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(71) Applicant: **Daikin Industries, Ltd.**
Osaka-shi, Osaka 530-8323 (JP)

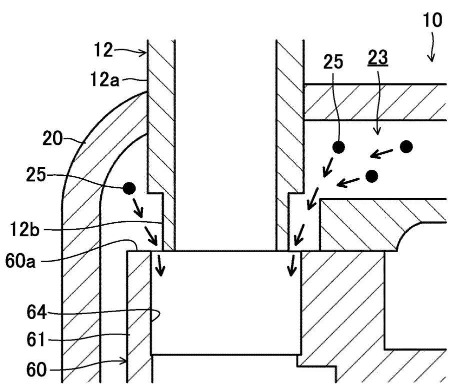
(72) Inventors:
- **TSUTSUMI, Satoru**
Osaka-shi, Osaka 530-8323 (JP)
- **YOKOYAMA, Tomomi**
Osaka-shi, Osaka 530-8323 (JP)
- **WADA, Ryousuke**
Osaka-shi, Osaka 530-8323 (JP)
- **TAKAO, Hidenobu**
Osaka-shi, Osaka 530-8323 (JP)

(74) Representative: **Goddar, Heinz J.**
Boehmert & Boehmert
Anwaltspartnerschaft mbB
Pettenkoferstrasse 22
80336 München (DE)

(54) SCROLL COMPRESSOR

(57) A downstream end of a suction pipe (12) overlaps with an upstream end of a suction port (64) as viewed in the axial direction. A casing (20) has therein an internal space (23) through which a refrigerant containing oil flows. A fixed scroll (60) has a suction port (64) communicating with the internal space (23) and a compression chamber (S). The refrigerant flowing through the internal space (23) and containing oil droplets (25) passes through a gap between the downstream end of the suction pipe (12) and an open surface (60a) of the suction port (64) and flows into the suction port (64).

FIG.2



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a scroll compressor.

BACKGROUND ART

[0002] Patent Document 1 discloses a scroll compressor configured to perform a first operation in which among a fixed-side oil groove, a movable-side oil gro ove, and a compression chamber (or a fluid chamber), only the fixed-side oil groove and the movable-side oil groove communicate with each other, and a second operation in which the movable-side oil groove simultaneously communicates with both of the fixed-side oil groove and the compression chamber after the first operation.

CITATION LIST

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Unexamined Patent Publication No. 2016-160816

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0004] In the disclosure of Patent Document 1, the movable-side oil groove communicates with the space in the compression chamber, radially outward of a movable scroll. Less oil is thus supplied to the space in the compression chamber, radially inward of the movable scroll.

[0005] It is an object of the present disclosure to enable a supply of oil to spaces in a compression chamber radially inward and outward of a movable scroll.

SOLUTION TO THE PROBLEM

[0006] A first aspect of the present disclosure is directed to a scroll compressor including: a casing (20) to which a suction pipe (12) is connected; a fixed scroll (60) housed in the casing (20); and a movable scroll (70) that forms a compression chamber (S) with the fixed scroll (60). The casing (20) has therein an internal space (23) through which a refrigerant containing oil flows; the fixed scroll (60) has a suction port (64) that communicates with the internal space (23) and the compression chamber (S); the suction pipe (12) has a larger-diameter portion (12a) and a smaller-diameter portion (12b) provided downstream of the larger-diameter portion (12a), the smaller-diameter portion (12b) having an outer diameter smaller than an outer diameter of the larger-diameter portion (12b); the smaller-diameter portion (12b) has a downstream end overlapping with an upstream end of the suction port (64) as viewed in an axial direction; and the outer diameter of the smaller-diameter portion (12b) is smaller than a diameter of the upstream end of the suction port (64).

[0007] According to the first aspect, the suction pipe (12) has the larger-diameter portion (12a) and the smaller-diameter portion (12b). The outer diameter of the smaller-diameter portion (12b) is smaller than the inner diameter of the upstream end of the suction port (64). The oil flowing through the internal space (23) flows into the suction port (64) through the gap between the smaller-diameter portion (12b) of the suction pipe (12) and the suction port (64).

[0008] Accordingly, oil can be supplied to the spaces in the compression chamber (S) which are located radially inward and outward of the movable scroll (70).

[0009] A second aspect of the present disclosure is an embodiment of the first aspect. In the second aspect, the suction pipe (12) has a diameter-reducing portion (12c) provided between the larger-diameter portion (12a) and the smaller-diameter portion (12b) and having an outer diameter gradually reduced.

[0010] According to the second aspect, the diameter-reducing portion (12c) is provided between the larger-diameter portion (12a) and the smaller-diameter portion (12b), and has its outer diameter gradually reduced.

[0011] Thus, the oil flowing along the outer circumferential surface of the larger-diameter portion (12a) can flow smoothly from the diameter-reducing portion (12c) to the smaller-diameter portion (12b).

[0012] A third aspect of the present disclosure is an embodiment of the first or second aspect. In the third aspect, a tapered portion (64a) is formed in the fixed scroll (60) around a peripheral portion on an upstream side of the suction port (64).

[0013] According to the third aspect, the width of the opening of the suction port (64) is greater toward the upstream side due to the tapered portion (64a). This configuration allows the oil to flow easily along the tapered portion (64a) and efficiently into the suction port (64).

[0014] A fourth aspect of the present disclosure is an embodiment of any one of the first to third aspects. In the fourth aspect, a downstream end of the suction pipe (12) is flush with an open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0015] According to the fourth aspect, the downstream end of the suction pipe (12) is flush with an open surface (60a) of the fixed scroll (60) where the suction port (64) opens. The oil flowing through the internal space (23) passes through the gap between the downstream end of the suction pipe (12) and the open surface (60a) and flows into the suction port (64).

[0016] Accordingly, oil can be supplied to the spaces in the compression chamber (S) which are located radially inward and outward of the movable scroll (70).

[0017] A fifth aspect of the present disclosure is an embodiment of any one of the first to third aspects. In the fifth aspect, a downstream end of the suction pipe (12) is located at an outer position in the axial direction, away from an open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0018] According to the fifth aspect, the downstream end of the suction pipe (12) is located at an outer position in an axial direction, away from the open surface (60a) of the fixed scroll (60) where the suction port (64) opens. The oil flowing through the internal space (23) passes through the gap between the downstream end of the suction pipe (12) and the open surface (60a) and flows into the suction port (64).

[0019] Accordingly, oil can be supplied to the spaces in the compression chamber (S) which are located radially inward and outward of the movable scroll (70).

[0020] A sixth aspect of the present disclosure is an embodiment of the fifth aspect. In the sixth aspect, the following condition is satisfied: $0 \leq H/D \leq 0.3$ where H represents a gap between the downstream end of the suction pipe (12) and the open surface (60a), and D represents an inner diameter of the suction pipe (12).

[0021] According to the sixth aspect, the gap H between the downstream end of the suction pipe (12) and the open surface (60a) and the inner diameter D of the suction pipe (12) are determined to satisfy the above-described condition. This allows the oil flowing through the internal space (23) to flow into the suction port (64) efficiently, thus improving the efficiency of the compressor.

[0022] A seventh aspect of the present disclosure is an embodiment of any one of the first to third aspects. In the seventh aspect, a downstream end of the suction pipe (12) is located at an inner position in an axial direction relative to an open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0023] According to the seventh aspect, the downstream end of the suction pipe (12) is located at an inner position in an axial direction relative to the open surface (60a) of the fixed scroll (60) through which the suction port (64) opens. The oil flowing through the internal space (23) passes through the gap between the downstream end of the suction pipe (12) and the open surface (60a) and flows into the suction port (64).

[0024] Accordingly, oil can be supplied to the spaces in the compression chamber (S) which are located radially inward and outward of the movable scroll (70).

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 is a diagram illustrating a longitudinal sectional view of a configuration of a scroll compressor according to a first embodiment.

FIG. 2 is a diagram illustrating the positional relationship between a suction pipe and a suction port.

FIG. 3 is a diagram illustrating a transverse sectional view of configurations of a fixed scroll and a movable scroll.

FIG. 4 is a diagram illustrating a configuration of a scroll compressor according to a variation of the first embodiment, and corresponds to FIG. 2.

FIG. 5 is a graph showing the relationship between the efficiency and the ratio of the gap H to the inner diameter D of the suction pipe.

FIG. 6 is a diagram illustrating a longitudinal sectional view of a configuration of a scroll compressor according to a second embodiment.

FIG. 7 is a diagram illustrating the positional relationship between a suction pipe and a suction port.

FIG. 8 is a diagram illustrating a transverse sectional view of configurations of a fixed scroll ad a movable scroll.

FIG. 9 is a diagram illustrating a configuration of a scroll compressor according to a first variation of the second embodiment, and corresponds to FIG. 7.

FIG. 10 is a diagram illustrating a configuration of a scroll compressor according to a second variation of the second embodiment, and corresponds to FIG. 7.

FIG. 11 is a diagram illustrating a configuration of a scroll compressor according to a third embodiment, and corresponds to FIG. 7.

DESCRIPTION OF EMBODIMENTS

«First Embodiment»

[0026] A first embodiment will be described.

[0027] As illustrated in FIG. 1, a scroll compressor (10) includes a casing (20), an electric motor (30), and a compression mechanism (40). The electric motor (30) and the compression mechanism (40) are housed in the casing (20). The casing (20) has a vertically oriented cylindrical shape, and is configured as a closed dome.

[0028] The scroll compressor (10) is provided in a refrigerant circuit of a vapor compression refrigeration cycle. In this refrigerant circuit, a refrigerant compressed in the scroll compressor (10) condenses in a condenser, has its pressure decreased in a decompression mechanism, evaporates in an evaporator, and is then sucked into the scroll compressor (10).

[0029] The electric motor (30) includes a stator (31) fixed to the casing (20) and a rotor (32) inside the stator (31). The rotor (32) is fixed to a drive shaft (11).

[0030] The casing (20) has, at its bottom, an oil reservoir (21) for storing oil. A suction pipe (12) is connected to an upper portion of the casing (20). A discharge pipe (13) is connected to a central portion of the casing (20).

