

Fig. 6 shows a pipe line system of a two stage compression and two stage expansion refrigerating cycle in which a rolling piston type rotary two stage compressor 1 incorporating an accumulator 2, a condenser 13, a first expansion valve 15, a gas-liquid separator 17, a second expansion valve 19 and an evaporator 21 are connected in that order; Fig. 7 is a sectional view illustrating the rolling piston type rotary two stage compressor 1, and Fig. 8 shows the details of an essential part of a two stage compression mechanism.

Within a closed container 3, a motor 5 is disposed in a motor chamber 8 in the upper space of the container 3, a two stage compression mechanism 4 is disposed below the motor 5 around and below which an oil sump 35 is defined.

The stator 5a of the motor 5 is shrinkage-fitted in the inner wall of the closed container 3.

The two stage compression mechanism 4 is composed of a high pressure stage compression element 9 in the upper part, a low pressure stage compression element 7 in the lower
10 part, and a planar intermediate plate 36 interposed between both compression elements (7, 9), and is welded and secured to the inner wall of the closed container 3 at several positions (which are not shown) on the outer peripheral parts of a discharge cover 37 of the low pressure stage compression element 7 and the intermediate plate 36.

The cylinder volume of the high pressure stage compression element 9 is set to 45 to 65 % of that of the low pressure stage compression element 7.

A drive shaft 6 which are supported by an upper
20 bearing member 11 attached to the upper surface of a second cylinder block 9a of the high pressure stage compression element 9 and a lower bearing member 12 attached to the lower surface of a first cylinder block 7a of the low pressure stage compression element 7, is coupled and secured to the rotor 5b of the motor 5.

A first crankshaft 6a and a second crankshaft 6b of the drive shaft 6 are shifted in their eccentric directions by an angle of 180 deg. from each other.

Vanes 28, 39 abut against the outer peripheral surfaces of first and second pistons 7b, 9b fitted respectively on the first and second crankshafts 6a, 6b of the drive shaft 6 so as to divide each the cylinders of the low and high pressure stage compression elements 7, 9 into a suction chamber and a compression chamber, and the coil springs 40, 41 urge the vanes 38, 39 at the rear surfaces of the latter.

The rear end part of the coil spring 41 in the high
10 pressure stage compression element 9 is supported at the inner wall of the closed container 3 while the rear end part of the coil spring 42 in the low pressure stage compression element 7 is supported by a cap 42 sealingly attached to the first cylinder block 7a.

A rear chamber 43 for the vane 39 in the high pressure stage compression element 9 is opened to the oil sump 35, but a rear chamber 44 for the vane 38 in the low pressure stage compression element 7 is sealed at its one end by the cap 42 so that the communication to the oil sump 35 is
20 blocked.

The discharge cover 37 of the low pressure stage compression element 7 is attached to the first cylinder block 7a together with the lower bearing member 12 so as to define a low stage compression chamber 45, and the bottom part thereof defines therein a discharge chamber oil sump 46.

The discharge chamber oil sump 46 is partitioned from the upper space of the low stage discharge chamber 45 by

means of a partition plate 48 secured to the discharge cover 37 and is having a plurality of small holes 47, and the bottom part thereof is communicated with the rear chamber 44 for the vane 38 through an oil return passage 49 composed of oil return holes 49a, 49b which are formed in the discharge cover 37 and the lower bearing member 12.

A discharge cover 50 formed of a vibration suppressing steel plate is disposed surrounding the outer periphery of the upper bearing member 11 so as to define a
10 high stage discharge chamber 51.

A sound suppressing chamber 52 which is a recess formed in one end part of the rotor 5b of the motor 5 is communicated with a high stage discharge chamber 51 through the intermediary of an annular passage 53 between a projection 11a of the upper bearing member 11 and a projection 50a of the cover 50 surrounding the outer periphery of the projection 11a, and is also communicated with the internal space of the closed container 3 through an
20 annular passage 54 between the inner surface of an end ring 5c of the rotor 5b and the projection 50a of the discharge cover 50.

The low stage discharge chamber 54 and an suction chamber 56 in the high pressure stage compression element 9 are communicated with each other through a communication passage 55 composed for a gas passage 55a formed in the lower bearing member 12, a gas passage 55b formed in the first cylinder block 7a and a gas passage 55c formed in the intermediate plate 36.

A bypass passage 57 branching from the communication passage 55 is composed of a bypass passage 57a and a bypass passage 57b which are formed in the second cylinder block 9a of the high pressure stage compression element 9 and the upper bearing member 11, respectively, and is opened at its downstream side to the high stage discharge chamber 51.

The bypass passage 57a (refer to Fig.8) is disposed therein with a bypass valve device 58 which is
10 composed of a valve element 58 (the external shape thereof is shown in Fig. 9) having at its outer periphery a notch and made of a steel sheet, and a coil spring 58b, and which allows only a fluid stream from the communication passage 55 into the high stage discharge chamber 51.

The coil spring 58b has a shape memory alloy characteristic which has been conventionally well-known and in which its spring constant increases as the temperature thereof rises, so as to increase its urging force for the valve element.

20 The gas passage 55b forming a part of the communication passage 55 is communicated with the downstream side of the gas-liquid separator through the intermediary of a communication passage 59 so as to form a coolant injection passage 72.

The communication passage 59 is inserted in the first cylinder block 7a, and is sealed at its outer periphery by a O-ring seal 66, and a valve element 60 having a shape similar to that shown in Fig. 9 is disposed between one end

part of the communication passage 59 and the gas passage 55b so as to constitute a check valve device 71.

The check valve device 71 is adapted to allow a fluid stream from the gas-liquid separator 17 into the gas passage 55b.

The intermediate plate 36 is formed therein with an oil injection passage 61 having a constriction intermediate thereof, and having its upstream side communicated with the oil sump 35 and its downstream side intermittently
10 communicated with the rear chamber 44 for the vane 38 and the compression chamber in the high pressure stage compression element 9.

A downstream side passage 61a of the oil injection passage 61 and the rear chamber 44 are opened at the slide surface of the vane 44 so that they are communicated with each other during a period in which the vane 38 is advanced toward the piston 7b by more than about one half of its stroke, but are blocked off against each other during the other period.

20 A downstream side passage 61b of the oil injection passage 61 and the compression chamber in the high pressure stage compression element 9 are opened at positions so that the communication therebetween is initiated when the vane 39 is advanced toward the piston 7b by about one-third of its stroke, and the blockage therebetween is initiated by the slide end surface of the piston 9b when the vane 39 is returned by about one-third of its stroke (Refer to Fig. 10).

The drive shaft 6 is formed therein with a shaft hole 62 piercing therethrough along the center axis thereof, and a pump device 63 is attached to the lower part thereof.

5 Spiral oil grooves 64, 64a are formed on the outer peripheral surface of the drive shaft supported by the upper and lower bearing members 11, 12, the upstream side of the spiral oil groove 64 being communicated with the downstream side of the pump device 63 through the intermediary of a radial oil hole branching from the shaft hole 62, and the
10 downstream side of the spiral oil groove 64 being not communicated with the sound suppression chamber 52.

 The downstream side of the accumulator 2 is communicated with a suction chamber (which is not shown) in the low pressure stage compression element 7, and a
15 discharge pipe 7e is provided in the upper part of the closed container 3.

 The gas-liquid separator 17 has its bottom part which is connected thereto with a liquid pipe 65 communicated with the second expansion valve 19, and the
20 outer surface of the barrel of the gas-liquid separator 17 is coated thereover with a polyethylene film, and is heated so that it is subjected to a heat insulating process with a polyethylene foaming agent foamed up to about 5 mm.

 Fig. 11 shows an opening condition of a bypass
25 passage 57 just after cold start of the compressor, a condition in which one end part of the communication passage 59 is blocked by the valve element 60, and a condition in which the vane 38 blocks the communication between the

downstream side passage 61a of the oil injection passage 61 and the rear chamber 44.

Fig. 12 shows a second embodiment of the present invention in which an oil injection passage 61c communicating the oil sump 35 with the rear chamber 44 has a constriction passage part which is defined by a very shallow groove formed in the joint surfaces of the intermediate plate and the first cylinder block 7a, and the opening of the oil return hole 49c extending from the low stage discharge chamber 45 to the rear chamber 44 is formed in the upper part of the rear chamber 44.

Next explanation will be made of a slide vane type rotary two stage coolant compressor in a third embodiment of the present invention with reference to Figs. 13 and 14.

A two stage compression mechanism 104 is composed of, similar to the first embodiment, a high pressure stage compression element 109 in the upper part, and an intermediate plate 136 and a low pressure stage compression element 107 in the lower part, which are arranged in that order.

A drive shaft 106 coupled to a rotor 5b in a motor 5 is fitted thereon with a first rotor 107b and a second rotor 109b which are arranged so that the high pressure stage compression element 109 initiates its suction and compression with a phase lag of about 60 to 80 deg. with respect to the suction and compression timings of the low pressure stage compression element 107, and a vane 138 is inserted in a vane groove 68a formed in the first rotor 107b, and a vane

139 is inserted in vane groove 68b formed in the second rotor 109b.

The vane groove 68b in the high pressure stage compression element 109 is always communicated with the oil sump 35 through the intermediary of a shaft hole 162 formed piercing through the drive shaft 106, a radial hole 69 branching from the shaft hole 162 and an annular groove 70 which is formed in the intermediate plate 136 at its surface on the second rotor 109b side.

10 A downstream side passage 161b of the oil injection passage 161 having the constriction passage part formed in the intermediate plate 136 is intermittently communicated with the compression chamber in the high pressure stage compression element 109, similar to the first embodiment, and the position where the downstream side passage 161b is opened to the compression chamber corresponds to a position at which the forward end of the vane 139 advances furthest.

20 Further, a downstream side passage 161a of the oil injection passage 161 is intermittently communicated with the vane groove 68a in association with the rotation of the first rotor 107b in the low pressure stage compression element 107, and the vane groove 68a is communicated with the low stage discharge chamber 45 through the intermediary of an oil return passage composed of an oil return hole 149b formed in the lower bearing member 112 in the low pressure stage compression element 107 and an oil return hole 49a formed in the discharge cover 37.

The other structure is similar to that in the first embodiment, and accordingly, the explanation thereof will be abbreviated.

Next, explanation will be made of the structure of a discharge chamber in the low pressure stage compression element and the structure of an oil passage communicated thereto in a rolling piston type rotary two stage coolant compressor in a fourth embodiment of the present invention with reference to Fig. 15.

10 The downstream side of a first accumulator provided thereto with a suction pipe 202a having a bore 202 having a diameter which is about 1.5 times as large as that of the suction pipe of a conventional accumulator used for conventional compressors so as to restrain the supercharge action of the accumulator (which is a phenomenon such that the gas pressure in the suction pipe exhibits pulsation, following the suction operation of the compressor so that gas whose pressure is cyclically raised flows into the suction chamber and is then compressed in this condition,
20 thereby the suction efficiency is raised) is connected to the suction side of the low pressure stage compression element 207, similar to the first embodiment.

A low stage discharge chamber 245 of the low pressure stage compression element 207 is composed of a first cylinder block 207a and a discharge cover 237 which is attached to the first cylinder block 207a so as to surround the lower bearing member 211 supporting the drive

shaft 6, and has an internal volume which is smaller than that of the arrangement of the first embodiment.

The high pressure stage compression element 209 is arranged to initiate its suction and compression with a phase lag of about 60 to 80 deg. with respect to the suction and compression timing of the low pressure stage compression element 207 so as to restrain excessive pressure rise in the low stage discharge chamber 245, and accordingly, the compression power of the low pressure stage compression
10 element 207 can be reduced.

The upper part of the low stage discharge chamber 245 communicated with a rear chamber 244 is connected to the suction side of the high pressure stage compression element 209 through the intermediary of a communication passage 255, and a second accumulator 202b connected to the intermediate part of the communication passage 255 is connected, at its downstream side, to the gas-liquid separator (not shown), as is similar to the first embodiment, having a downstream side connection end to which a valve element 206 similar to that
20 in the first embodiment is fitted.

The valve element 206 is urged by a coil spring 207 for blocking the opening end of the connection from the gas-liquid separator 17 so as to constitute a check valve device 271, the coil spring incorporating a shape memory characteristic such that its spring constant decreases as the temperature thereof rises so as to decrease the urging force for the valve element 206.

The other structure is similar to that in the first

embodiment, and accordingly, the explanation thereof will be abbreviated.

The operation of the two stage compressor constructed as mentioned above, and the refrigerating cycle thereof will be explained.

Referring to Figs. 6 to 11, when the drive shaft 6 is rotated by the motor 5, the low pressure stage compression element 7 initiates, at first, suction so that coolant gas flows into the suction chamber of the low pressure stage
10 compression element 7 from the accumulator 2. The volume of the low stage suction chamber increases as the crank angle of the drive shaft 6 advances while the compression is progressed simultaneously in the low stage compression chamber so as to gradually increase the pressure of compressed coolant gas.

The compressed coolant gas is discharged from a discharge port (which is not shown) formed in the lower bearing member 12 into the low stage discharge chamber 45 as the low stage side crank angle advances by about an angle of
20 170 deg. after initiation of the suction.

The coolant gas discharged into the low stage discharge chamber 45 counterflows into the rear chamber 44 by way of the oil return passage 49 composed of the oil return hole 49a and the oil return hole 49b together with lubrication oil pooled in the bottom part of the oil sump 46 in the discharge chamber so as to urge the rear surface of the vane 38 toward the first piston 7b.

Just after the start, coolant gas discharged into

the low stage discharge chamber 45 is fed into the suction chamber 56 in the high pressure stage compression element 9 by way of the communication passage 55 composed of the gas passage 55a, the gas passage 55b and the gas passage 55c.

With a lag of 75 deg. from the initiation of the suction of the low pressure stage compression element 7, the high pressure stage compression element 9 initiates the suction and compression.

Just after the start, coolant gas in the low stage discharge chamber 45 and the communication passage 55 has a pressure which is higher than that of the condenser 13 or the gas-liquid separator 17 which are connected to the internal space of the closed container and the rolling piston type rotary two stage compressor 1.

Accordingly, as shown in Fig. 11, a pressure differential between discharged coolant gas passing through the communication passage 55 and coolant gas in the gas-liquid separator 17 causes the valve element 60 to move so as to block the end part of the connection pipe 59 from the gas-liquid separator 17, and accordingly, the coolant injection passage 72 is closed so as to inhibit coolant gas in the communication passage 55 from counterflowing into the gas-liquid separator 17.

Further, the pressure of coolant gas in the communication passage 55 is higher than the pressure in the high stage discharge chamber 51 communicated with the internal space of the closed container 3 so that the valve element 58a in the bypass valve device 58 is moved toward the

coil spring 58b, overcoming a small urging force of the latter at a low temperature, so as to open the bypass passage 57, and accordingly, a part of coolant gas passing through the communication passage 55 flows into the high stage discharge chamber 51 so as to reduce the compression load at the high stage compression element just after starting while the pressure of coolant gas in the suction chamber 56 lowers. As a result, the vane 39 in the high pressure stage compression element 9, which depends upon
10 only the urging force of the coil spring 41 is retracted, following a motion of the outer peripheral surface of the second piston 9b with no jumping phenomenon caused by the coolant gas having an increased pressure which abruptly flows into the suction chamber 56 so that the vane is abruptly retracted, and accordingly, smooth light load compression is initiated without occurrence of sound of bump between the vane 39 and the second piston 9b, and leakage of compressed gas.

It is noted that insufficiency and excess occur
20 between the volume of coolant gas discharged into the low stage discharge chamber 45 from the low pressure stage compression element 7 and the volume of the suction chamber of the high pressure stage compression element 9 since the suction and compression of the high pressure stage compression element 9 are initiated with a lag of 60 to 80 deg. from the initiation of the suction and compression of the low pressure stage compression element 7, and the excessive and insufficient volumes vary with the progress of the crank angle of the drive shaft 6. As a result, a
30 range of crank angle in which the volume of coolant gas discharged

into the low stage discharge chamber 45 is insufficient, and a range of crank angle in which the coolant gas is excessive are both present, and accordingly, pressure pulsation occurs in coolant gas in the low stage discharge chamber 45 and the communication passage 55. The higher the rotational speed of the drive shaft 6, the more the pressure pulsation tends to be excessive.

The coolant gas discharged into the high stage discharge chamber 51 flows into the sound suppression chamber 52 by way of the annular passage 53, and thereafter, the coolant gas is fed into the closed container 3.

With the passage of time after a cold start of the compressor, the pressure in the motor chamber 8, and the condenser 13 and the gas-liquid separator 17 which are communicated with the motor chamber 8 increases so that the opening part making contact with the valve element 58a in the check valve device 58 in the bypass passage 57 is strongly urged by the gas pressure in the high stage discharge chamber 51 and the coil spring 58b whose spring constant is increased due to a temperature rise so as to completely close the bypass passage 57, and the valve element 60 having blocked the one end part of the communication passage 59 is shifted toward the communication passage 55 so as to communicate the gas-liquid separator 17 with the communication passage 55.

Further, lubrication oil in the oil sump 35 upon which the discharge pressure is applied, exerts a back pressure against the rear surface of the vane 39 in

cooperation with the coil spring 41 in the high pressure stage compression element 9, and flows by a small flow rate into the suction chamber 56 and the compression chamber through the slide surface gap while lubricating the slide surface of the vane 39. Further, the pressure of the lubrication oil is decreased through the intermediary of the downstream side passage 61b of the oil injection passage 61 having the constriction passage part, and the lubrication oil is then intermittently fed into the compression chamber 10 so as to serve as a sealing oil film in the gap of the compression chamber and to lubricate the slide surface of the second piston 39.

The pressure of lubrication oil in the oil sump 35 is decreased down to a value substantially equal to the discharge pressure of the low pressure stage compression element 7 through the intermediary of the downstream side passage 61a of the oil injection passage 61 having the constriction passage part, and thereafter, the opening of the downstream side passage 61a is opened to the rear 20 chamber 44 so as to allow the lubrication oil to flow into the rear chamber 44 during a period from the time when the vane 38 in the low pressure stage compression element 7 is advanced toward the first piston 7b by about one-third to the time when it is again retracted by about one-third.

The lubrication oil having flown in the rear chamber 44, lubricates the slide surface of the vane 38, and flows into the low stage discharge chamber 45 by way of the oil return holes 49b, 49a so as to mix into discharged

coolant gas. The thus obtained mixture flows into the suction chamber 56 in the high pressure stage compression element 9. The lubrication oil having flown into the suction chamber 56 in the high pressure stage compression element 9 merges into lubrication oil having flown into the suction chamber 56 through the rear chamber 43 and the downstream side passage 61b so as to serve to seal the gap in the compression chamber and to lubricate and cool the slide surface.

- 10 The lubrication oil in the oil sump 35 is fed to the bearing surfaces of the lower and upper bearing members 12, 11 supporting the drive shaft 6, and to the inner surfaces of the first and second pistons 7b, 9b by way of the shaft hole 62 and the radial hole 69 under viscous pumping action given by the spiral oil groove 64 formed on the outer surface of the drive shaft 6 and by the pump device 63 provided at the lower end of the drive shaft 6. The lubrication oil having been fed into the spiral oil groove 64a is discharged into the sound suppression chamber 52 from the
- 20 top end of the upper bearing member 12 under the viscous pumping action, then is mixed into high pressure discharge gas compressed by two stages and discharged from the high discharge chamber 51, and is finally discharged into the motor chamber 8 through the annular passage 54.

The discharged coolant gas from which the lubrication oil is separated in the motor chamber 8 is fed into the refrigerating cycle on the outside of the compressor by way of the discharge pipe 7e.

Gas-liquid mixture coolant gas which expands up to that corresponding to the discharge pressure of the low pressure stage compression element 7 after its pressure being reduced by way of the condenser 13 and the first expansion valve 15, flows into the gas-liquid separator 17 so as to be separated in a gas phase and a liquid phase, and accordingly, the liquefied coolant gas is pooled in the bottom of the gas-liquid separator 17.

10 The gas-liquid mixture coolant gas in the upper space of the gas-liquid separator 17 flows into the communication passage 55 in the rolling piston type rotary two stage compressor 1 by way of the communication passage 59 opened to the upper space of the gas-liquid separator 17, then merges into discharge coolant gas from the low pressure stage compression element 7 so as to lower the temperature of the discharge gas on the low stage side, and flows into the suction chamber 56 in the high pressure stage compression element 9.

20 The two stage-compressed discharge coolant gas from the high pressure stage compression element 9 sucks thereinto unevaporated coolant gas from the gas-liquid separator 17 so as to be restrained from abnormally increasing its temperature. As a result, a decrease in the slide part gap becomes less, and it is possible to prevent the temperature of the motor 5 from abnormally increasing, thereby the input of the compressor can be reduced.

Meanwhile, liquefied coolant collected in the bottom part of the gas-liquid separator 17 circulates from

the liquid pipe 65 successively through the second expansion valve 19 and the evaporator 21, and is then returned into the accumulator 2 after second expansion and heat absorption.

It is noted that the coolant in the gas-liquid separator 17 is heat-insulated and sound-shielded by the foamed polyethylene material surrounding the outer peripheral part of the barrel of the gas-liquid separator 17, and accordingly, it is possible to prevent sound of bump between the coolant and the inner surface of the gas-liquid separator 17 upon inflow of the coolant into the gas-liquid separator 17 from being externally transmitted, and to reduce the heat absorption by the coolant.

Next, explanation will be made of the operation of the second embodiment with reference to Fig. 12.

Lubrication oil in the sump 35 in the bottom part of the motor chamber 8 upon which the discharge pressure acts, flows into the rear chamber 44 for the vane 38 in the low pressure stage compression element 7 after its pressure is decreased through the intermediary of the downstream side passage 61c having the constriction passage part, and then urges the rear surface of the vane 38 in a foamed condition while it lubricates the slide surface of the vane 38. Lubrication oil in the rear chamber 44 flows into the low stage discharge chamber 45 by way of the always opened oil return passage 49 and the oil return hole 49a, but the oil surface is held at the level of the upstream opening end of the oil return passage 49c always (during operation and rest

of the compressor), and accordingly, the pressure of the lubrication oil is maintained at a value corresponding to the pressure of the low stage discharge chamber 45.

During a period until the pressure of the lubrication oil in the oil sump 35 feeds again the lubrication oil into the rear chamber 44 through the downstream side passage 61c under pressure differential after the compressor is restarted from a rest condition thereof, a gas pressure from the low stage discharge chamber 45 acts upon
10 lubrication oil remaining in the rear chamber 44 during the rest of the compressor, and accordingly, the slide surface of the vane 38 is lubricated.

The other operation is similar to that of the first embodiment, and accordingly, the explanation thereof will be abbreviated.

Next, explanation will be made of the operation of the third embodiment with reference to Figs. 13 and 14.

The vanes 138, 139 fitted in the vane grooves 68a, 68b in the first and second rotors 107b, 109b are rotated
20 while they reciprocate through the grooves, in association with the rotation of the drive shaft 106.

Lubrication oil in the vane grooves 68a, 68b are subjected to pumping action due to the reciprocation of the vanes 138, 139. The vanes 138, 139 are urged radially outward under back pressure caused by the pressure produced at this time, so that each of the vanes defines a suction chamber and a compression chamber in the associated cylinder, and

accordingly, coolant gas is subjected to suction and compression.

Lubrication oil in the oil sump 35 upon which a discharge pressure acts, is intermittently fed into the vane groove 68a in the first rotor 107b after its pressure is decreased by means of the injection passage 161a downstream of the oil injection passage 161, and is always fed into the vane groove 68b in the second rotor 109b without its pressure being decreased, successively through the axial hole 162
10 formed piercing through the drive shaft 106, the radial hole 69 and the annular groove 70.

Foamed Lubrication oil containing coolant gas fed into the vane groove 68a in the first rotor 107b intermittently flows into the low stage discharge chamber 45 by way of the oil return hole 149 and the oil return hole 49a, but its pressure is suitably boosted intermittently under pumping action during the reciprocation of the vane 138, and accordingly, the lubrication oil serves to lubricate the slide surface of the vane 138.

20 It is noted that the lubrication oil fed into the vane groove 68b in the second rotor 109b is always communicated with the oil sump 35, and accordingly, the degree of boost-up under the pumping action caused by the reciprocation of the vane 139 is less.

Further, lubrication in the oil sump 35 is intermittently fed into the cylinder in the high pressure stage compression element 109 after its pressure is decreased by means of the injection passage 161 downstream

of the oil injection passage 161, and accordingly, it serves to seal the compression chamber gap and to lubricate the slide surface.

The other operation is similar to that of the first embodiment, and accordingly, the explanation thereof will be abbreviated.

Next, explanation will be made of the operation of the fourth embodiment with reference to Fig. 15.

Coolant gas having flown into the first accumulator 202 under the operation of the two stage compressor, flows into the suction chamber in the low pressure stage compression element 7 by way of the suction pipe 202a while its cyclic pressure pulsation is restrained, and after being compressed, is successively fed into the suction side of the high pressure stage compression element 209. Since the supercharging action of the first accumulator 202 is restrained, the volume of suction gas into the low pressure stage compression element 207 per revolution of the first drive shaft 6 does not vary substantially even though the operating speed of the compressor varies, and therefore, the low stage discharge gas is fed out at a substantially uniform rate, with respect to the cylinder volume of the high pressure stage compression element 209. As a result, the pressure of the low stage discharge gas is maintained to be substantially constant without being abnormally increased, even though the operating speed of the compressor varies, thereby it is possible to reduce excessive compression in the compression chamber in the low pressure stage

compression element 107.

The evaporated coolant having flown into the second accumulator 202b from the gas-liquid separator (which is not shown) flows into the suction side of the high pressure stage compression element 209 by way of the check valve device 271 together with the low stage discharge gas.

Meanwhile, the low stage discharge coolant gas discharged into the low stage discharge chamber 245 having a small internal volume is diffused without separating
10 lubrication oil therefrom, and then involves lubrication oil flowing into the adjacent rear chamber 244 from the oil sump 35 through the oil injection passage 261 so as to lubricate the slide surface of the rear chamber 244, and thereafter, is fed into the high pressure stage compression element 209.

After the operation of the compressor is stopped, the temperature of the coil spring 270 lowers so as to increase its spring constant, resulting in a shift of the valve element 206 toward the second accumulator 202b so as to block the passage thereto, and accordingly, during rest
20 of the compressor, it is possible to prevent liquid coolant from flowing into the communication passage 255 by way of the second accumulator 202b.

The other operation is similar to that of the first embodiment, and accordingly, explanation thereof will be abbreviated.