[0031] A housing (50) is fixed to the casing (20). The housing (50) is located above the electric motor (30). The compression mechanism (40) is located above the housing (50). The discharge pipe (13) has an inflow end between the electric motor (30) and the housing (50).

[0032] The drive shaft (11) extends vertically along the center axis of the casing (20). The drive shaft (11) includes a main shaft portion (14) and an eccentric portion (15) connected to the upper end of the main shaft portion

(14).

[0033] The main shaft portion (14) has a lower portion rotatably supported by a lower bearing (22) provided in the casing (20). The lower bearing (22) is fixed to the inner circumferential surface of the casing (20). The main shaft portion (14) has an upper portion extending so as to pass through the housing (50) and rotatably supported by an upper bearing (51) of the housing (50).

[0034] The compression mechanism (40) includes a fixed scroll (60) and a movable scroll (70). The fixed scroll (60) is fixed to the upper surface of the housing (50). The movable scroll (70) is interposed between the fixed scroll (60) and the housing (50).

[0035] The housing (50) includes an annular portion (52) and a concave portion (53). The annular portion (52) forms the outer circumference of the housing (50). The concave portion (53) is provided in an upper central portion of the housing (50) and formed in a dish-like shape with a concave center. The upper bearing (51) is located below the concave portion (53).

[0036] The housing (50) is fixed to the inside of the casing (20) by press fitting. The inner circumferential surface of the casing (20) and the outer circumferential surface of the annular portion (52) of the housing (50) are in airtight contact with each other throughout the entire circumference. The housing (50) partitions the interior of the casing (20) into an upper space (23) (internal space) for housing the compression mechanism (40) and a lower space (24) for housing the electric motor (30).

[0037] The fixed scroll (60) includes a fixed-side end plate (61), a substantially cylindrical outer circumferential wall (63) that stands on the outer edge of the lower surface of the fixed-side end plate (61), and a spiral fixed-side wrap (62) that stands on a portion of the fixed-side end plate (61) inside the outer circumferential wall (63).

[0038] The fixed-side end plate (61) is located on the outer circumference and continuous with the fixed-side wrap (62). The end surface of the fixed-side wrap (62) and the end surface of the outer circumferential wall (63) are substantially flush with each other. The fixed scroll (60) is fixed to the housing (50).

[0039] The movable scroll (70) includes a movable-side end plate (71), a spiral movable-side wrap (72) located on the upper surface of the movable-side end plate (71), and a boss (73) located at a central portion of the lower surface of the movable-side end plate (71).

[0040] The eccentric portion (15) of the drive shaft (11) is inserted into the boss (73), whereby the boss (73) is connected to the drive shaft (11). An Oldham coupling (46) is provided at an upper portion of the housing (50). The Oldham coupling (46) blocks the rotation of the movable scroll (70) on its axis.

[0041] The compression mechanism (40) includes, between the fixed scroll (60) and the movable scroll (70), a compression chamber (S) into which a refrigerant flows. The movable scroll (70) is placed so that the movable-side wrap (72) meshes with the fixed-side wrap (62) of the fixed scroll (60). Here, the lower surface of the outer circumferential wall (63) of the fixed scroll (60) serves as a facing surface that faces the movable scroll (70). On the other hand, the upper surface of the movable-side end plate (71) of the movable scroll (70) serves as a facing surface that faces the fixed scroll (60).

[0042] As illustrated also in FIG. 2, the outer circumferential wall (63) of the fixed scroll (60) has a suction port (64) communicating with the compression chamber (S). The suction port (64) extends in the vertical direction. The suction pipe (12) extending vertically is located upstream of the suction port (64).

[0043] The suction pipe (12) is connected to an upper portion of the casing (20). An outer portion of a downstream end portion of the suction pipe (12) is cut away around the entire circumference. The suction pipe (12) therefore has a larger-diameter portion (12a) and a smaller-diameter portion (12b) having an outer diameter smaller than that of the larger-diameter portion (12a). The outer diameter of the smaller-diameter portion (12b) is smaller than the inner diameter of the suction port (64).

[0044] The downstream end of the suction pipe (12) overlaps with the upstream side of the suction port (64) as viewed in the axial direction. In the example illustrated in FIG. 2, the suction pipe (12) is positioned to be coaxial with the suction port (64). The downstream end of the suction pipe (12) is flush with an open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0045] Thus, there is a gap between the outer circumference of the downstream end of the suction pipe (12) (the outer circumference of the smaller-diameter portion (12b)) and the inner periphery of the upstream end of the suction port (64). The gap forms a ring-shaped opening as viewed in the axial direction. The suction port (64) communicates with the upper space (23) and the compression chamber (S) through the ring-shaped opening.

[0046] A refrigerant containing oil droplets (25) flows through the upper space (23). The refrigerant containing the oil droplets (25) and flowing through the upper space (23) is sucked through the ring-shaped opening into the suction port (64). In the example illustrated in FIG. 2, the suction pipe (12) is positioned to be coaxial with the suction port (64). However, the suction pipe (12) may be shifted slightly within a range that does not inhibit the flow of the refrigerant toward the suction port (64) through the opening.

[0047] As illustrated in FIG. 3, the compression chamber (S) is divided into outer chambers (S1) radially outward of the movable scroll (70), and inner chambers (S2) radially inward of the movable scroll (70). Specifically, when the inner circumferential surface of the outer circumferential wall (63) of the fixed scroll (60) and the outer circumferential surface of the movable-side wrap (72) of the movable scroll (70) substantially come into contact with each other, the outer chamber (S1) and the inner chambers (S2) become separate sections with the contact portion serving as a boundary.

[0048] As illustrated in FIG. 1, the fixed-side end plate (61) of the fixed scroll (60) has, at its center, an outlet

(65). A high-pressure chamber (66) to which the outlet (65) is open is provided in the upper surface of the fixed-side end plate (61) of the fixed scroll (60). The high-pressure chamber (66) communicates with the lower space (24) via a path (not shown) formed through the fixed-side end plate (61) of the fixed scroll (60) and the housing (50). The high-pressure refrigerant compressed by the compression mechanism (40) flows out to the lower space (24).

[0049] An oil supply hole (16) is provided inside the drive shaft (11) so as to extend vertically from the lower end to the upper end of the drive shaft (11). A lower end portion of the drive shaft (11) is immersed in the oil reservoir (21). The oil supply hole (16) supplies the oil in the oil reservoir (21) to the lower bearing (22) and the upper bearing (51), and to the gap between the boss (73) and the drive shaft (11). The oil supply hole (16) is open to the upper end surface of the drive shaft (11) and supplies oil to above the drive shaft (11).

[0050] The concave portion (53) of the housing (50) communicates with the oil supply hole (16) of the drive shaft (11) via the inside of the boss (73) of the movable scroll (70). The high-pressure oil is supplied to the concave portion (53), so that a high pressure equivalent to the discharge pressure of the compression mechanism (40) acts on the concave portion (53). The movable scroll (70) is pressed onto the fixed scroll (60) by the high pressure that acts on the concave portion (53).

[0051] An oil path (55) is provided in the housing (50) and the fixed scroll (60). The oil path (55) has an inflow end that communicates with the concave portion (53) of the housing (50). The oil path (55) has an outflow end open to the facing surface of the fixed scroll (60). Through the oil path (55), the high-pressure oil in the concave portion (53) is supplied to the facing surfaces of the movable-side end plate (71) of the movable scroll (70) and the outer circumferential wall (63) of the fixed scroll (60).

[0052] As illustrated in FIG. 3, the facing surface of the outer circumferential wall (63) of the fixed scroll (60) has an oil supply groove (80). The oil supply groove (80) is formed in the facing surface, of the outer circumferential wall (63) of the fixed scroll (60), which faces the movable-side end plate (71) of the movable scroll (70). The oil supply groove (80) extends substantially in an arc shape along the inner circumferential surface of the outer circumferential wall (63) of the fixed scroll (60). The oil path (55) communicates with the oil supply groove (80), and oil is supplied to the oil supply groove (80) from the oil path (55).

[0053] The outer periphery of the fixed scroll (60) has a plurality of cutouts (68). The cutouts (68) communicate with the upper space (23). The oil supplied to the oil supply groove (80) flows through the cutouts (68) toward the upper space (23).

-Operation-

[0054] A basic operation of the scroll compressor (10) will be described. As illustrated in FIG. 1, when activated, the electric motor (30) rotatably drives the movable scroll (70) of the compression mechanism (40). Since the rotation of the movable scroll (70) is blocked by the Oldham coupling (46), the movable scroll (70) performs only the eccentric rotation about the axis of the drive shaft (11).

[0055] As illustrated in FIG. 3, when the movable scroll (70) rotates eccentrically, the compression chamber (S) is sectioned into the outer chamber (S1) and the inner chambers (S2). The plurality of inner chambers (S2) are formed between the fixed-side wrap (62) of the fixed scroll (60) and the movable-side wrap (72) of the movable scroll (70). As the movable scroll (70) rotates eccentrically, these inner chambers (S2) gradually come closer to the center (i.e., the outlet (65)) and the volumes of these inner chambers (S2) gradually decrease. The refrigerant is gradually compressed in the inner chambers (S2) in this manner.

[0056] When the inner chamber (S2) with the minimum volume communicates with the outlet (65), the high-pressure gas refrigerant in the inner chamber (S2) is discharged to the high-pressure chamber (66) via the outlet (65). The high-pressure gas refrigerant in the high-pressure chamber (66) flows out to the lower space (24) via the path formed in the fixed scroll (60) and the housing (50). The high-pressure gas refrigerant in the lower space (24) is discharged outside the casing (20) via the discharge pipe (13).

-Oil Supply Operation-

[0057] Next, an oil supply operation of the scroll compressor (10) will be described in detail with reference to FIGS. 1 to 3.

[0058] Once the high-pressure gas refrigerant flows out to the lower space (24) of the scroll compressor (10), the lower space (24) becomes a high-pressure atmosphere, and the pressure of the oil in the oil reservoir (21) increases. The high-pressure oil in the oil reservoir (21) flows upward through the oil supply hole (16) of the drive shaft (11) and flows out from the opening at the upper end of the eccentric portion (15) of the drive shaft (11) to the inside of the boss (73) of the movable scroll (70).