According to the embodiments as mentioned above, the two stage compression mechanism in which the discharge side of the low pressure stage compression element 7 is

connected in series with the suction side of the high pressure stage compression element 9 through the intermediary of the communication passage 55 is constituted so that the compressed gas is discharged from the high pressure stage compression element 9 into the motor chamber 8 in which the motor 5 is housed within the closed container 3, the oil sump 35 is provided in the bottom part thereof while the bypass passage 57 is provided between the communication passage 55 and the motor chamber 8, and the bypass valve device 58 which allows only communication from the communication passage 55 to the motor chamber 8 when the pressure in the communication passage 55 is higher than that in the motor chamber 8, is disposed in the bypass passage 57. Accordingly, coolant gas which is sucked into the low pressure stage compression element 7, simultaneously with a start of the compressor, is compressed and discharged, and is then fed to the suction side of the high pressure stage compression element 9 by way of the communication passage 55. During this period, since the pressure of the coolant gas passing through the communication passage 55 is higher than that in the motor chamber 8 which is equal to the pressure before the start of the compressor, a part of the coolant gas in the communication passage 55 flows into the motor chamber 8 by way of the bypass valve device 58 so that the compression is initiated in such a condition that the pressure of suction gas in the high pressure stage compression element 9 is dropped, and accordingly, the compression load at the initial stage of the start is low,

thereby it is possible to smoothly start the compressor and to reduce vibration and noise.

Further, during hot water supply operation or air-conditioning heating operation with a two stage compression
5 and two stage expansion refrigerating cycle in the winter season, for a while just after the initiation of defrosting operation by changing over between a pipe line to the heat sink side and a pipe line to the radiator side with the use of a solenoid valve or the like upon frosting on the outer
10 surface of a heat sink side heat-exchanger, high pressure liquefied coolant on the radiator side flows into the suction side of the two stage coolant compressor 1 by a large volume, and accordingly, liquid compression occurs in the compression chamber in the low pressure stage compression
15 element 7 so that the pressure in the communication passage 55 abnormally rises, while the pressure in the motor chamber 8 abruptly drops due to the change-over into the defrosting operation so that the relationship between the pressure in the communication passage 55 and the pressure in the motor
20 chamber 8 is reversed. Even in this case, the bypass passage 57 is opened to lower the pressure in the communication passage 55, thereby it is possible to avoid a failure of the compressor.

Further, according to the embodiments as mentioned
25 above, the two stage compression mechanism in which the discharge side of the low pressure stage compression element 7 is connected in series with the suction side of the high

pressure stage compression element 9 through the intermediary of the communication passage 55 is constituted so that the compressed gas is discharged from the high pressure stage compression element 9 into the motor chamber 8 in which the motor 5 is housed within the closed container 3, the oil sump 35 is provided in the bottom part thereof while the bypass passage 57 is provided between the communication passage 55 and the motor chamber 8, and the bypass valve device 58 which allows only communication from the

10 communication passage 55 to the motor chamber 8 when the pressure in the communication passage 55 is higher than that in the motor chamber 8, is disposed in the bypass passage 57. In addition, lubrication oil from the oil sump 35 upon which a discharge gas pressure acts, is introduced through pressure reduction or directly into the rear chambers 44, 43 for the vanes 38, 39 which define a suction chamber and a compression chamber in the cylinders of the low and high pressure stage compression elements 7, 9 while they extend and retract within the cylinders so that the low stage

20 discharge pressure is effected as a back pressure in the rear chamber 44 while the high stage discharge pressure is effected as a back pressure in the rear chamber 43, and accordingly, with the progress of the time after a start of the compressor, the high stage discharge pressure increases so that the vanes 38, 29 having the rear surfaces to which the lubrication oil from the oil sump 35 in the bottom part of the motor chamber 8 is introduced, define a suction chamber and a compression chamber in the cylinders while the

sealing degree thereof is increased gradually. Thus, the sealing degree at the time of a start of the compressor is low so that the pressure of the compression chamber at the initial stage of the chamber is not so high, and accordingly, a smooth start can be made, thereby it is possible to reduce vibration and noise.

Further, simultaneously with the start of the compressor, when coolant gas sucked into the low pressure stage compression element 7 is compressed and discharged and is fed to the suction side of the high pressure stage compression element 9, since the low stage discharge pressure passing through the communication passage 55 is higher than the pressure in the motor chamber 8 which is equal to the pressure before the start of the compressor, a part of the coolant gas in the communication passage 55 flows into the motor chamber 8 by way of the bypass valve device 58, and accordingly, the compression of suction gas in the high pressure stage compression element 9 is initiated in a pressure drop condition while the vane 39 whose rear surface urging force by lubrication oil is small is retracted by the compression chamber pressure so that vane 38 slightly separates from the second piston 9b, causing lowering of the sealing degree of the compression chamber, that is, the compression load can be further decreased, thereby it is possible to provide a more quiet start operation.

Further, according to the embodiments as mentioned above, the two stage compression mechanism in which the discharge side of the low pressure stage

compression element 7 is connected in series with the suction side of the high pressure stage compression element 9 through the intermediary of the communication passage 55 is constituted so that the compressed gas is discharged from the high pressure stage compression element 9 into the motor chamber 8 in which the motor 5 is housed within the closed container 3, the oil sump 35 is provided in the bottom part thereof while the bypass passage 57 is provided between the communication passage 55 and the motor chamber 8, and the bypass valve device 58 which allows only communication from the communication passage 55 to the motor chamber 8 when the pressure in the communication passage 55 is higher than that in the motor chamber 8, is disposed in the bypass passage 57. In addition, the bypass passage 57 is communicated with the discharge chamber 51 in the high pressure stage compression element 9. Accordingly, a part of coolant gas in the communication passage 55 flows into the discharge chamber 51 in the high pressure stage compression element 9 when the pressure of the coolant gas in the communication passage abnormally rises, and it then merges into discharge gas compressed in the cylinder in the high pressure stage compression element 9 so as to produce a normal discharge gas stream discharged into the motor chamber, thereby it is possible to restrain abnormal rise in pressure in the communication passage 55 so as to reduce the compression load, and to prevent lubrication oil from flowing into a pipeline system outside of the compressor, without coolant gas

discharged from the bypass passage 57 diffusing lubrication oil in the oil sump 35 in the bottom part of the motor chamber 8, so as to prevent the durability of the slide part from lowering due to a lack of lubrication oil.

5 Further, according to the embodiments as mentioned above, the two stage compression mechanism in which the discharge side of the low pressure stage compression element 7 is connected in series with the suction side of the high pressure stage compression element 9 through the
10 intermediary of the communication passage 55 is constituted so that the compressed gas is discharged from the high pressure stage compression element 9 into the motor chamber 8 in which the motor 5 is housed within the closed container 3, the oil sump 35 is provided in the bottom part thereof
15 while the bypass passage 57 is provided between the communication passage 55 and the motor chamber 8, and the bypass valve device 58 which allows only communication from the communication passage 55 to the motor chamber 8 when the pressure in the communication passage 55 is higher than that
20 in the motor chamber 8, is disposed in the bypass passage 57. In addition, the urging force for pressing the valve element 58a in the bypass valve device 58 toward the valve seat, is given by the coil spring 58. Accordingly, an abnormal rise in pressure in the communication passage 55 is retrained so
25 as to reduce the compression load, and discharge coolant gas is prevented from counterflowing from the motor chamber 8 into the communication passage 55 due to unnecessary opening of the bypass passage 57, thereby it is possible to stabilize

the two stage compression so as to reduce vibration and noise and to continue highly efficient operation.

Further, according to the embodiments as mentioned above, the two stage compression mechanism in which the
5 discharge side of the low pressure stage compression element 7 is connected in series with the suction side of the high pressure stage compression element 9 through the intermediary of the communication passage 55 is constituted so that the compressed gas is discharged from the high
10 pressure stage compression element 9 into the motor chamber 8 in which the motor 5 is housed within the closed container 3, the oil sump 35 is provided in the bottom part thereof while the bypass passage 57 is provided between the communication passage 55 and the motor chamber 8, and the
15 bypass valve device 58 which allows only communication from the communication passage 55 to the motor chamber 8 when the pressure in the communication passage 55 is higher than that in the motor chamber 8, is disposed in the bypass passage 57. In addition, the urging force for pressing the valve element
20 58a in the bypass valve device 58 toward the valve seat, is given by the coil spring 58 which incorporates a shape memory characteristic such that its urging force increases as the temperature thereof rises while its urging force decreases as the temperature thereof lowers. Accordingly, the urging
25 force of the coil spring 58b for urging the valve element toward the valve seat is small at the initial stage of a cold start, but it increases when the temperature of the coil

spring 38b rises, thereby the opening of the bypass passage 57 is promoted in the case of an abnormal rise in pressure communication passage 55 at the initial stage of the cold start. Thus, the reduction of the compression load can be promoted. Further, during stable operation, leakage of discharge coolant gas from the motor chamber 8 into the communication passage 55 is inhibited, thereby it is possible to prevent the compression efficiency from lowering.

Further, according to the embodiments as mentioned above, the two stage compression mechanism in which the discharge side of the low pressure stage compression element 7 is connected in series with the suction side of the high pressure stage compression element 9 through the intermediary of the communication passage 55 is constituted so that the compressed gas is discharged from the high pressure stage compression element 9 into the motor chamber 8 in which the motor 5 is housed within the closed container 3, the oil sump 35 is provided in the bottom part thereof while the bypass passage 57 is provided between the communication passage 55 and the motor chamber 8, and the bypass valve device 58 which allows only communication from the communication passage 55 to the motor chamber 8 when the pressure in the communication passage 55 is higher than that in the motor chamber 8, is disposed in the bypass passage 57. In addition, the urging force for pressing the valve element 58a in the bypass valve device 58 toward the valve seat is given by applying the pressure in the discharge chamber 51

in the high pressure stage compression element 9 to the rear surface of the valve element 58a in the bypass valve device 58. The urging force which urges the valve element 58a toward the valve seat depends only upon the coil spring 58b at the
5 initial stage of a start, but during stable operation, the pressure in the discharge chamber 51 is applied to the rear surface of the valve element 58a in addition to the urging force of the coil spring 58b. Thus, the opening of the bypass passage 57 is promoted when the pressure in the communi-
10 cation passage 55 abnormally rises at the initial stage of a start, and accordingly, the reduction of the compression load can be promoted while the compression load can be gradually reduced, following up a rise in the high stage discharge pressure after a start of the compressor, thereby
15 it is possible to smoothly control the load in a range from the start to the stable operation so as to enhance the durability. In particular, during high compression ratio operation, high pressure discharge coolant gas strongly presses the rear surface of the valve element 58a toward the
20 valve seat so as to further enhance the blocking of the bypass valve device 58, and accordingly, the quantity of leakage gas from the discharge chamber 51 into the communication passage is decreased, thereby it is possible to prevent the compression efficiency from lowering due to
25 the provision of the bypass passage 57.

Further, according to the embodiments as mentioned above, the two stage compression mechanism in which the discharge side of the low pressure stage compression element

7 is connected in series with the suction side of the high pressure stage compression element 9 through the intermediary of the communication passage 55 is constituted so that the compressed gas is discharged from the high pressure stage compression element 9 into the motor chamber 8 in which the motor 5 is housed within the closed container 3, the oil sump 35 is provided in the bottom part thereof while the bypass passage 57 is provided between the communication passage 55 and the motor chamber 8, and the bypass valve device 58 which allows only communication from the communication passage 55 to the motor chamber 8 when the pressure in the communication passage 55 is higher than that in the motor chamber 8, is disposed in the bypass passage 57. In addition, the discharge chamber 51 in the high pressure stage compression element 9 is disposed downstream of the bypass passage 57. Accordingly, an abnormal rise in the pressure in the communication passage 55 is reduced, and sound of expansion caused when the coolant gas in the communication passage is bypassed, can be suppressed during the coolant gas pass through the discharge chamber 51, thereby sound transmitted to the motor chamber 8 is reduced so as to restrain noise caused by the bypass action for reducing the compression load.

Although the explanation has been made of the two stage compressor in the above-mentioned embodiments, similar technical effects and advantage can be expected with an arrangement obtained by applying and developing the

arrangement of the embodiments, for a compressor having several stages higher than the two stages.

Further, although it has been explained in the above-mentioned embodiments that lubrication oil upon which a high stage discharge pressure acts, is pooled in the closed container, the lubrication oil can be pooled in a discharge side oil separator provided outside of the compressor, and in this case, a passage is provided for introducing the lubrication oil into the compressor therefrom in view of the size of the closed container or an oil separating ability.

Further, although explanation has been made of the coolant compressor in the above-mentioned embodiment, similar technical effects and advantages can be obtained even for a multi-stage gas compressor for compressing gas other than coolant gas (such as, oxygen, nitrogen, helium, air).

INDUSTRIAL USABILITY

As clear from the embodiments as mentioned above, according to the present invention, there is provided a multi-stage gas compressor having a plurality of compression elements constituting a multi-stage compression mechanism in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages such that a discharge side of each lower pressure stage compression element is communicated with a suction side of each higher pressure stage compression element through a communication passage so as to constitute a two-stage compression mechanism, a motor coupled to a drive shaft of the multi-stage compression mechanism and located in a motor chamber within a closed container in which the multi-stage

compression mechanism is located, so as to discharge compressed gas from a final stage compression element of said multi-stage compression mechanism into the motor chamber, an oil sump provided in a bottom part of the closed container, a bypass passage connected between an intermediate part of one of the communication passages and the motor chamber, and a bypass valve device located in the bypass passage, for allowing only communication from the one of the communication passages to the motor chamber when the pressure of the one of the communication passages is higher than that of the motor chamber. Accordingly, coolant gas which is sucked into the low pressure stage compression element, simultaneously with a start of the compressor, is compressed and discharged, and is then fed to the suction side of the high pressure stage compression element by way of the communication passage. During this period, since the pressure of the coolant gas passing through the communication passage is higher than that in the discharge gas discharging space or the space communicated thereto which is equal to the pressure before the start of the compressor, a part of the coolant gas in the communication passage flows into the discharge gas discharging space or the space communicated thereto by way of the bypass valve device so that the compression is initiated in such a condition that the pressure of suction gas in the high pressure stage compression element is dropped, and accordingly, the compression load at the initial stage of the start is low, thereby it is possible to smoothly start the compressor and to reduce vibration and noise.

Further, according to the present invention, there is provided a multi-stage gas compressor having a plurality

of compression elements constituting a multi-stage compression mechanism in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages such that a discharge side of each lower pressure stage compression element is communicated with a suction side of each higher pressure stage compression element through a communication passage so as to constitute a two-stage compression mechanism, a motor coupled to a drive shaft of the multi-stage compression mechanism and located in a motor chamber within a closed container in which the multi-stage compression mechanism is located so as to discharge compressed gas from a final stage compression element of said multi-stage compression mechanism into the motor chamber, an oil sump provided in a bottom part of the closed container, a bypass passage connected between an intermediate part of one of the communication passages and the motor chamber, and a bypass valve device located in the bypass passage, for allowing only communication from the one of the communication passages to the motor chamber when the pressure of the one of the communication passages is higher than that of the motor chamber, wherein each of the compression elements includes a cylinder in which a vane is urged by a rear chamber against a rotary piston rotated by the motor while the vane extends and retracts so as to define a suction chamber and a compression chamber in the cylinder, and lubrication oil is fed into the rear chamber from the oil sump so as to press the rear end face of the vane. Accordingly, with the progress of the time after a start of the compressor, the highest stage discharge pressure increases so that the vanes having the rear surfaces to which the lubrication oil from the oil sump in

the bottom part of the discharge gas discharging space is introduced, define a suction chamber and a compression chamber in the cylinders while the sealing degree thereof is increased gradually. Thus, the sealing degree at the time of
5 a start of the compressor is low so that the pressure of the compression chamber at the initial stage of the chamber is not so high, and accordingly, a smooth start can be made, thereby it is possible to reduce vibration and noise.

Further, simultaneously with the start of the
10 compressor, when coolant gas sucked into the low pressure stage compression element is compressed and discharged, and is fed to the suction side of the high pressure stage compression element, since the low stage discharge pressure passing through the communication passage is higher than the
15 pressure in the discharge gas discharging space which is equal to the pressure before the start of the compressor, a part of the coolant gas in the communication passage flows into the discharge gas discharging space by way of the bypass valve device, and accordingly, the compression of suction
20 gas in the high pressure stage compression element is initiated in a pressure drop condition while the vane whose rear surface urging force by lubrication oil is small is retracted by the compression chamber pressure, causing lowering of the sealing degree of the compression chamber,
25 that is, the compression load can be further decreased, thereby it is possible to provide a more quiet start operation.

Further, according to the present invention, there is provided a multi-stage gas compressor having a plurality of compression elements constituting a multi-stage compression mechanism in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages such that a discharge side of each lower pressure stage compression element is communicated with a suction side of each higher pressure stage compression element through a communication passage so as to constitute a two-stage compression mechanism, a motor coupled to a drive shaft of the multi-stage compression mechanism and located in a motor chamber within a closed container in which the multi-stage compression mechanism is located, so as to discharge compressed gas from a final stage compression element of said multi-stage compression mechanism into the motor chamber, an oil sump provided in a bottom part of said closed container, a bypass passage connected between an intermediate part of one of the communication passages and the motor chamber, and a bypass valve device located in the bypass passage, for allowing only communication from the one of the communication passages to the motor chamber when the pressure of the one of the communication passages is higher than that of the motor chamber, wherein the bypass passage is communicated with the high pressure stage compression element by way of a discharge chamber which is adjacent to and which is communicated with the high pressure stage compression element. Accordingly, a part of coolant gas in the communication passage flows into the discharge chamber in the

high pressure stage compression element when the pressure of the coolant gas in the communication passage abnormally rises, and it then merges into discharge gas compressed in the cylinder in the high pressure stage compression element so as to produce a normal discharge gas stream discharged into the discharge gas discharging space or the space communicated thereto, thereby it is possible to restrain abnormal rise in pressure in the communication passage so as to reduce the compression load, and to prevent lubrication oil from flowing into a pipe line system outside of the compressor, without coolant gas discharged from the bypass passage diffusing lubrication oil in the oil sump in the bottom part of the discharge gas discharging space, thereby it is possible to prevent the durability of the slide part from lowering due to a lack of lubrication oil.

Further, according to the present invention, there is provide a multi-stage gas compressor having a plurality of compression elements constituting a multi-stage compression mechanism in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages such that a discharge side of each lower pressure stage compression element is communicated with a suction side of each higher pressure stage compression element through a communication passage so as to constitute a two-stage compression mechanism, a motor coupled to a drive shaft of the multi-stage compression mechanism and located in a motor chamber within a closed container in which the multi-stage compression mechanism is located so as to discharge compressed gas from a final stage

compression element of said multi-stage compression mechanism into the motor chamber, an oil sump provided in a bottom part of the closed container, a bypass passage connected between an intermediate part of one of the communication passages and the motor chamber, and a bypass valve device located in the bypass passage, for allowing only communication from the one of the communication passages to the motor chamber when the pressure of the one of the communication passages is higher than that of the motor chamber. In addition, the urging
10 force for pressing a valve element in the bypass valve device toward the valve seat, is given by a coil device. Accordingly, an abnormal rise in pressure in the communication passage is restrained so as to reduce the compression load, and discharge coolant gas is prevented from counterflowing from the discharge gas discharging space into the communication passage due to unnecessary opening of the bypass passage even though pressure pulsation occurs more or less in gas in the communication passage, thereby it is possible to stabilize the two stage compression so as to
20 reduce vibration and noise and to continue highly efficient operation.

Further, according to the present invention, there is provided a multi-stage gas compressor having a plurality of compression elements constituting a multi-stage compression mechanism in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages such that a discharge side of each lower pressure stage compression element is
30 communicated with a suction side of each higher pressure

stage compression element through a communication passage so as to constitute a two-stage compression mechanism, a motor coupled to a drive shaft of the multi-stage compression mechanism and located in a motor chamber within a closed container in which the multi-stage compression mechanism is located so as to discharge compressed gas from a final stage compression element of said multi-stage compression mechanism into the motor chamber, an oil sump provided in a bottom part of the closed container, a bypass passage connected between
10 an intermediate part of one of the communication passages and the motor chamber, and a bypass valve device located in the bypass passage, for allowing only communication from the one of the communication passages to the motor chamber when the pressure of the one of the communication passages is higher than that of the motor chamber. In addition, the urging force for pressing the valve element in the bypass valve device toward the valve seat, is given by a spring device which incorporates a shape memory characteristic such that
20 its urging force increases as the temperature thereof rises while its urging force decreases as the temperature thereof lowers. Accordingly, the urging force of the spring device for urging the valve element toward the valve seat is small at the initial stage of a cold start, but it increases when the temperature of the spring device rises, thereby the opening of the bypass passage is promoted in the case of an abnormal rise in a pressure communication passage at the initial stage of a cold start. Thus, the reduction of the compression load can be promoted. Further, during stable operation, leakage of discharge coolant gas from the
30 discharge gas discharging space or the space communicated

thereto into the communication passage is inhibited, thereby it is possible to prevent the compression efficiency from lowering.

Further, according to the present invention, there is provided a multi-stage gas compressor having a plurality of compression elements constituting a multi-stage compression mechanism in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages such that a discharge side of each lower pressure stage compression element is communicated with a suction side of each higher pressure stage compression element through a communication passage so as to constitute a two-stage compression mechanism, a motor coupled to a drive shaft of the multi-stage compression mechanism and located in a motor chamber within a closed container in which the multi-stage compression mechanism is located so as to discharge compressed gas from a final stage compression element of said multi-stage compression mechanism into the motor chamber, an oil sump provided in a bottom part of the closed container, a bypass passage connected between an intermediate part of one of the communication passages and the motor chamber, and a bypass valve device located in the bypass passage, for allowing only communication from the one of the communication passages to the motor chamber when the

pressure of the one of the communication passages is higher than that of the motor chamber. In addition, the pressure in the discharge gas discharging space or the space communicated thereto is applied to the rear surface of the valve element in the bypass valve device so as to urge the valve element toward the valve seat. The urging force which urges the valve element toward the valve seat depends only upon the spring device at the initial stage of a start, but during stable operation, the pressure in the discharge gas

10 discharging space or the space communicated thereto is applied to the rear surface of the valve element in addition to the urging force of the spring device. Thus, the opening of the bypass passage is promoted when the pressure in the communication passage abnormally rises at the initial stage of a start, and accordingly, the reduction of the compression load can be promoted while the compression load can be gradually reduced, following up a rise in the high stage discharge pressure after a start of the compressor, thereby it is possible to smoothly control the load in a range from

20 the start to the stable operation so as to enhance the durability. In particular, during high compression ratio operation, high pressure discharge coolant gas strongly press the rear surface of the valve element toward the valve seat so as to further enhance the blocking of the bypass valve device, and accordingly, the quantity of leakage gas from the

discharge gas discharging space or the space communicated thereto into the communication passage is decreased, thereby it is possible to prevent the compression efficiency from lowering due to the provision of the bypass passage.

Further, according to the present invention, there is provided a multi-stage gas compressor having a plurality of compression elements constituting a multi-stage compression mechanism in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages such that a discharge side of each lower pressure stage compression element is communicated with a suction side of each higher pressure stage compression element through a communication passage so as to constitute a two-stage compression mechanism, a motor coupled to a drive shaft of the multi-stage compression mechanism and located in a motor chamber within a closed container in which the multi-stage compression mechanism is located so as to discharge compressed gas from a final stage compression element of said multi-stage compression mechanism into the motor chamber, an oil sump provided in a bottom part of the closed container, a bypass passage connected between an intermediate part of one of the communication passages and the motor chamber, and a bypass valve device located in the bypass passage, for allowing only communication from the one

of the communication passages to the motor chamber when the pressure of the one of the communication passages is higher than that of the motor chamber. In addition, the discharge chamber in the high pressure stage compression element is disposed downstream of the bypass passage. Accordingly, an abnormal rise in the pressure in the communication passage is restrained, and sound of expansion caused when coolant gas in the communication passage is bypassed, can be suppressed during a period in which the coolant gas passes through the discharge chamber, thereby sound directly transmitted to the discharge gas discharging space can be attenuated so as to restrain generation of noise caused by the bypass action for reducing the compression load.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A multi-stage gas compressor including:
a plurality of compression elements constituting a multi-stage compression mechanism in which discharge sides of pressure stage compression elements are successively communicated with suction sides of following stage compression elements through respective communication passages such that a discharge side of each lower pressure stage compression element is communicated with a suction side of each higher pressure stage compression element through a communication passage so as to constitute a two-stage compression mechanism;
a motor coupled to a drive shaft of the multi-stage compression mechanism and located in a motor chamber within a closed container in which the multi-stage compression mechanism is located, so as to discharge compressed gas from a final stage compression element of said multi-stage compression mechanism into said motor chamber;
an oil sump provided in a bottom part of said closed container;
a bypass passage connected between an intermediate part of one of the communication passages and said motor chamber;
and
a bypass valve device located in that bypass passage for allowing only communication from said one of the communication passages to said motor chamber when the pressure of the one of the communication passages is higher than that of the motor chamber.

2. A multi-stage gas compressor as defined in claim 1, wherein each of the compression elements includes a cylinder in which a vane is urged by a rear chamber, formed at one end of said vane on the side remote from the

cylinder, against a rotary piston rotated by the motor while the vane extends and retracts, so as to define a suction chamber and a compression chamber in the cylinder, and lubrication oil is fed into said rear chamber from the oil sump so as to press the vane against the piston.

3. A multi-stage gas compressor as set forth in claim 1 or 2, wherein said bypass passage is provided by way of a discharge chamber which is adjacent to and communicates with a compression chamber in the final compression element.

4. A multi-stage compressor as set forth in claim 1, 2 or 3, wherein the pressure within the motor chamber is applied to the valve element on the side remote from the communication passage in said bypass valve device.

5. A multi-stage compressor as set forth in claim 4, wherein the pressure within the discharge chamber which is formed in the final compression element between the motor chamber and the bypass valve device in the bypass passage is applied to a rear surface of the valve element so as to urge the valve element against the valve seat.

6. A multi-stage gas compressor as set forth in any one of claims 1 to 5, wherein a spring means is provided to bias a valve element toward a valve seat in said bypass valve device.

7. A multi-stage gas compressor as set forth in claim 6, wherein said spring means has a shape memory characteristic, such that the bias force urging the valve element toward a valve seat increases as the temperature thereof becomes higher and decreases as the temperature thereof becomes lower.