[0059] The oil supplied to the boss (73) is supplied to the gap between the eccentric portion (15) of the drive shaft (11) and the boss (73). Accordingly, the concave portion (53) of the housing (50) becomes a high-pressure atmosphere equivalent to the discharge pressure of the compression mechanism (40). The high pressure of the concave portion (53) presses the movable scroll (70) onto the fixed scroll (60).

[0060] The high-pressure oil accumulated in the concave portion (53) flows out through the oil path (55) to the oil supply groove (80). Accordingly, the high-pressure oil corresponding to the discharge pressure of the compression mechanism (40) is supplied to the oil supply groove (80). The oil in the oil supply groove (80) is used to lubricate the facing surfaces of the fixed scroll (60) and the movable scroll (70).

[0061] The oil supplied to the facing surface of the fixed scroll (60) flows radially outward when the movable scroll (70) rotates relative to the fixed scroll (60) and is discharged to the upper space (23) through the cutouts (68).

[0062] The refrigerant discharged to the upper space (23) and containing the oil droplets (25) is supplied to the suction port (64) through the gap between the suction pipe (12) and the suction port (64). The oil sucked into the suction port (64) is distributed to the outer chamber (S1) located radially outward of the movable-side wrap (72) of the movable scroll (70) and the inner chamber (S2) located radially inward of the movable-side wrap (72) of the movable scroll (70) (see the arrows in FIG. 3). As a result, the oil sealing performances of the outer chamber (S1) and the inner chamber (S2) can improve.

-Advantages of First Embodiment-

[0063] The scroll compressor (10) of this embodiment includes the casing (20) to which the suction pipe (12) is connected, the fixed scroll (60) housed in the casing (20), and the movable scroll (70) that forms the compression chamber (S) with the fixed scroll (60). The casing (20) has therein the upper space (23) (internal space) through which the refrigerant containing oil flows. The fixed scroll (60) has the suction port (64) communicating with the upper space (23) and the compression chamber (S). The downstream end of the suction pipe (12) overlaps with the upstream end of the suction port (64) as viewed in the axial direction, and is flush with the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0064] In this embodiment, the downstream end of the suction pipe (12) is flush with the open surface (60a) of the fixed scroll (60) where the suction port (64) opens. The oil flowing through the upper space (23) passes through the gap between the downstream end of the suction pipe (12) and the open surface (60a) and flows into the suction port (64).

[0065] Accordingly, oil can be supplied to the spaces in the compression chamber (S) which are located radially inward and outward of the movable scroll (70).

[0066] Specifically, the oil supplied to the facing surface of the fixed scroll (60) flows radially outward when the movable scroll (70) rotates relative to the fixed scroll (60) and is discharged to the upper space (23) through the cutouts (68).

[0067] The refrigerant discharged to the upper space (23) and containing the oil droplets (25) is supplied to the suction port (64) through the gap between the downstream end of the suction pipe (12) and the open surface (60a). Thereafter, oil is distributed to the spaces in the compression chamber (S) which are located radially inward and outward of the movable scroll (70). As a result, the oil sealing performances of the inner and outer spaces can improve.

-Variation of First Embodiment-

[0068] In the following description, the same reference characters designate the same components as those of the foregoing embodiment, and the description is focused only on the difference.

[0069] As illustrated in FIG. 4, the suction pipe (12) is connected to an upper portion of the casing (20). An outer portion of a downstream end portion of the suction pipe (12) is cut away around the entire circumference. The suction pipe (12) therefore has a larger-diameter portion (12a) and a smaller-diameter portion (12b) having an outer diameter smaller than that of the larger-diameter portion (12a). The outer diameter of the smaller-diameter portion (12b) is smaller than the inner diameter of the suction port (64).

[0070] The downstream end of the suction pipe (12) overlaps with the upstream side of the suction port (64) as viewed in the axial direction. The downstream end of the suction pipe (12) is located at an outer position in an axial direction, away from the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0071] Thus, there is a gap between the outer circumference of the downstream end of the suction pipe (12) (the outer circumference of the smaller-diameter portion (12b)) and the inner periphery of the upstream end of the suction port (64). The gap forms a ring-shaped opening as viewed in the axial direction. A predetermined gap is formed between the downstream end of the suction pipe (12) and the open surface (60a). The refrigerant flowing through the upper space (23) and containing oil droplets (25) is sucked into the suction port (64) through the gap between the suction pipe (12) and the suction port (64).

[0072] The inventors of this application have discovered that appropriately setting the size of the gap between the suction pipe (12) and the suction port (64) improves the efficiency. In the following description, H represents the gap between the downstream end of the suction pipe (12) and the open surface (60a), and D represents the inner diameter of the suction pipe (12).

[0073] In the graph shown in FIG. 5, the state where the ratio H/D (i.e., gap H/inner diameter D) is 0.0 indicates that the downstream end of the suction pipe (12) is flush with the open surface (60a) of the fixed scroll (60) where the suction port (64) opens. That is, the state where the "gap H/inner diameter D" is 0.0 corresponds to the configuration described in the foregoing embodiment.

[0074] With reference to the state where the ratio "gap H/inner diameter D" is 0.0, the direction in which the downstream end of the suction pipe (12) is inserted into the suction port (64) is defined as a negative direction, and the direction in which the downstream end of the suction pipe (12) is apart from the suction port (64) is defined as a positive direction.

[0075] Here, the suction pipe (12), if inserted deeply into the suction port (64) as in the known configuration, lessens the suction effect of a dynamic pressure. In FIG. 5, the efficiency of the compressor having the known configuration is indicated by the dot-dash line.

[0076] Further, as shown in FIG. 5, in the course of increasing the "gap H/inner diameter D" from 0.0, there appears the gap H that maximizes the efficiency, and thereafter, the efficiency tends to decrease gradually. Too large gap H lessens the suction effect of the dynamic pressure. Thus, it is recommended that the gap H be set to be in a range in which the efficiency is not lower than in the known configuration (a range above the dot-dash line in FIG. 5).

[0077] Referring to the graph of FIG. 5, the range of the ratios H/D from 0 to 0.3 corresponds to the range in which the efficiency is not lower than in the known configuration (the range above the dot-dash line in FIG. 5).

[0078] Thus, the inventors of this application have determined the gap H between the downstream end of the suction pipe (12) and the open surface (60a) and the inner diameter D of the suction pipe (12) to satisfy the condition of $0 \leq H/D \leq 0.3$.

- Advantages of Variation -

[0079] The scroll compressor (10) of this variation is configured such that the downstream end of the suction pipe (12) overlaps with the upstream end of the suction port (64) as viewed in the axial direction, and is located at an outer position in the axial direction, away from the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0080] In this variation, the downstream end of the suction pipe (12) is located at an outer position in the axial direction, away from the open surface (60a) of the fixed scroll (60) where the suction port (64) opens. The oil flowing through the upper space (23) passes through the gap between the downstream end of the suction pipe (12) and the open surface (60a) and flows into the suction port (64).

[0081] Accordingly, oil can be supplied to the spaces in the compression chamber (S) which are located radially inward and outward of the movable scroll (70).

[0082] In the scroll compressor (10) of this variation, the gap H between the downstream end of the suction pipe (12) and the open surface (60a) and the inner diameter D of the suction pipe (12) are determined to satisfy the condition of $0 \leq H/D \leq 0.3$.

[0083] In this variation, the gap H between the downstream end of the suction pipe (12) and the open surface (60a) and the inner diameter D of the suction pipe (12) are determined to satisfy the above-described condition. This allows the oil flowing through the internal space (23) to flow into the suction port (64) efficiently, thus improving the efficiency of the compressor.

[0084] While the embodiment and variations have been described above, it will be understood that various changes in form and details can be made without departing from the spirit and scope of the claims. The above embodiment and variations may be appropriately combined or replaced as long as the functions of the target of the present disclosure are not impaired.

«Second Embodiment»

[0085] A second embodiment will be described.

[0086] As illustrated in FIG. 6, a scroll compressor (10) includes a casing (20), an electric motor (30), and a compression mechanism (40). The electric motor (30) and the compression mechanism (40) are housed in the casing (20). The casing (20) has a vertically oriented cylindrical shape, and is configured as a closed dome.

[0087] The scroll compressor (10) is provided in a refrigerant circuit of a vapor compression refrigeration cycle. In this refrigerant circuit, a refrigerant compressed in the scroll compressor (10) condenses in a condenser, has its pressure decreased in a decompression mechanism, evaporates in an evaporator, and is then sucked into the scroll compressor (10).

[0088] The electric motor (30) includes a stator (31) fixed to the casing (20) and a rotor (32) inside the stator (31). The rotor (32) is fixed to a drive shaft (11).

[0089] The casing (20) has, at its bottom, an oil reservoir (21) for storing oil. A suction pipe (12) is connected to an upper portion of the casing (20). A discharge pipe (13) is connected to a central portion of the casing (20).

[0090] A housing (50) is fixed to the casing (20). The housing (50) is located above the electric motor (30). The compression mechanism (40) is located above the housing (50). The discharge pipe (13) has an inflow end between the electric motor (30) and the housing (50).

[0091] The drive shaft (11) extends vertically along the center axis of the casing (20). The drive shaft (11) includes a main shaft portion (14) and an eccentric portion (15) connected to the upper end of the main shaft portion (14).

[0092] The main shaft portion (14) has a lower portion rotatably supported by a lower bearing (22) provided in the casing (20). The lower bearing (22) is fixed to the inner circumferential surface of the casing (20). The main shaft portion (14) has an upper portion extending so as to pass through the housing (50) and rotatably supported by an upper bearing (51) of the housing (50).

[0093] The compression mechanism (40) includes a fixed scroll (60) and a movable scroll (70). The fixed scroll (60) is fixed to the upper surface of the housing (50). The movable scroll (70) is interposed between the fixed scroll (60) and the housing (50).

[0094] The housing (50) includes an annular portion (52) and a concave portion (53). The annular portion (52) forms the outer circumference of the housing (50). The concave portion (53) is provided in an upper central portion of the housing (50) and formed in a dish-like shape with a concave center. The upper bearing (51) is located below the concave portion (53).

[0095] The housing (50) is fixed to the inside of the casing (20) by press fitting. The inner circumferential surface of the casing (20) and the outer circumferential surface of the annular portion (52) of the housing (50) are in airtight contact with each other throughout the entire circumference. The housing (50) partitions the interior of the casing (20) into an upper space (23) (internal space) for housing the compression mechanism (40) and a lower space (24) for housing the electric motor (30).

[0096] The fixed scroll (60) includes a fixed-side end plate (61), a substantially cylindrical outer circumferential wall (63) that stands on the outer edge of the lower surface of the fixed-side end plate (61), and a spiral fixed-side wrap (62) that stands on a portion of the fixed-side end plate (61) inside the outer circumferential wall (63).

[0097] The fixed-side end plate (61) is located on the outer circumference and continuous with the fixed-side wrap (62). The end surface of the fixed-side wrap (62) and the end surface of the outer circumferential wall (63) are substantially flush with each other. The fixed scroll (60) is fixed to the housing (50).

[0098] The movable scroll (70) includes a movable-side end plate (71), a spiral movable-side wrap (72) located on the upper surface of the movable-side end plate (71), and a boss (73) located at a central portion of the lower surface of the movable-side end plate (71).

[0099] The eccentric portion (15) of the drive shaft (11) is inserted into the boss (73), whereby the boss (73) is connected to the drive shaft (11). An Oldham coupling (46) is provided at an upper portion of the housing (50). The Oldham coupling (46) blocks the rotation of the movable scroll (70) on its axis.

[0100] The compression mechanism (40) includes, between the fixed scroll (60) and the movable scroll (70), a compression chamber (S) into which a refrigerant flows. The movable scroll (70) is placed so that the movable-side wrap (72) meshes with the fixed-side wrap (62) of the fixed scroll (60). Here, the lower surface of the outer circumferential wall (63) of the fixed scroll (60) serves as a facing surface that faces the movable scroll (70). On the other hand, the upper surface of the movable-side end plate (71) of the movable scroll (70) serves as a facing surface that faces the fixed scroll (60).

[0101] As illustrated also in FIG. 7, the outer circumferential wall (63) of the fixed scroll (60) has a suction port (64) communicating with the compression chamber (S). The suction port (64) extends in the vertical direction. The suction pipe (12) extending vertically is located upstream of the suction port (64).

[0102] The suction pipe (12) is connected to an upper portion of the casing (20). An outer portion of a downstream end portion of the suction pipe (12) is cut away around the entire circumference. The suction pipe (12) therefore has a larger-diameter portion (12a), a smaller-diameter portion (12b), and a diameter-reducing portion (12c).

[0103] The smaller-diameter portion (12b) is provided downstream of the larger-diameter portion (12a), and has an outer diameter smaller than that of the larger-diameter portion (12a). The outer diameter of the smaller-diameter portion (12b) is smaller than the inner diameter of the suction port (64). The diameter-reducing portion (12c) is provided between the larger-diameter portion (12a) and the smaller-diameter portion (12b), and has its outer diameter gradually reduced.

[0104] The downstream end of the suction pipe (12) overlaps with the upstream side of the suction port (64) as viewed in the axial direction. In the example illustrated in FIG. 7, the suction pipe (12) is positioned to be coaxial with the suction port (64). The downstream end of the suction pipe (12) is located at an inner position relative to the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0105] Thus, there is a gap between the outer circumference of the downstream end of the suction pipe (12) (the outer circumference of the smaller-diameter portion (12b)) and the inner periphery of the upstream end of the suction port (64). The gap forms a ring-shaped opening as viewed in the axial direction. The suction port (64) communicates with the upper space (23) and the compression chamber (S) through the ring-shaped opening.

[0106] A refrigerant containing oil droplets (25) flows through the upper space (23). The refrigerant containing the oil droplets (25) and flowing through the upper space (23) is sucked through the ring-shaped opening into the suction port (64). In the example illustrated in FIG. 7, the suction pipe (12) is positioned to be coaxial with the suction port (64). However, the suction pipe (12) may be shifted slightly within a range that does not inhibit the flow of the refrigerant toward the suction port (64) through the opening.

[0107] As illustrated in FIG. 8, the compression chamber (S) is divided into outer chambers (S1) radially outward of the movable scroll (70), and inner chambers (S2) radially inward of the movable scroll (70). Specifically, when the inner circumferential surface of the outer circumferential wall (63) of the fixed scroll (60) and the outer circumferential surface of the movable-side wrap (72) of the movable scroll (70) substantially come into contact with each other, the outer chamber (S1) and the inner chambers (S2) become separate sections with the contact portion serving as a boundary.

[0108] As illustrated in FIG. 6, the fixed-side end plate (61) of the fixed scroll (60) has, at its center, an outlet (65). A high-pressure chamber (66) to which the outlet (65) is open is provided in the upper surface of the fixed-side end plate (61) of the fixed scroll (60). The high-pressure chamber (66) communicates with the lower space (24) via a path (not shown) formed through the fixed-side end plate (61) of the fixed scroll (60) and the housing (50). The high-pressure refrigerant compressed by the compression mechanism (40) flows out to the lower space (24).

[0109] An oil supply hole (16) is provided inside the drive shaft (11) so as to extend vertically from the lower end to the upper end of the drive shaft (11). A lower end portion of the drive shaft (11) is immersed in the oil reservoir (21). The oil supply hole (16) supplies the oil in the oil reservoir (21) to the lower bearing (22) and the upper bearing (51), and to the gap between the boss (73) and the drive shaft (11). The oil supply hole (16) is open to the upper end surface of the drive shaft (11) and supplies oil to above the drive shaft (11).

[0110] The concave portion (53) of the housing (50) communicates with the oil supply hole (16) of the drive shaft (11) via the inside of the boss (73) of the movable scroll (70). The high-pressure oil is supplied to the concave portion (53), so that a high pressure equivalent to the discharge pressure of the compression mechanism (40) acts on the concave portion (53). The movable scroll (70) is pressed onto the fixed scroll (60) by the high pressure that acts on the concave portion (53).

[0111] An oil path (55) is provided in the housing (50) and the fixed scroll (60). The oil path (55) has an inflow end that communicates with the concave portion (53) of the housing (50). The oil path (55) has an outflow end open to the facing surface of the fixed scroll (60). Through the oil path (55), the high-pressure oil in the concave portion (53) is supplied to the facing surfaces of the movable-side end plate (71) of the movable scroll (70) and the outer circumferential wall (63) of the fixed scroll (60).

[0112] As illustrated in FIG. 8, the facing surface of the outer circumferential wall (63) of the fixed scroll (60) has an oil supply groove (80). The oil supply groove (80) is formed in the facing surface, of the outer circumferential wall (63) of the fixed scroll (60), which faces the movable-side end plate (71) of the movable scroll (70). The oil supply groove (80) extends substantially in an arc shape along the inner circumferential surface of the outer circumferential wall (63) of the fixed scroll (60). The oil path (55) communicates with the oil supply groove (80), and oil is supplied to the oil supply groove (80) from the oil path (55).

[0113] The outer periphery of the fixed scroll (60) has a plurality of cutouts (68). The cutouts (68) communicate with the upper space (23). The oil supplied to the oil supply groove (80) flows through the cutouts (68) toward the upper space (23).

-Operation-

[0114] A basic operation of the scroll compressor (10) will be described. As illustrated in FIG. 6, when activated, the electric motor (30) rotatably drives the movable scroll (70) of the compression mechanism (40). Since the rotation of the movable scroll (70) is blocked by the Oldham coupling (46), the movable scroll (70) performs only the eccentric rotation about the axis of the drive shaft (11).

[0115] As illustrated in FIG. 8, when the movable scroll (70) rotates eccentrically, the compression chamber (S) is sectioned into the outer chamber (S1) and the inner chambers (S2). The plurality of inner chambers (S2) are formed between the fixed-side wrap (62) of the fixed scroll (60) and the movable-side wrap (72) of the movable scroll (70). As the movable scroll (70) rotates eccentrically, these inner chambers (S2) gradually come closer to the center (i.e., the outlet (65)) and the volumes of these inner chambers (S2) gradually decrease. The refrigerant is gradually compressed in the inner chambers (S2) in this manner.

[0116] When the inner chamber (S2) with the minimum volume communicates with the outlet (65), the high-pressure gas refrigerant in the inner chamber (S2) is discharged to the high-pressure chamber (66) via the outlet (65). The high-pressure gas refrigerant in the high-pressure chamber (66) flows out to the lower space (24) via the path formed in the fixed scroll (60) and the housing (50). The high-pressure gas refrigerant in the lower space (24) is discharged outside the casing (20) via the discharge pipe (13).

-Oil Supply Operation-

[0117] Next, an oil supply operation of the scroll compressor (10) will be described in detail with reference to FIGS. 6 to 8.

[0118] Once the high-pressure gas refrigerant flows out to the lower space (24) of the scroll compressor (10), the lower space (24) becomes a high-pressure atmosphere, and the pressure of the oil in the oil reservoir (21) increases. The high-pressure oil in the oil reservoir (21) flows upward through the oil supply hole (16) of the drive shaft (11) and flows out from the opening at the upper end of the eccentric portion (15) of the drive shaft (11) to the inside of the boss (73) of the movable scroll (70).

[0119] The oil supplied to the boss (73) is supplied to the gap between the eccentric portion (15) of the drive shaft (11) and the boss (73). Accordingly, the concave portion (53) of the housing (50) becomes a high-pressure atmosphere equivalent to the discharge pressure of the compression mechanism (40). The high pressure of the concave portion (53) presses the movable scroll (70) onto the fixed scroll (60).

[0120] The high-pressure oil accumulated in the concave portion (53) flows out through the oil path (55) to the oil supply groove (80). Accordingly, the high-pressure oil corresponding to the discharge pressure of the compression mechanism (40) is supplied to the oil supply groove (80). The oil in the oil supply groove (80) is used to lubricate the facing surfaces of the fixed scroll (60) and the movable scroll (70).

[0121] The oil supplied to the facing surface of the fixed scroll (60) flows radially outward when the movable scroll (70) rotates relative to the fixed scroll (60) and is discharged to the upper space (23) through the cutouts (68).