FIG. 1
PRIOR ART

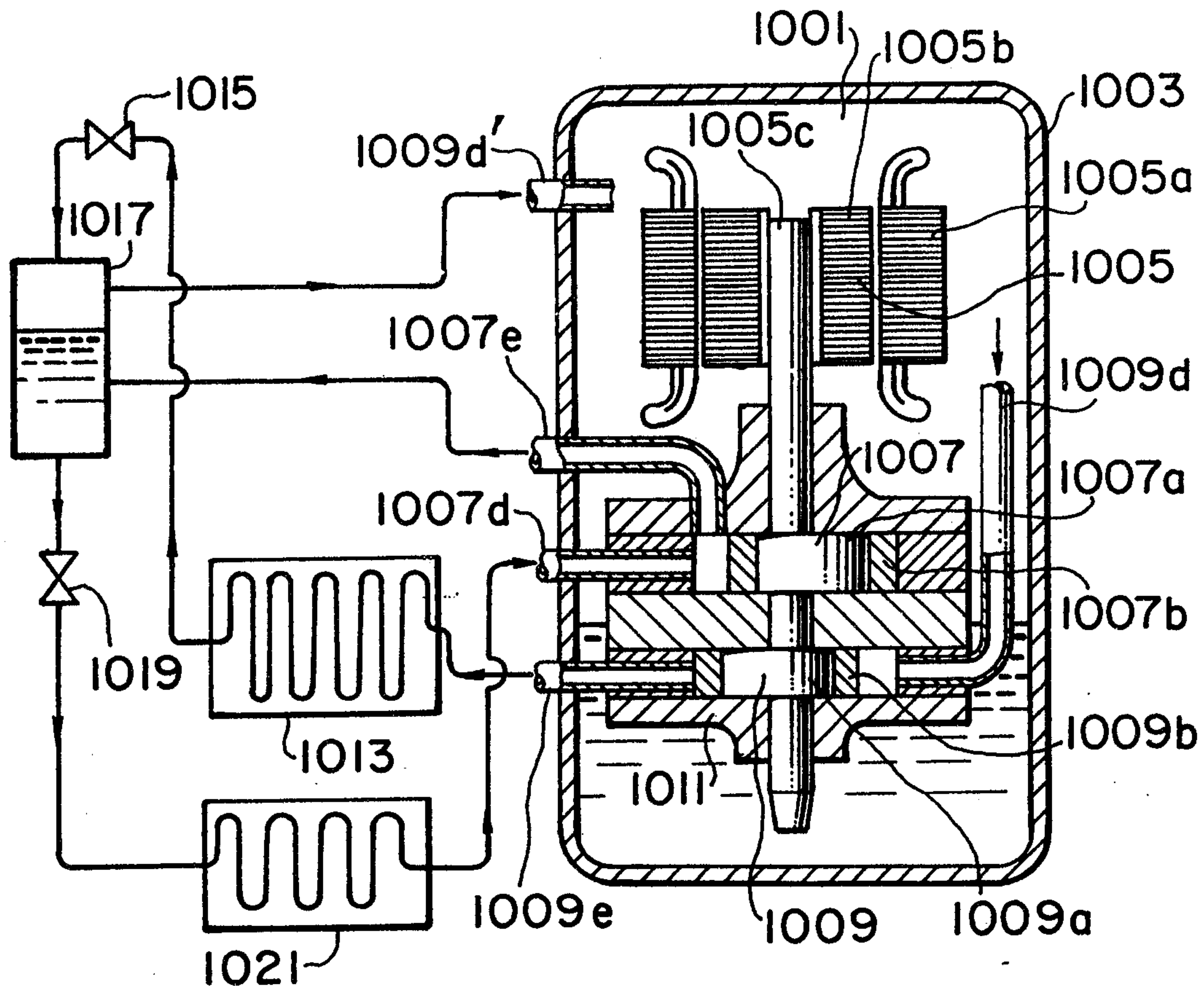
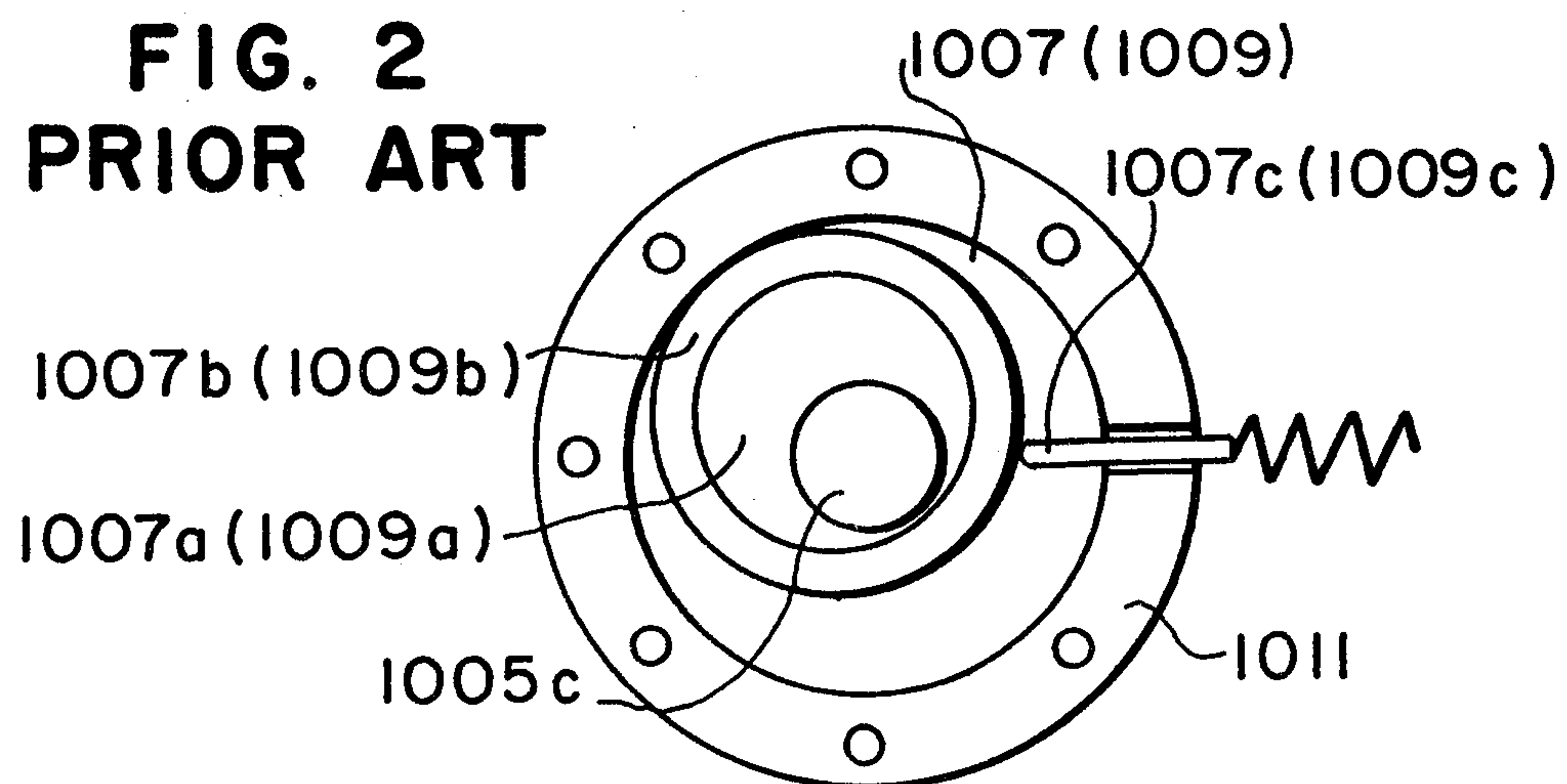


FIG. 2
PRIOR ART



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FIG. 3
PRIOR ART

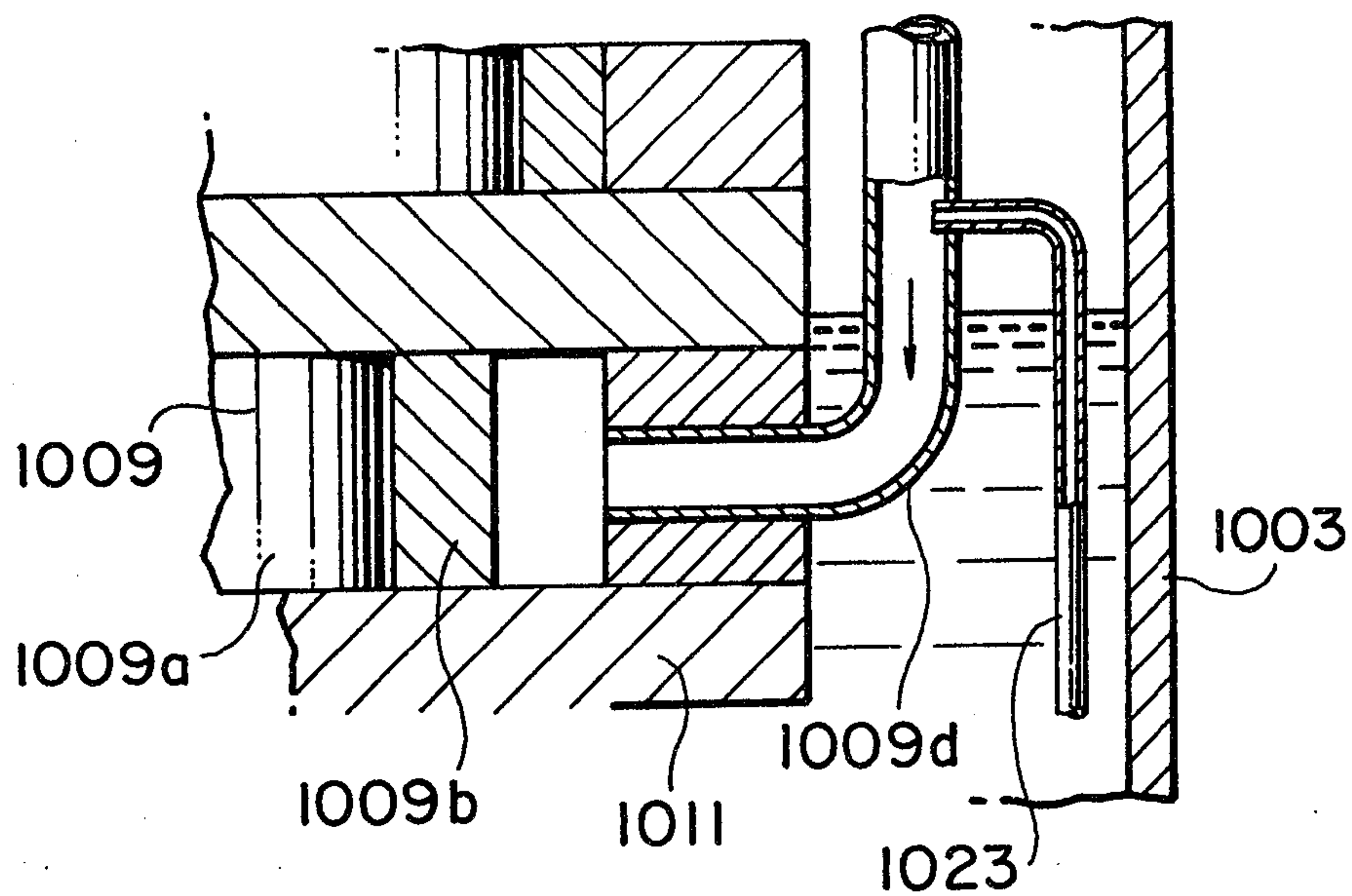
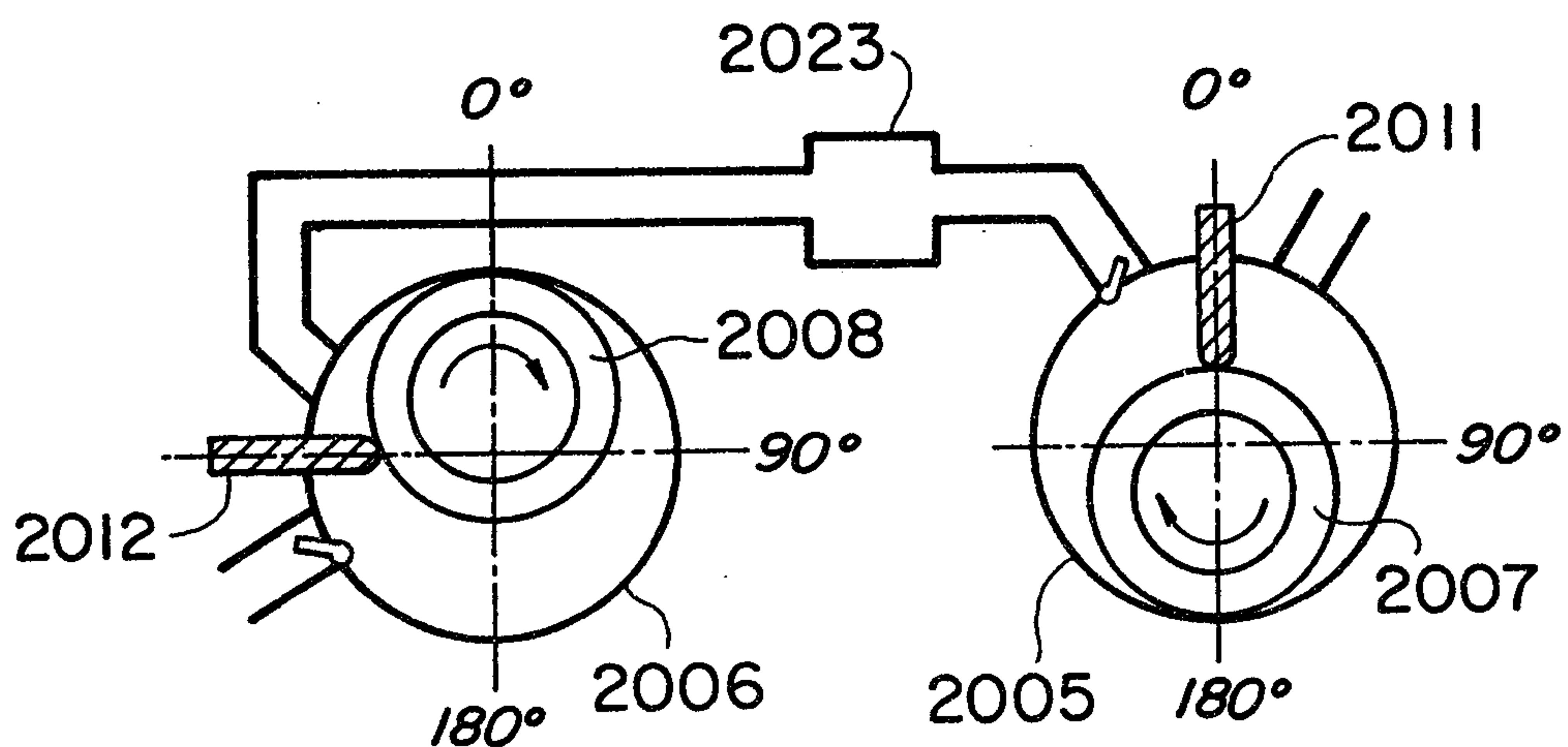
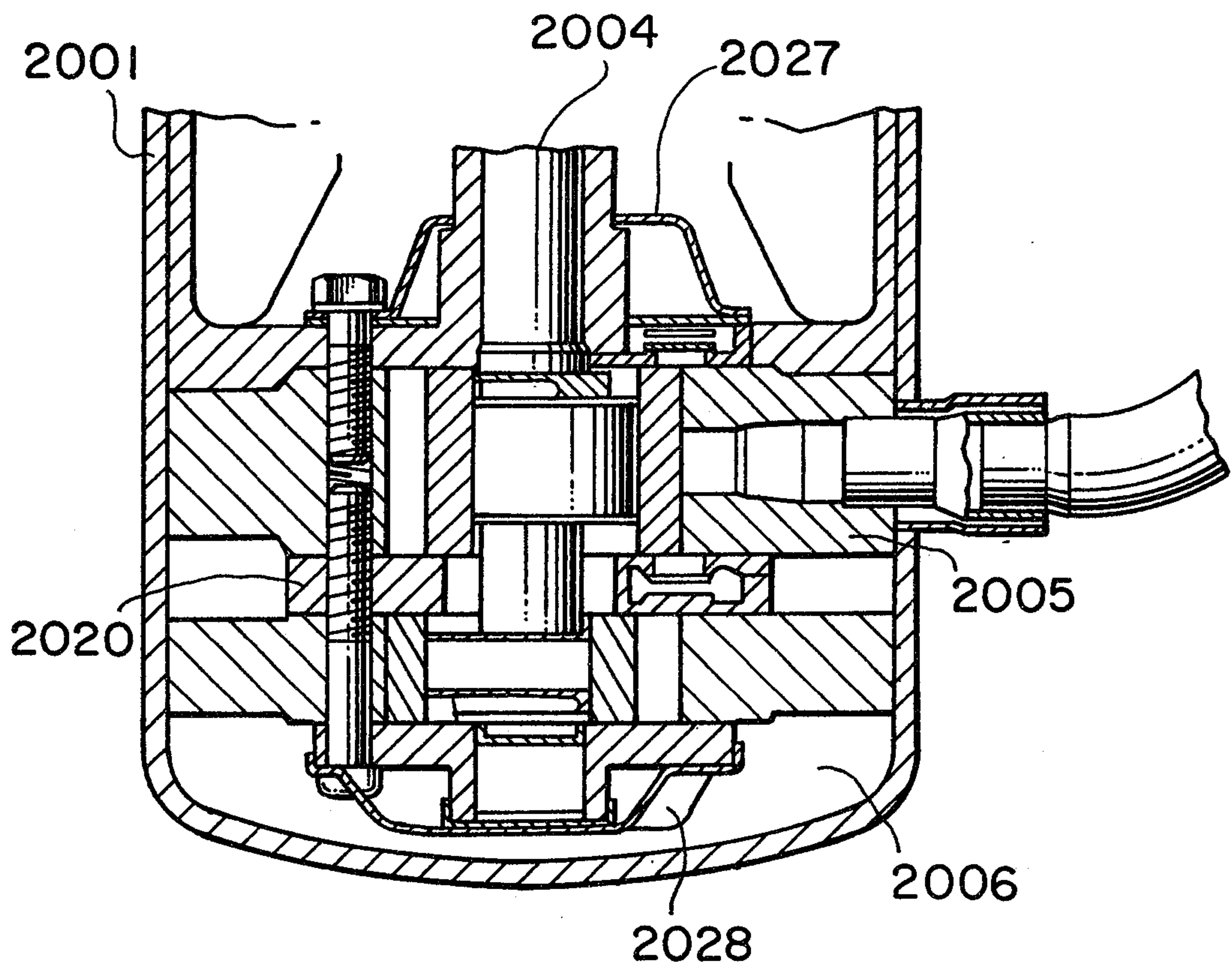