[0122] The refrigerant discharged to the upper space (23) and containing the oil droplets (25) collides with the outer periphery of the suction pipe (12). At this moment, the oil adheres to the outer circumferential surface of the suction pipe (12). The oil that has adhered to the larger-diameter portion (12a) of the suction pipe (12) flows along the inclined surface of the diameter-reducing portion (12c) and then smoothly along the smaller-diameter portion (12b).

[0123] As can be seen, even if the suction pipe (12) has the larger-diameter portion (12a) and the smaller-diameter portion (12b), the oil adhering to the outer circumferential surface of the suction pipe (12) can flow down smoothly due to the diameter-reducing portion (12c) connecting the larger-diameter portion (12a) and the smaller-diameter portion (12b) so as to be continuous with each other.

[0124] The oil that has flowed down along the outer circumferential surface of the suction pipe (12) passes through the gap between the suction pipe (12) and the suction port (64), and is supplied to the suction port (64). The oil sucked into the suction port (64) is distributed to the outer chamber (S1) located radially outward of the movable-side wrap (72) of the movable scroll (70) and the inner chamber (S2) located radially inward of the movable-side wrap (72) of the movable scroll (70) (see the arrows in FIG. 8). As a result, the oil sealing performances of the outer chamber (S1) and the inner chamber (S2) can improve.

- Advantages of Second Embodiment -

[0125] The scroll compressor (10) of the second embodiment includes the casing (20) to which the suction pipe (12) is connected, the fixed scroll (60) housed in the casing (20), and the movable scroll (70) that forms a compression chamber (S) with the fixed scroll (60). The casing (20) has therein an upper space (23) (internal space) through which a refrigerant containing oil flows; the fixed scroll (60) has a suction port (64) that communicates with the upper space (23) and the compression chamber (S); the suction pipe (12) has a larger-diameter portion (12a), a smaller-diameter portion (12b) provided downstream of the larger-diameter portion (12a), the smaller-diameter portion (12b) having an outer diameter smaller than an outer diameter of the larger-diameter portion (12a), and a diameter-reducing portion (12c) provided between the larger-diameter portion (12a) and the smaller-diameter portion (12b) and having an outer diameter gradually reduced; the smaller-diameter portion (12b) has a downstream end overlapping with an upstream end of the suction port (64) as viewed in an axial direction; and the outer diameter of the smaller-diameter portion (12b) is smaller than a diameter of the upstream end of the suction port (64).

[0126] In the second embodiment, the suction pipe (12) has the larger-diameter portion (12a), the smaller-diameter portion (12b), and the diameter-reducing portion (12c). The diameter-reducing portion (12c) is provided between the larger-diameter portion (12a) and the smaller-diameter portion (12b), and has its outer diameter gradually reduced. The outer diameter of the smaller-diameter portion (12b) is smaller than the inner diameter of the upstream end of the suction port (64). The oil flowing through the internal space (23) flows into the suction port (64) through the gap between the smaller-diameter portion (12b) of the suction pipe (12) and the suction port (64).

[0127] Accordingly, oil can be supplied to the spaces in the compression chamber (S) which are located radially inward and outward of the movable scroll (70).

[0128] Specifically, the oil supplied to the facing surface of the fixed scroll (60) flows radially outward when the movable scroll (70) rotates relative to the fixed scroll (60) and is discharged to the upper space (23) through the cutouts (68).

[0129] The refrigerant discharged to the upper space (23) and containing the oil droplets (25) is supplied to the suction port (64) through the gap between the suction pipe (12) and the suction port (64). Thereafter, oil is distributed to the spaces in the compression chamber (S) which are located radially inward and outward of the movable scroll (70). As a result, the oil sealing performances of the inner and outer spaces can improve.

[0130] Further, the oil adhering to the outer circumferential surface of the suction pipe (12) can flow smoothly from the smaller-diameter portion (12b) to the suction port (64) due to the diameter-reducing portion (12c) connecting the larger-diameter portion (12a) and the smaller-diameter portion (12b) so as to be continuous with each other.

[0131] Specifically, without the diameter-reducing portion (12c) in the suction pipe (12), the oil flowing along the outer circumferential surface of the larger-diameter portion (12a) falls straight down from a step between the larger-diameter portion (12a) and the smaller-diameter portion (12b). In this case, the oil does not flow from the larger-diameter portion (12a) toward the smaller-diameter portion (12b) and fails to flow into the suction port (64) from the smaller-diameter portion (12b).

[0132] In contrast, in this embodiment, the oil flowing along the outer circumferential surface of the larger-diameter portion (12a) can flow smoothly to the smaller-diameter portion (12b) from the diameter-reducing portion (12c).

- First Variation of Second Embodiment -

[0133] In the following description, the same reference characters designate the same components as those of the second embodiment, and the description is focused only on the difference.

[0134] As illustrated in FIG. 9, the suction pipe (12) has a larger-diameter portion (12a), a smaller-diameter portion (12b), and a diameter-reducing portion (12c). The smaller-diameter portion (12b) is provided downstream of the larger-diameter portion (12a), and has an outer diameter smaller than that of the larger-diameter portion (12a). The outer diameter of the smaller-diameter portion (12b) is smaller than the inner diameter of the suction port (64). The diameter-reducing portion (12c) is provided between the larger-diameter portion (12a) and the smaller-diameter portion (12b), and has its outer diameter gradually reduced.

[0135] The downstream end of the suction pipe (12) overlaps with the upstream side of the suction port (64) as viewed in the axial direction. The downstream end of the suction pipe (12) is flush with an open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0136] Thus, there is a gap between the outer circumference of the downstream end of the suction pipe (12) (the outer circumference of the smaller-diameter portion (12b)) and the inner periphery of the upstream end of the suction port (64). The gap forms a ring-shaped opening as viewed in the axial direction. The refrigerant flowing through the upper space (23) and containing oil droplets (25) is sucked into the suction port (64) through the gap between the suction pipe (12) and the suction port (64).

- Advantages of First Variation -

[0137] The scroll compressor (10) of the first variation is configured such that the downstream end of the suction pipe (12) is positioned to be flush with the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0138] In the first variation, the downstream end of the suction pipe (12) is positioned to be flush with the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0139] Thus, the oil flowing through the upper space (23) can easily flow into the suction port (64) through the gap between the downstream end of the suction pipe (12) and the open surface (60a). In other words, the suction effect of a dynamic pressure increases, and the thus efficiency increases, as compared to the case in which the downstream end of the suction pipe (12) is located inside the suction port (64).

- Second Variation of Second Embodiment -

[0140] As illustrated in FIG. 10, the suction pipe (12) has a larger-diameter portion (12a), a smaller-diameter portion (12b), and a diameter-reducing portion (12c). The smaller-diameter portion (12b) is provided downstream of the larger-diameter portion (12a), and has an outer diameter smaller than that of the larger-diameter portion (12a). The outer diameter of the smaller-diameter portion (12b) is smaller than the inner diameter of the suction port (64). The diameter-reducing portion (12c) is provided between the larger-diameter portion (12a) and the smaller-diameter portion (12b), and has its outer diameter gradually reduced.

[0141] The downstream end of the suction pipe (12) overlaps with the upstream side of the suction port (64) as viewed in the axial direction. The downstream end of the suction pipe (12) is located at an outer position in an axial direction, away from the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0142] Thus, there is a gap between the outer circumference of the downstream end of the suction pipe (12) (the outer circumference of the smaller-diameter portion (12b)) and the inner periphery of the upstream end of the suction port (64). The gap forms a ring-shaped opening as viewed in the axial direction. A predetermined gap is formed between the downstream end of the suction pipe (12) and the open surface (60a). The refrigerant flowing through the upper space (23) and containing oil droplets (25) is sucked into the suction port (64) through the gap between the suction pipe (12) and the suction port (64).

- Advantages of Second Variation -

[0143] The scroll compressor (10) of the second variation is configured such that the downstream end of the suction pipe (12) is located at an outer position in the axial direction, away from the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0144] In the second variation, the downstream end of the suction pipe (12) is located at an outer position in the axial direction, away from the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0145] Thus, the oil flowing through the upper space (23) can easily flow into the suction port (64) through the gap between the downstream end of the suction pipe (12) and the open surface (60a). In other words, the suction effect of a dynamic pressure increases, and the thus efficiency increases, as compared to the case in which the lower end of the suction pipe (12) is located inside the suction port (64).

[0146] In this second variation, similarly to the above-described variation of the first embodiment, the gap H between the downstream end of the suction pipe (12) and the open surface (60a) and the inner diameter D of the suction pipe (12) are determined to satisfy the condition of $0 \leq H/D \leq 0.3$ in one preferred embodiment (see FIG. 5).

[0147] This allows the oil flowing through the internal space (23) to flow into the suction port (64) efficiently, thus improving the efficiency of the compressor.

«Third Embodiment»

[0148] A third embodiment will be described.

[0149] As illustrated in FIG. 11, the suction pipe (12) has a larger-diameter portion (12a), a smaller-diameter portion (12b), and a diameter-reducing portion (12c). The smaller-diameter portion (12b) is provided downstream of the larger-diameter portion (12a), and has an outer diameter smaller than that of the larger-diameter portion (12a). The outer diameter of the smaller-diameter portion (12b) is smaller than the inner diameter of the suction port (64). The diameter-reducing portion (12c) is provided between the larger-diameter portion (12a) and the smaller-diameter portion (12b), and has its outer diameter gradually reduced.

[0150] The downstream end of the suction pipe (12) overlaps with the upstream side of the suction port (64) as viewed in the axial direction. The downstream end of the suction pipe (12) is located at an inner position relative to the open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

[0151] A tapered portion (64a) is formed in the fixed scroll (60) around a peripheral portion on the upstream side of the suction port (64). The tapered portion (64a) gradually widens toward the upstream side of the suction port (64).

- Advantages of Third Embodiment -

[0152] The scroll compressor (10) of the third embodiment is configured such that a tapered portion (64a) is formed in the fixed scroll (60) around a peripheral portion on the upstream side of the suction port (64).

[0153] In the third embodiment, the width of the opening of the suction port (64) is greater toward the upstream side due to the tapered portion (64a). This configuration allows the oil to flow easily along the tapered portion (64a) and efficiently into the suction port (64).

<<Other Embodiments»

[0154] The embodiments described above may be modified as follows.

[0155] In the third embodiment, the downstream end of the suction pipe (12) is located inside the suction port (64) in the configuration in which the tapered portion (64a) is formed around the peripheral portion of the suction port (64). However, the embodiment is not limited thereto.

[0156] For example, as in the first variation, the downstream end of the suction pipe (12) may be positioned to be flush with the open surface (60a) of the suction port (64) in the configuration in which the tapered portion (64a) is formed around the peripheral portion of the suction port (64). Alternatively, as in the second variation, the downstream end of the suction pipe (12) may be located at an outer position in the axial direction, away from the open surface (60a) where the suction port (64) opens.

[0157] While the embodiment and variations have been described above, it will be understood that various changes in form and details can be made without departing from the spirit and scope of the claims. The above embodiment and variations may be appropriately combined or replaced as long as the functions of the target of the present disclosure are not impaired.

INDUSTRIAL APPLICABILITY

[0158] As described above, the present disclosure is useful for a scroll compressor.

DESCRIPTION OF REFERENCE CHARACTERS

[0159]

10	Scroll Compressor
12	Suction Pipe
12a	Larger-Diameter Portion
12b	Smaller-Diameter Portion
12c	Diameter-Reducing Portion
20	Casing
23	Upper Space (Internal Space)
60	Fixed Scroll
60a	Open Surface
64	Suction Port
64a	Tapered Portion
70	Movable Scroll

Claims

1. A scroll compressor comprising: a casing (20) to which a suction pipe (12) is connected; a fixed scroll (60) housed in the casing (20); and a movable scroll (70) that forms a compression chamber (S) with the fixed scroll (60),

    the casing (20) having therein an internal space (23) through which a refrigerant containing oil flows,
    the fixed scroll (60) having a suction port (64) that communicates with the internal space (23) and the compression chamber (S),
    the suction pipe (12) having a larger-diameter portion (12a) and a smaller-diameter portion (12b) provided downstream of the larger-diameter portion (12a), the smaller-diameter portion (12b) having an outer diameter smaller than an outer diameter of the larger-diameter portion (12b),
    the smaller-diameter portion (12b) having a downstream end overlapping with an upstream end of the suction port (64) as viewed in an axial direction, and
    the outer diameter of the smaller-diameter portion (12b) being smaller than a diameter of the upstream end of the suction port (64).

2. The scroll compressor of claim 1, wherein
    the suction pipe (12) has a diameter-reducing portion (12c) provided between the larger-diameter portion (12a) and the smaller-diameter portion (12b) and having an outer diameter gradually reduced.

3. The scroll compressor of claim 1 or 2, wherein
    a tapered portion (64a) is formed in the fixed scroll (60) around a peripheral portion on an upstream side of the suction port (64).

4. The scroll compressor of any one of claims 1 to 3, wherein
    a downstream end of the suction pipe (12) is flush with an open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

5. The scroll compressor of any one of claims 1 to 3, wherein
    a downstream end of the suction pipe (12) is located at an outer position in the axial direction, away from

an open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

6. The scroll compressor of claim 5, wherein the following condition is satisfied:

$$0 \leq H/D \leq 0.3$$

where H represents a gap between the downstream end of the suction pipe (12) and the open surface (60), and D represents an inner diameter of the suction pipe (12).

7. The scroll compressor of any one of claims 1 to 3, wherein
a downstream end of the suction pipe (12) is located at an inner position in an axial direction relative to an open surface (60a) of the fixed scroll (60) where the suction port (64) opens.

FIG.1

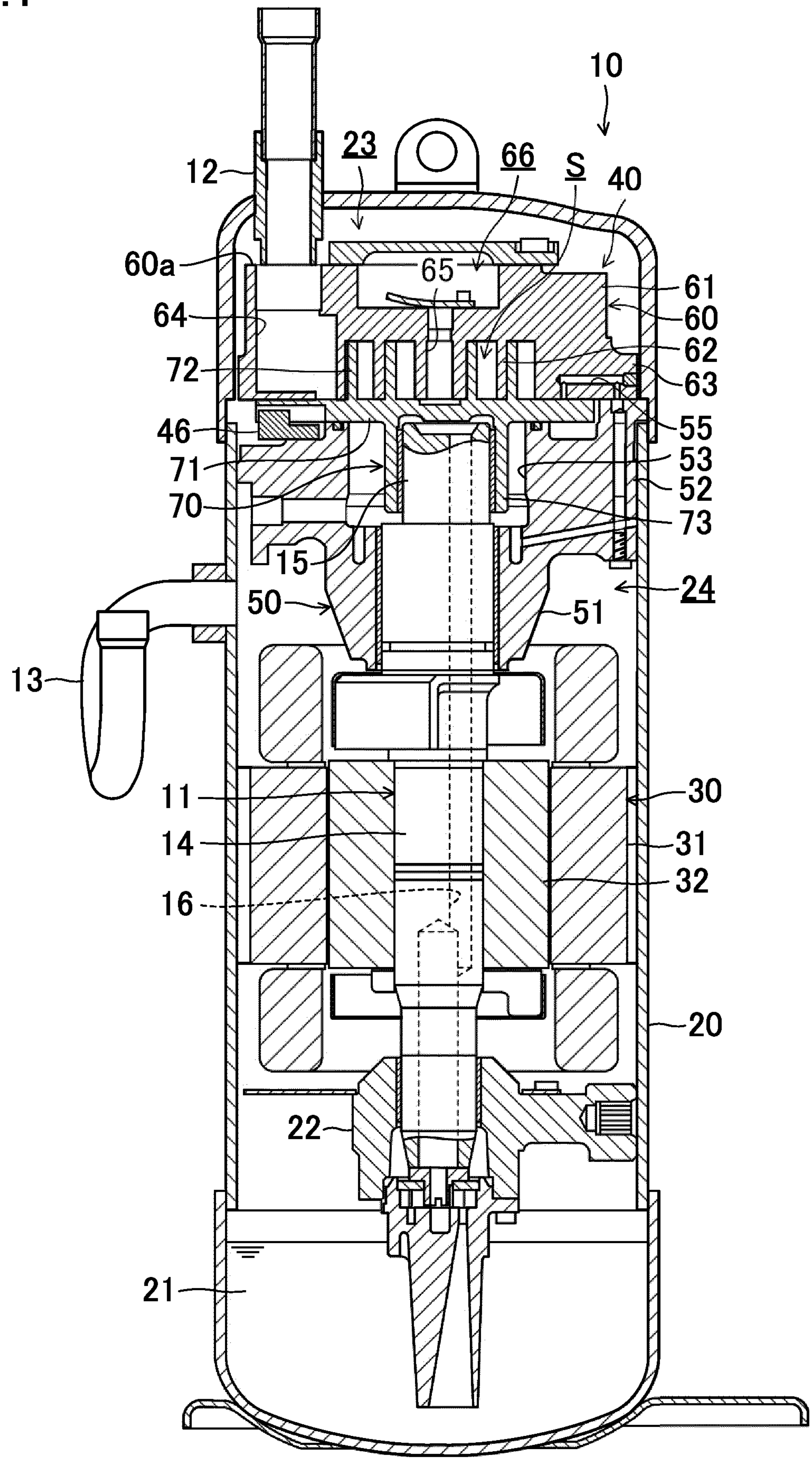

10
23
66
S
40
12
65
60a
61
60
64
62
72
63
55
46
53
71
52
70
73
15
24
50
51
13
11
30
14
31
32
16
20
22
21