FIG. 4
PRIOR ART



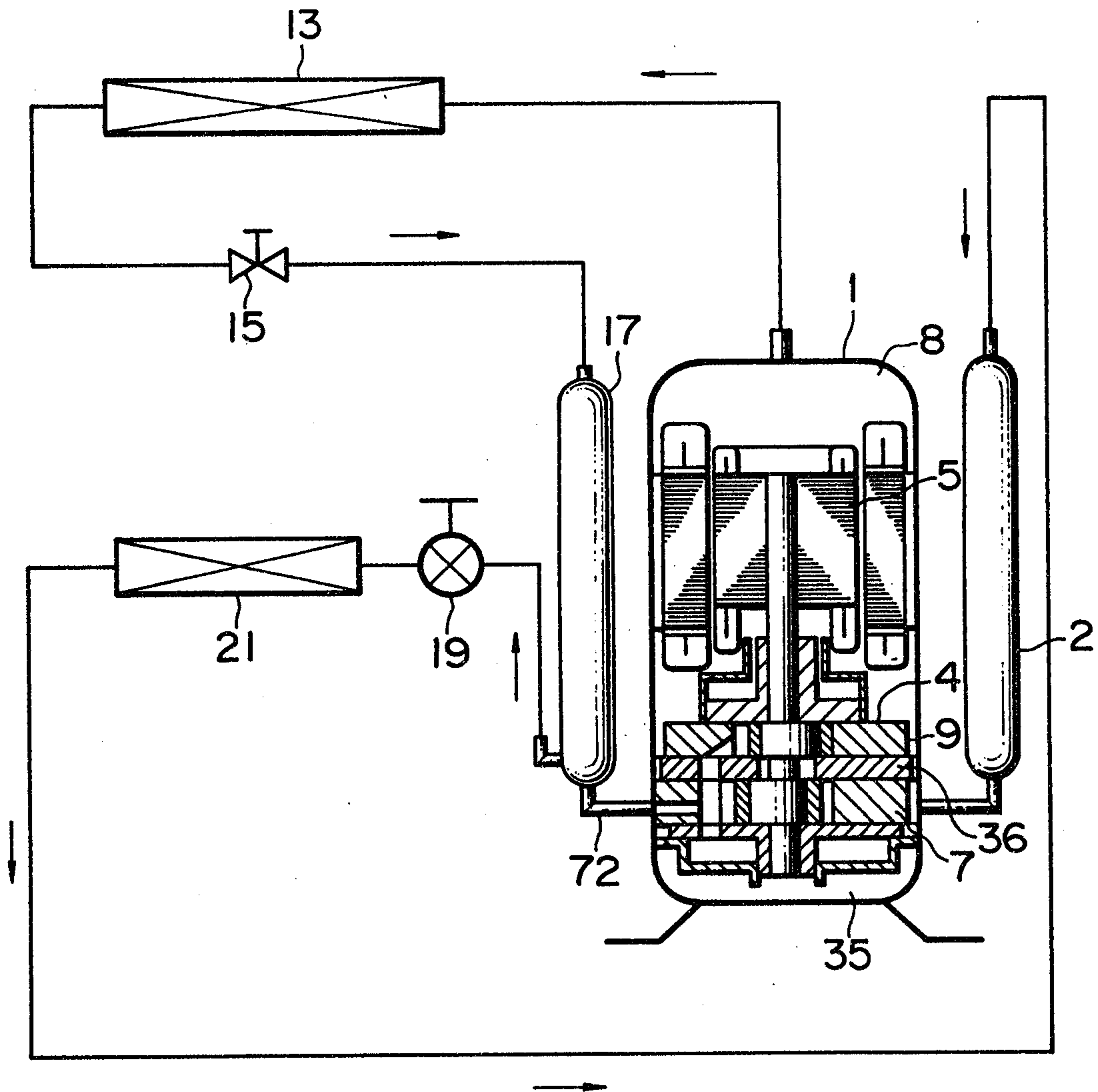
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FIG. 5
PRIOR ART



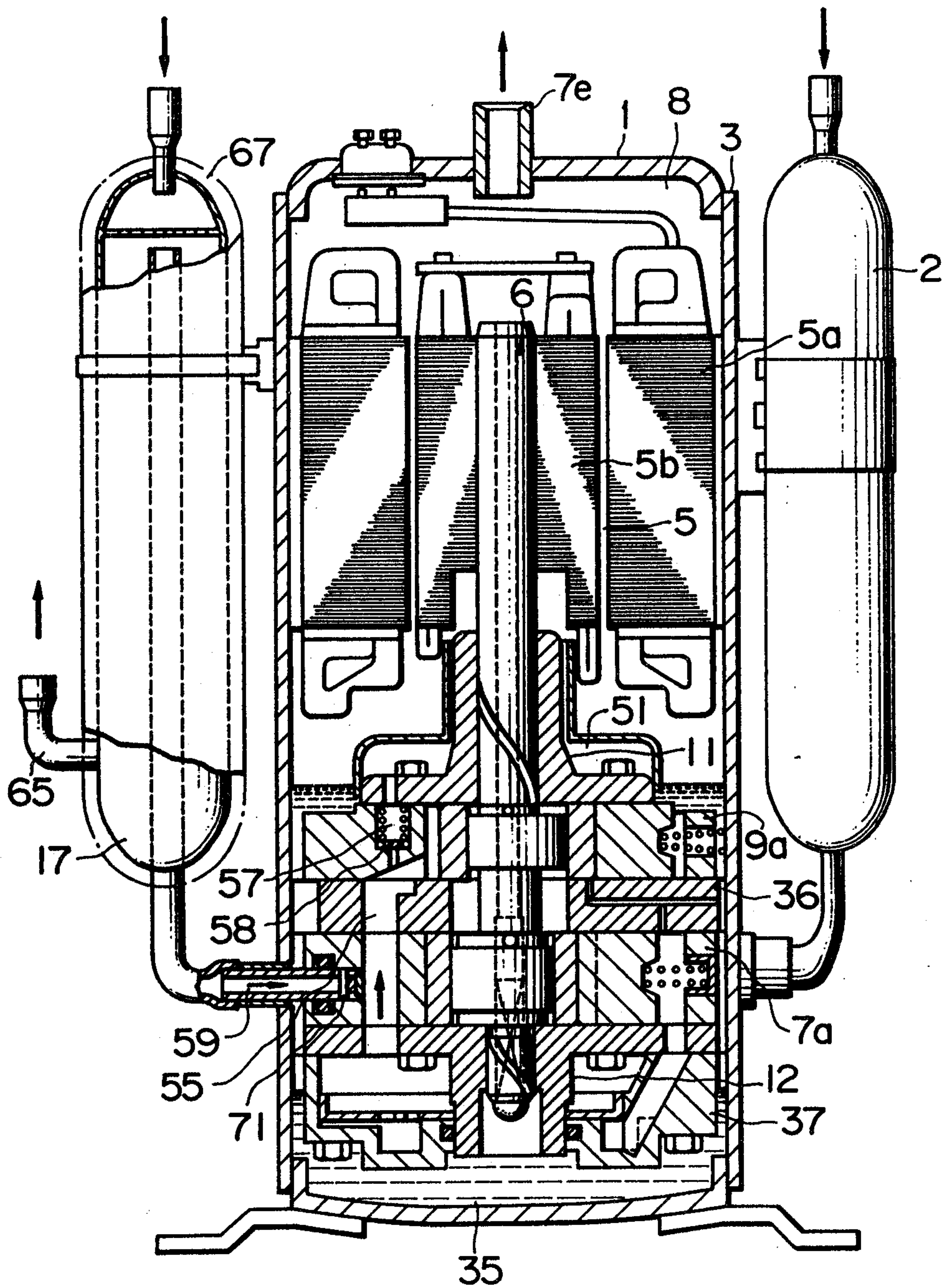
Heath & Clerk

FIG. 6



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FIG. 7



Marks & Clerk

FIG. 9

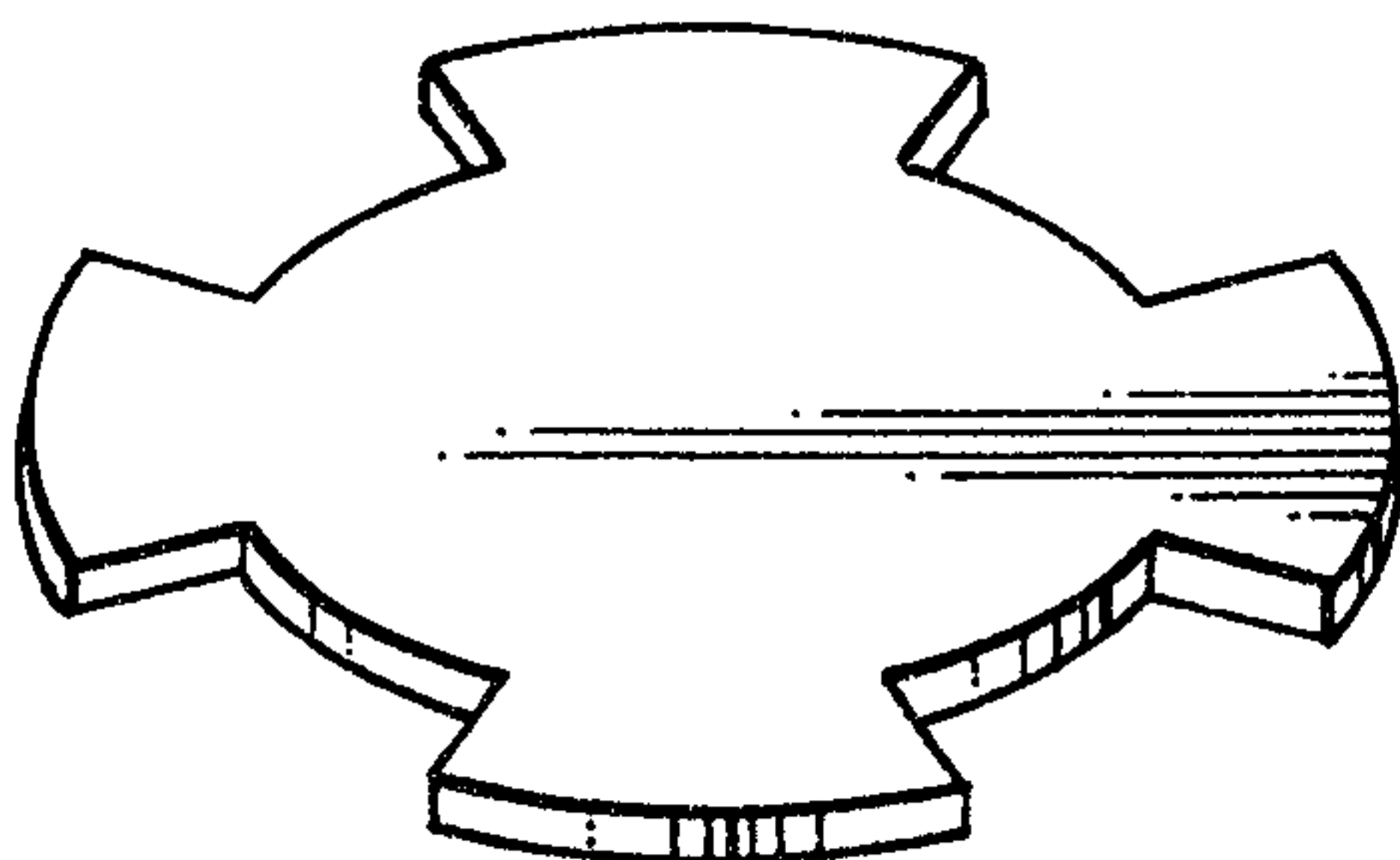
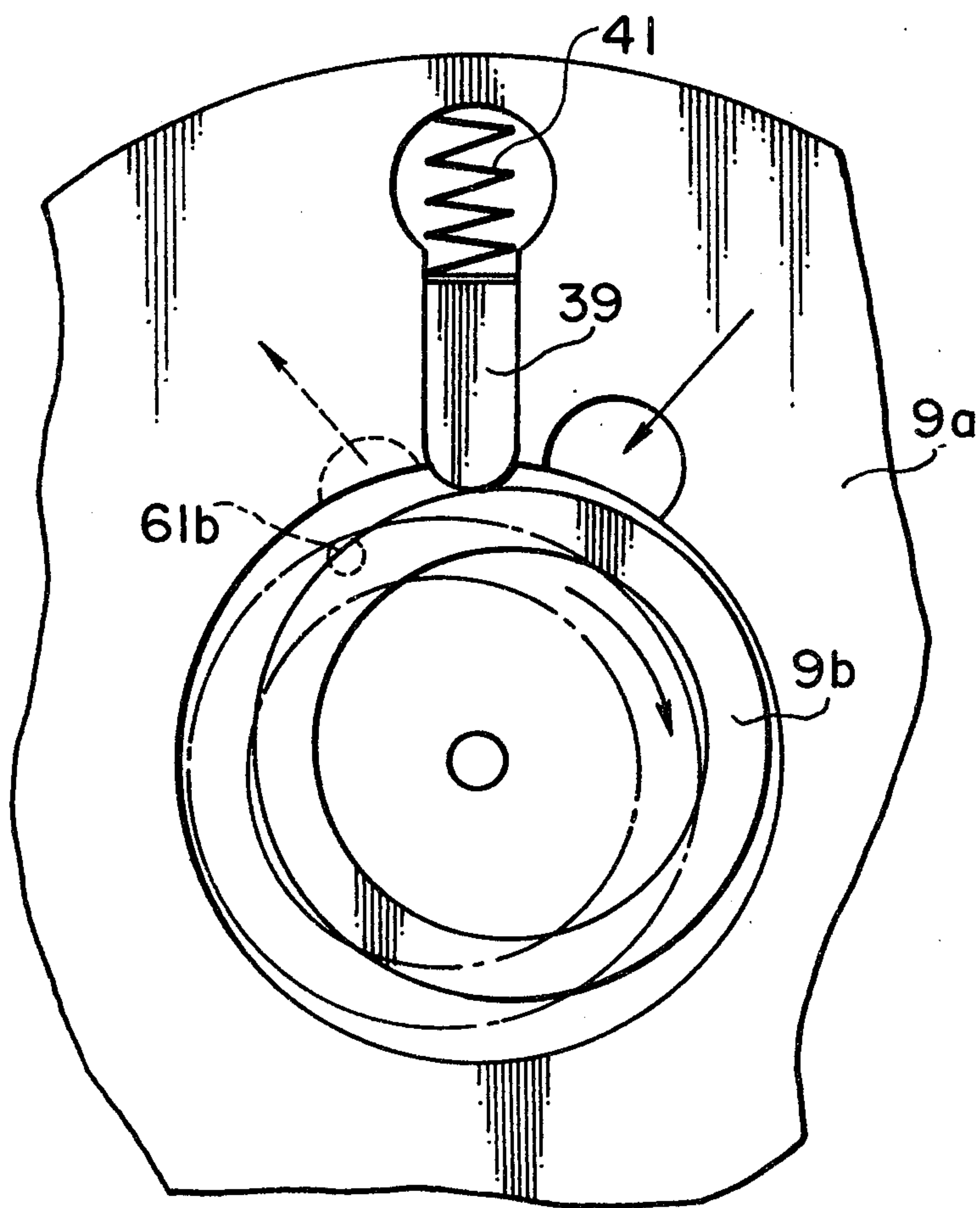