FIG.2

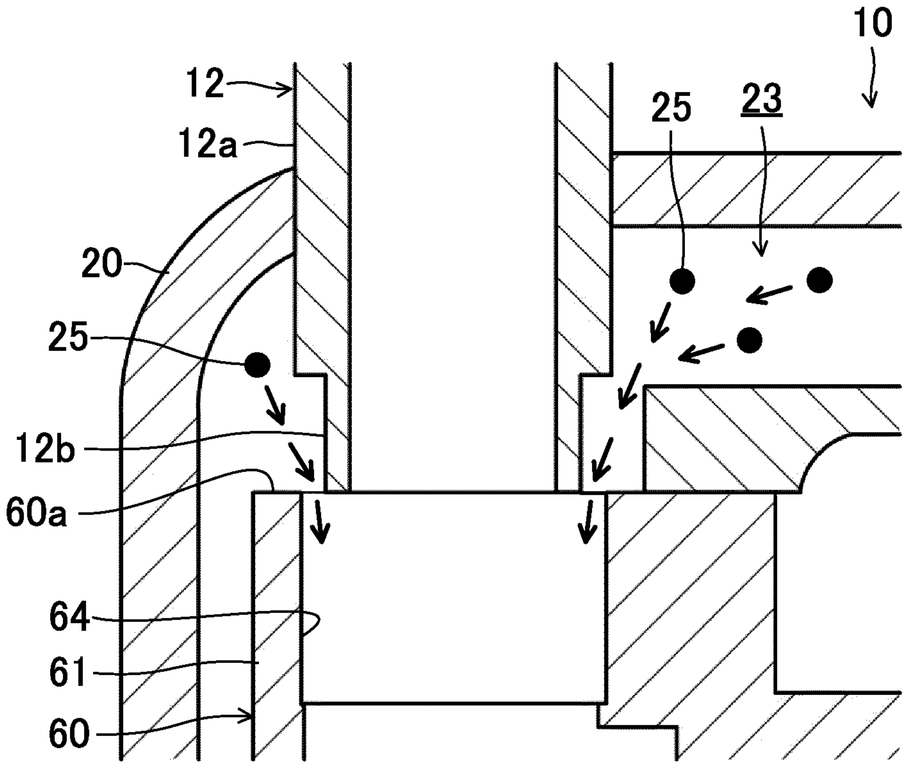


FIG.3

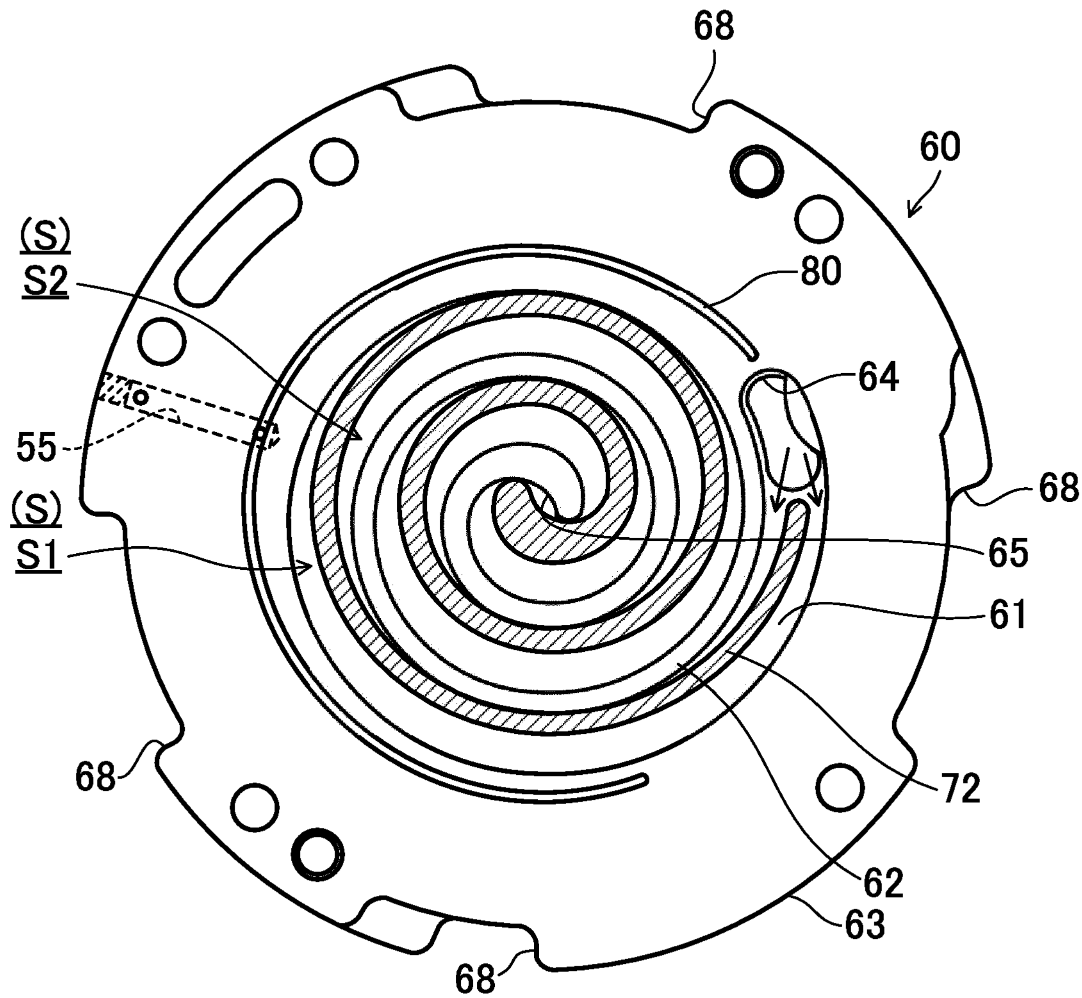


FIG.4

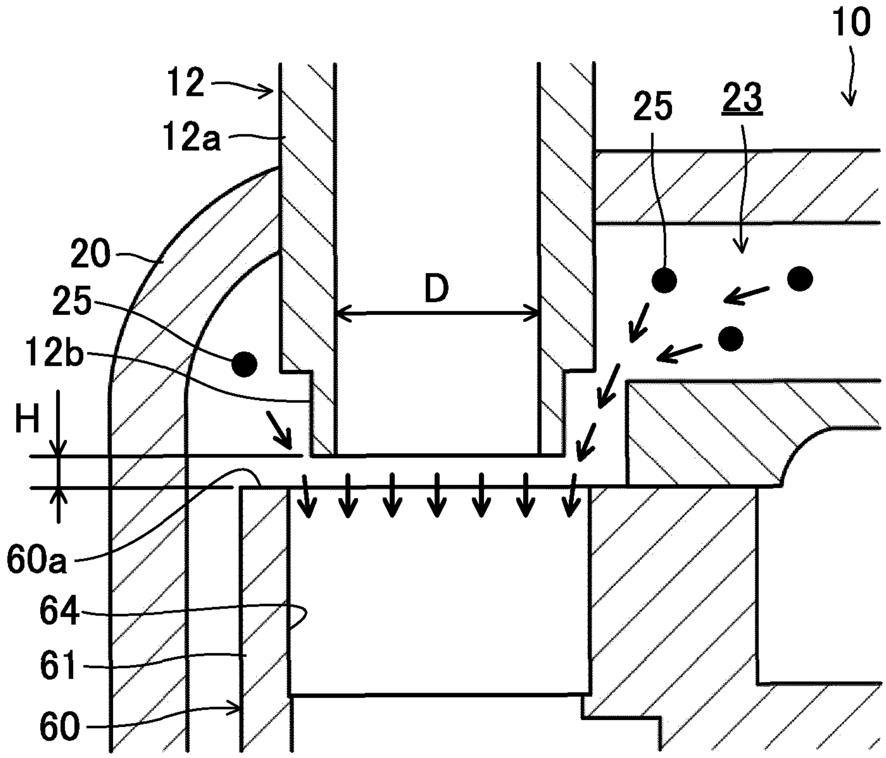

10
12
12a
25
23
20
25
D
12b
H
60a
64
61
60

FIG.5

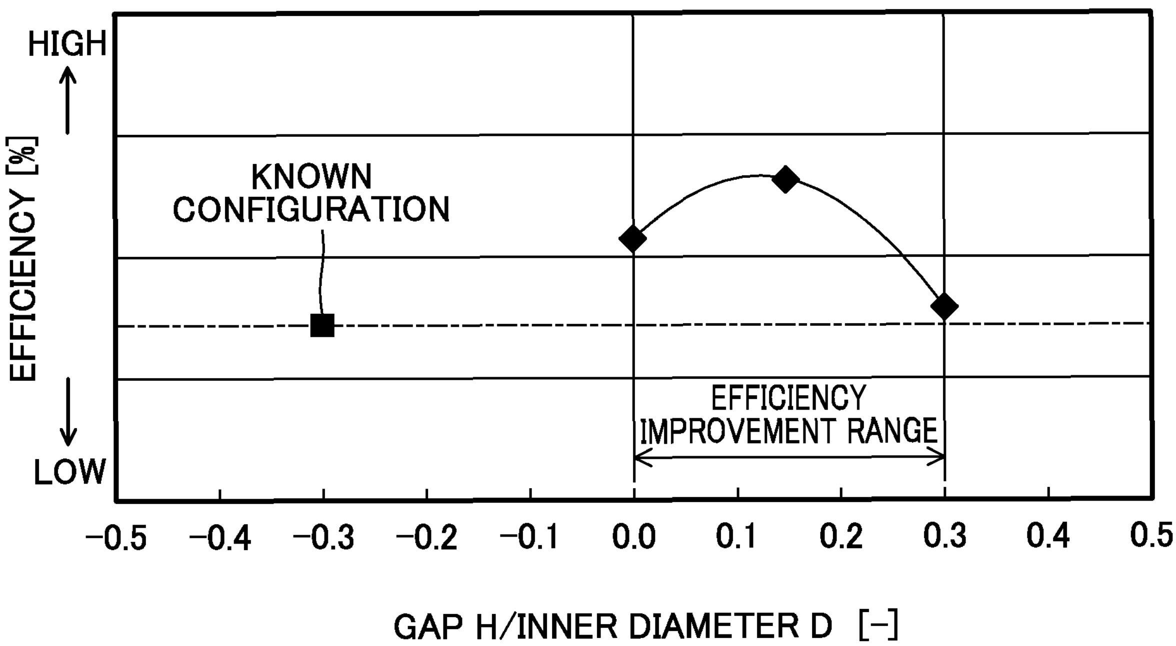

HIGH
EFFICIENCY [%]
LOW
KNOWN
CONFIGURATION
EFFICIENCY
IMPROVEMENT RANGE
−0.5
−0.4
−0.3
−0.2
−0.1
0.0
0.1
0.2
0.3
0.4
0.5
GAP H/INNER DIAMETER D [−]