FIG. 10



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FIG. II

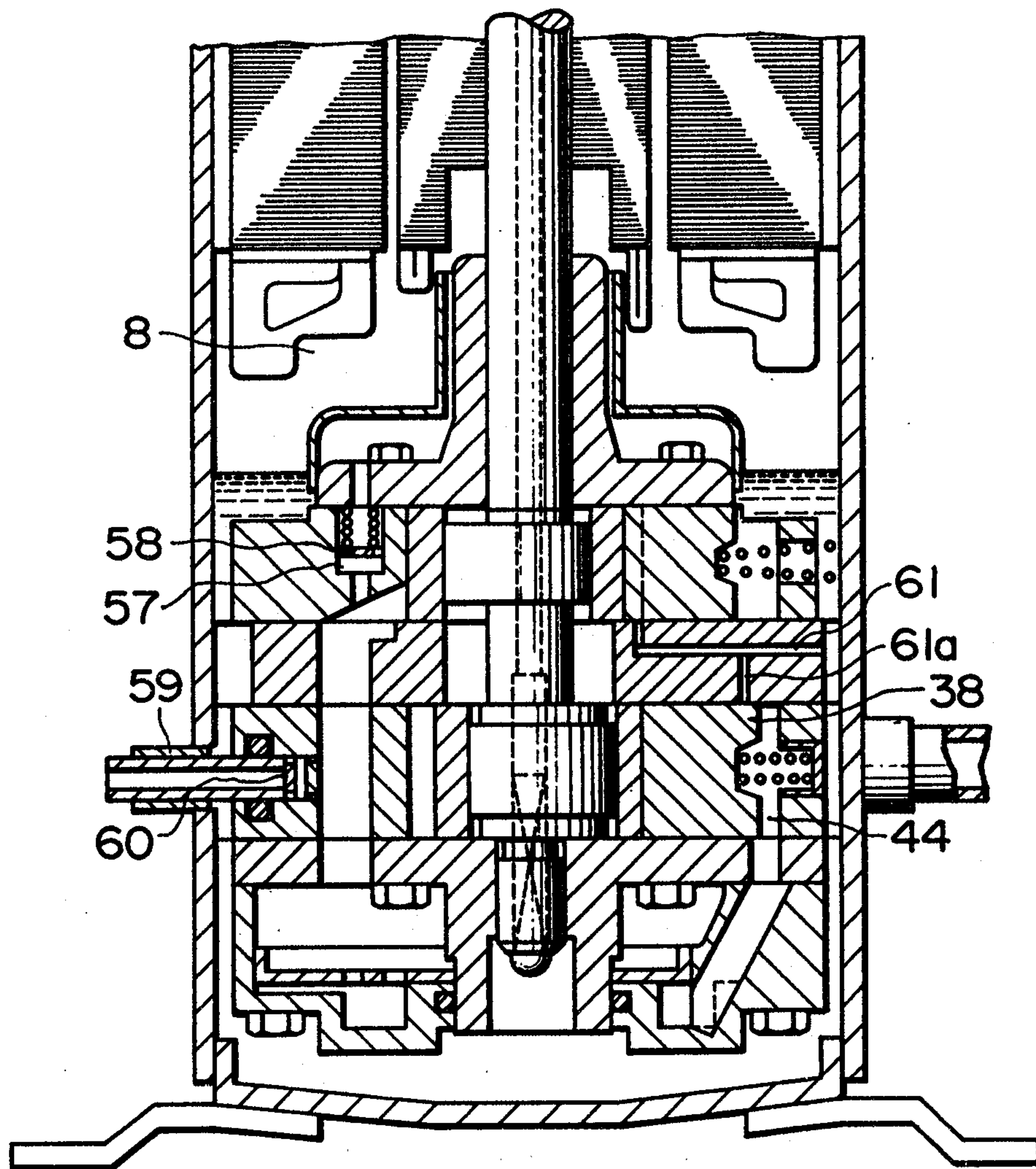
*Rankes & Clark*

FIG. 12

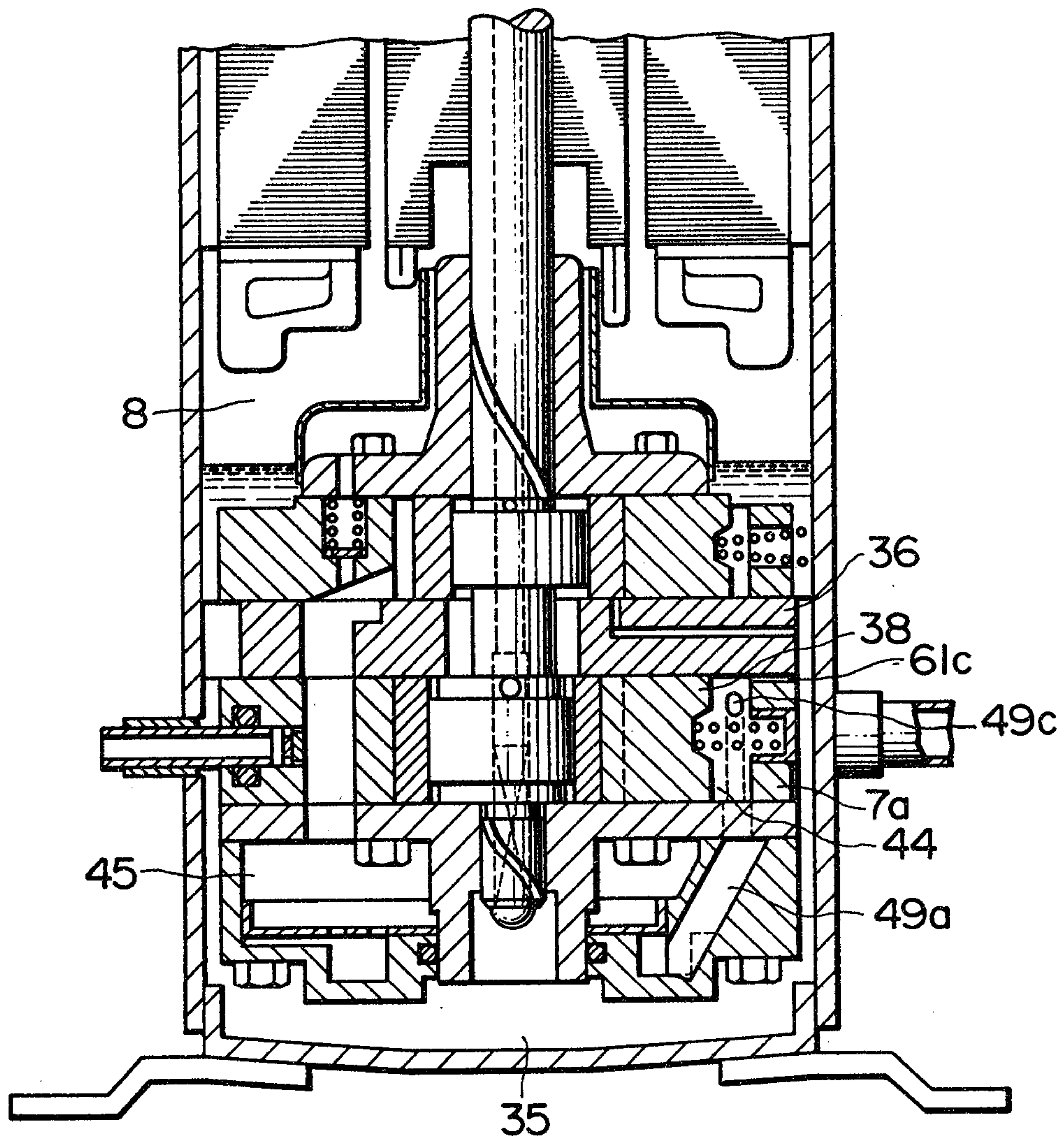
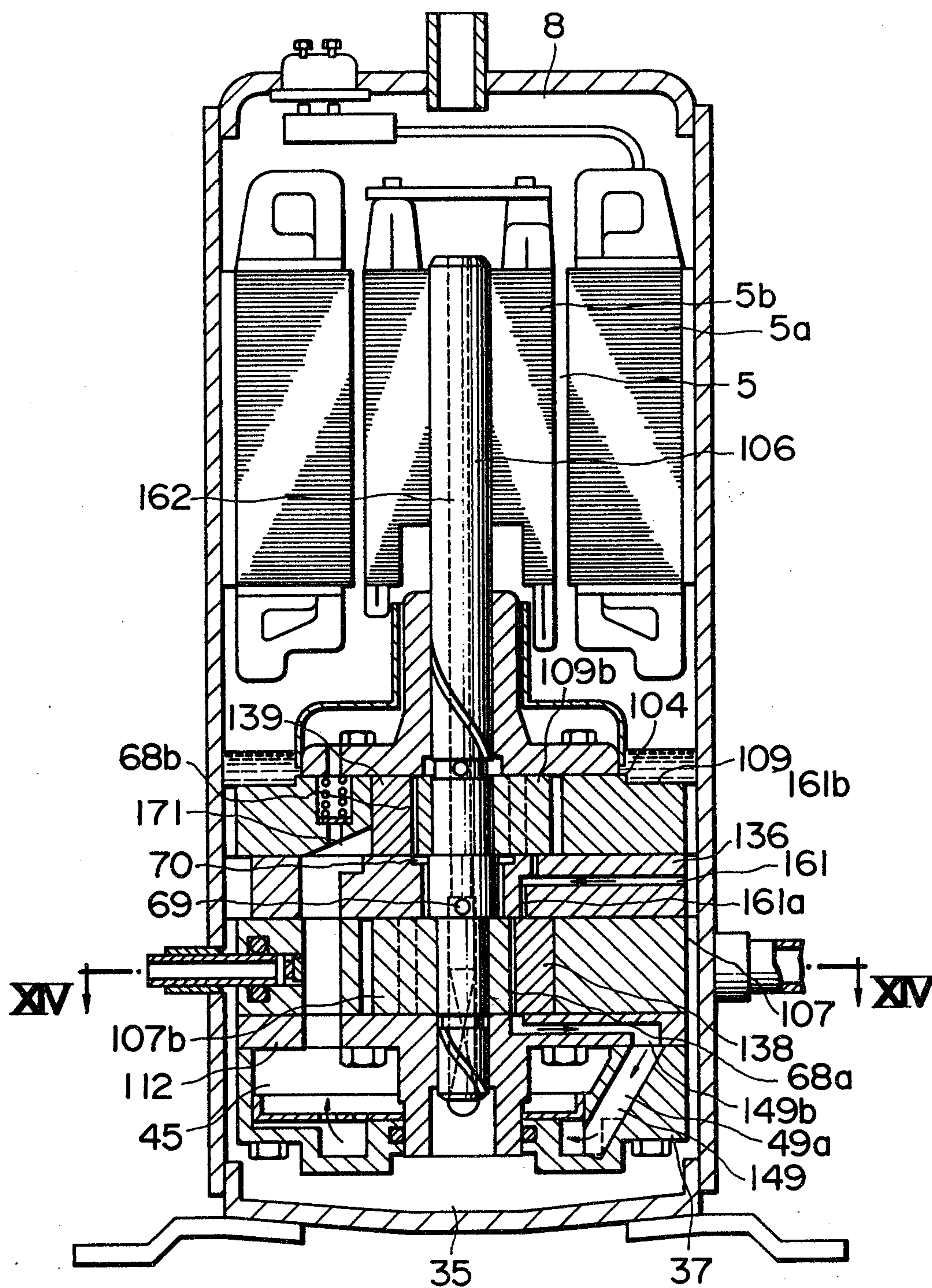
*Ward & Clark*

FIG. 13



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FIG. 14

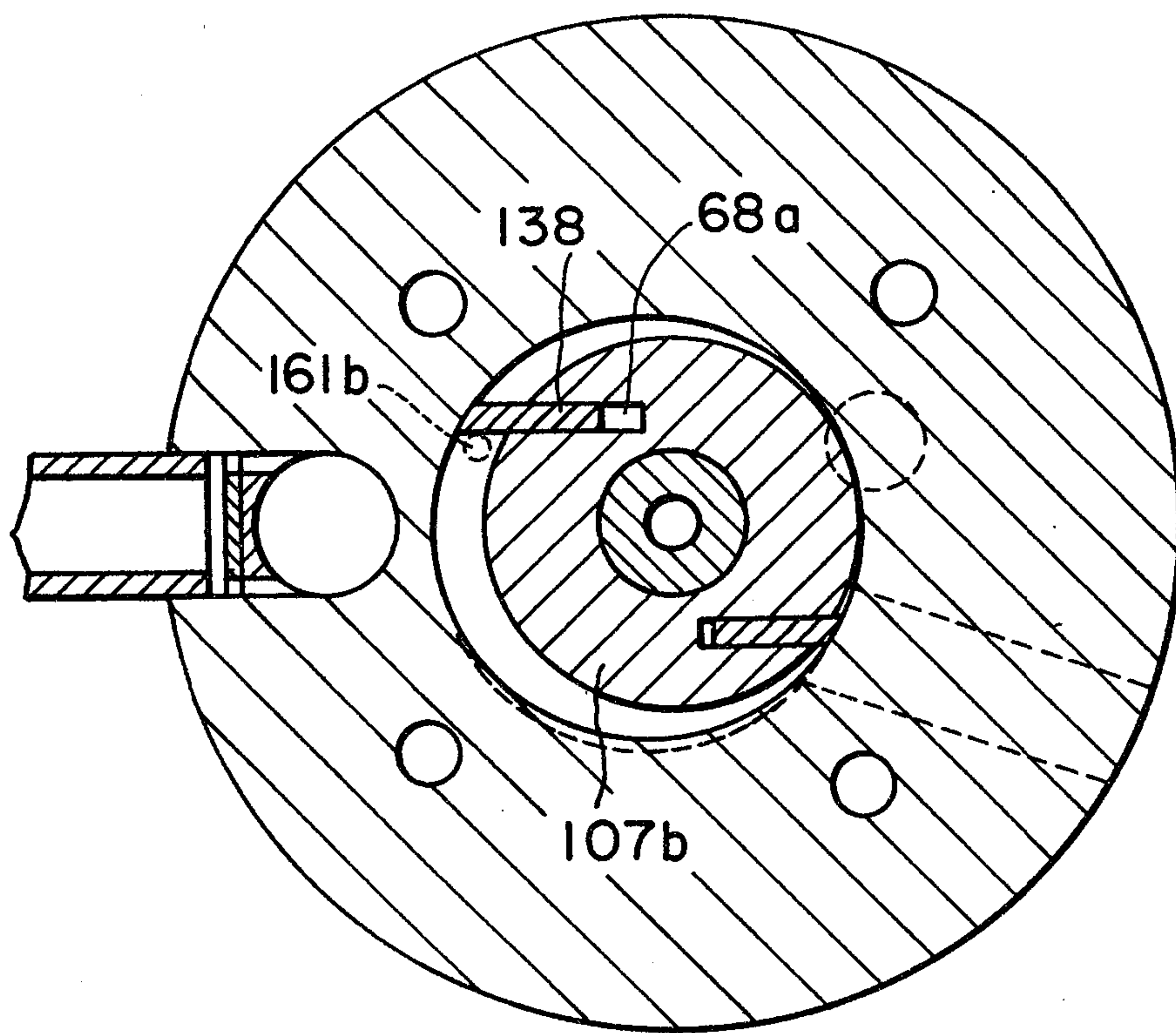
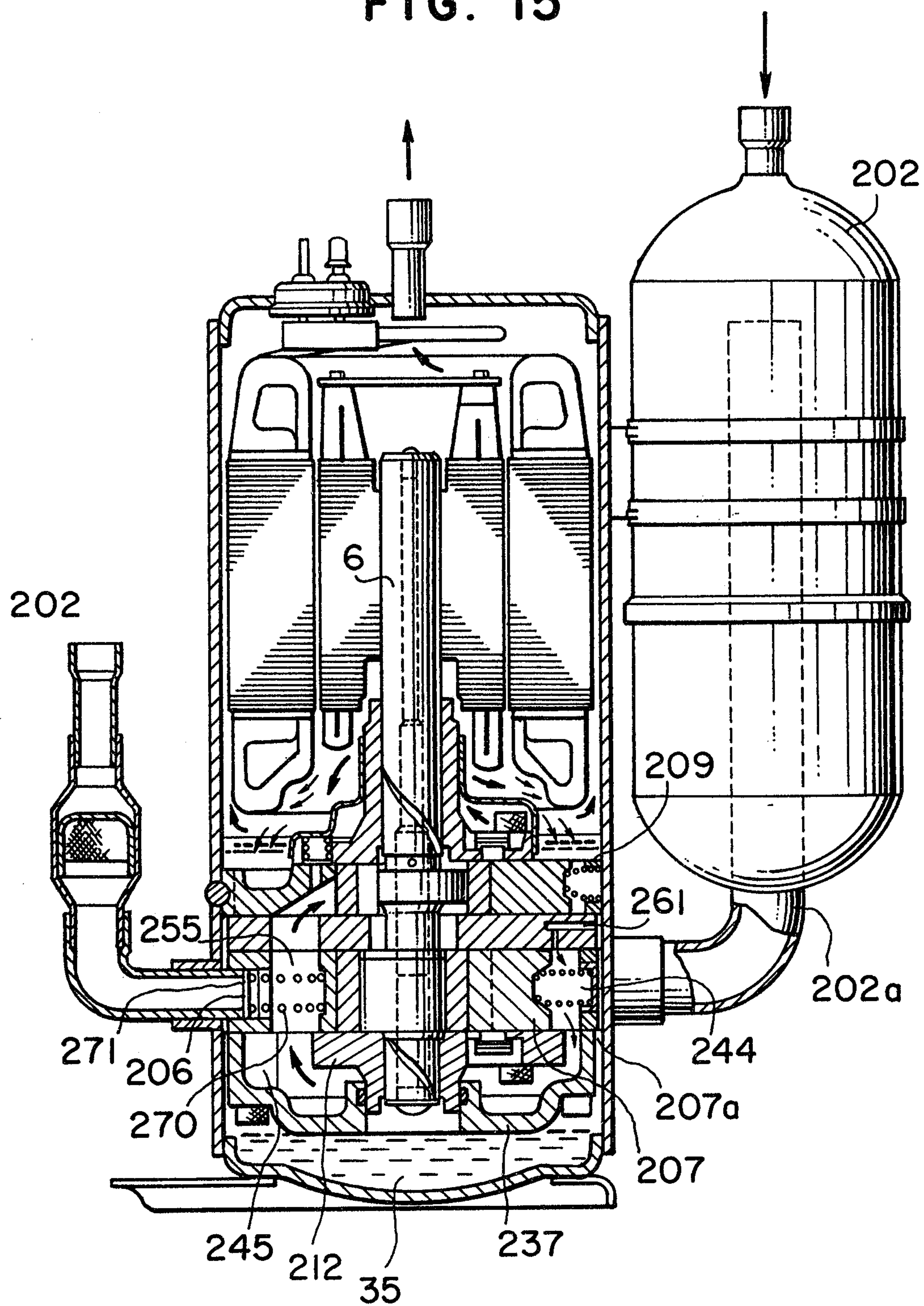
*Hecks & Clark*

FIG. 15



W. A. Clark