FIG.6

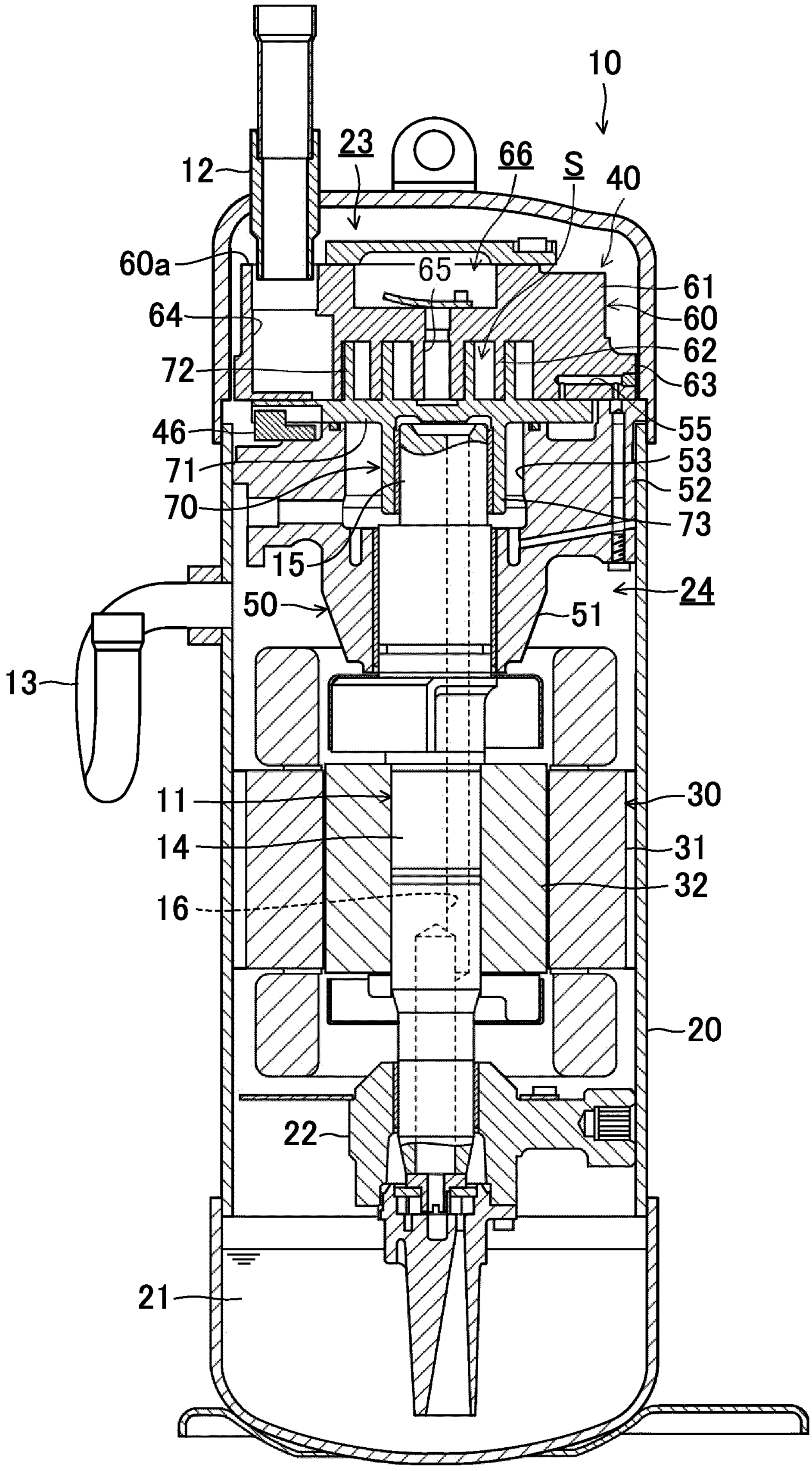

10
23
66
S
40
12
60a
65
61
60
64
62
72
63
46
55
71
53
52
70
73
15
24
50
51
13
11
30
14
31
16
32
20
22
21

FIG.7

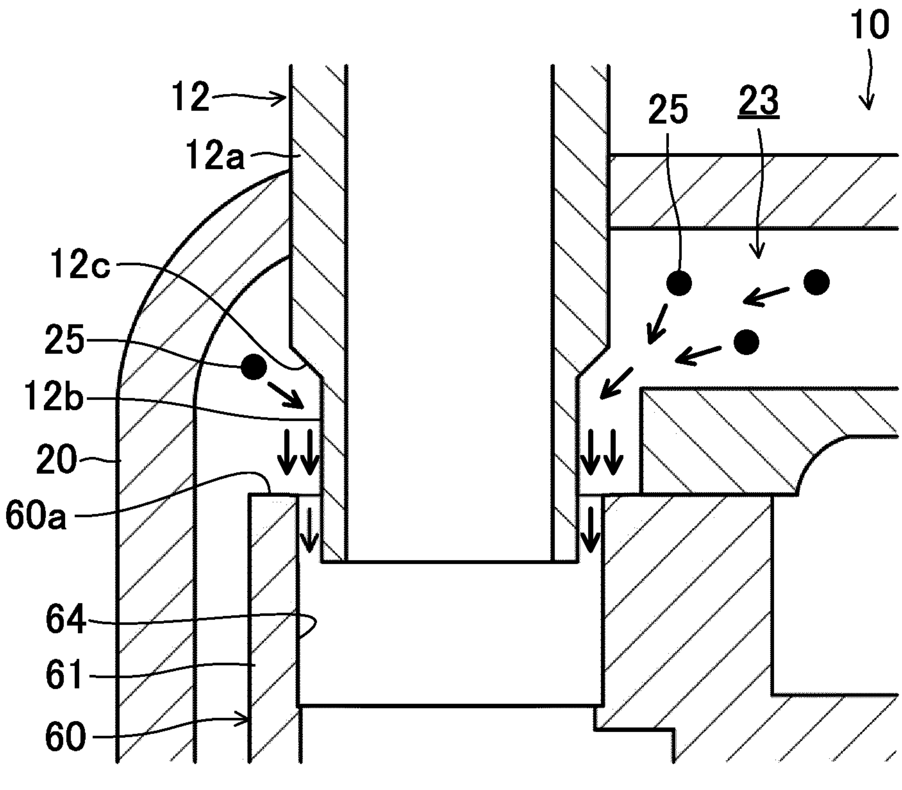


FIG.8

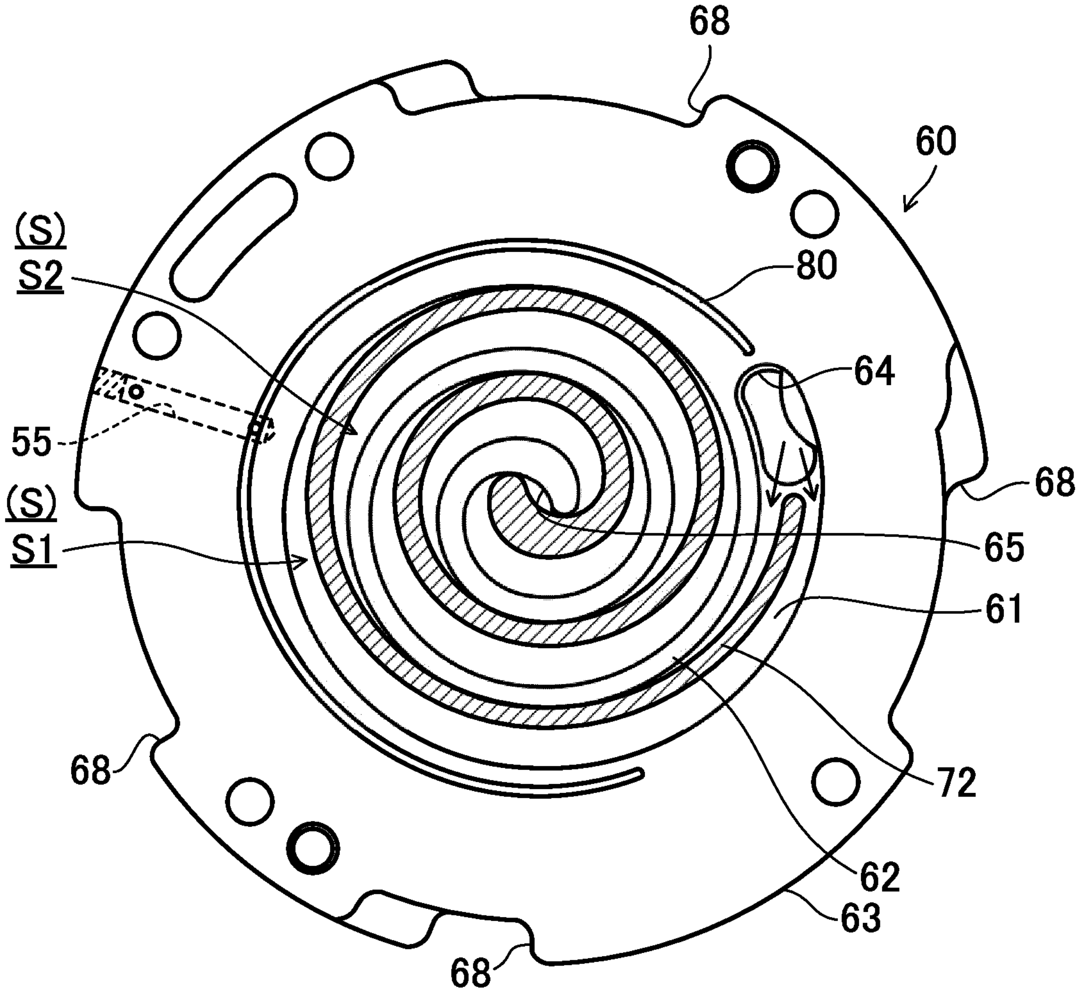


FIG.9

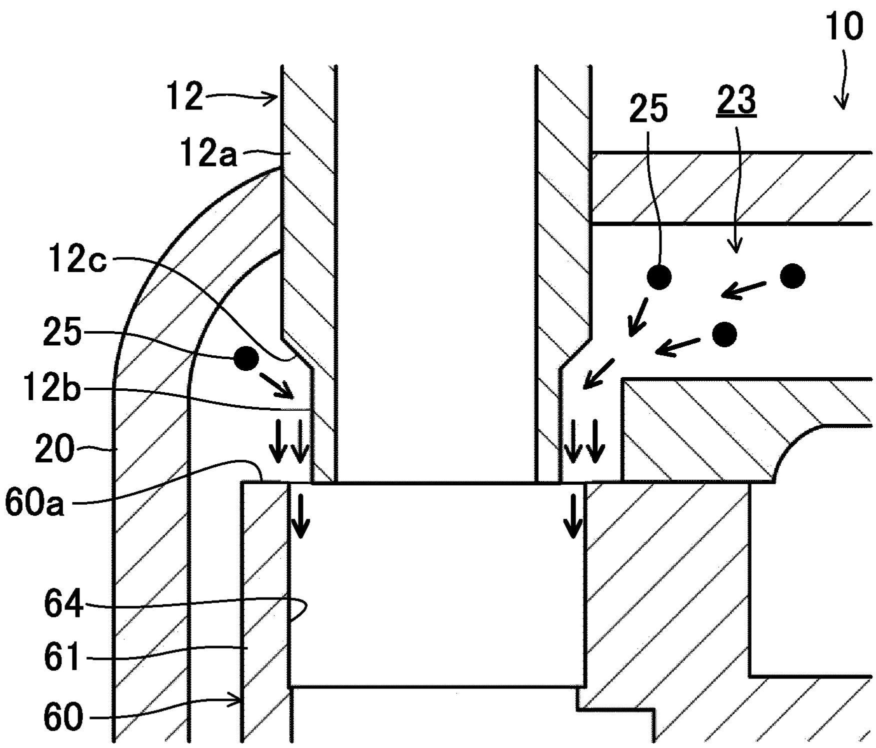

10
12
12a
25
23
12c
25
12b
20
60a
64
61
60

FIG.10

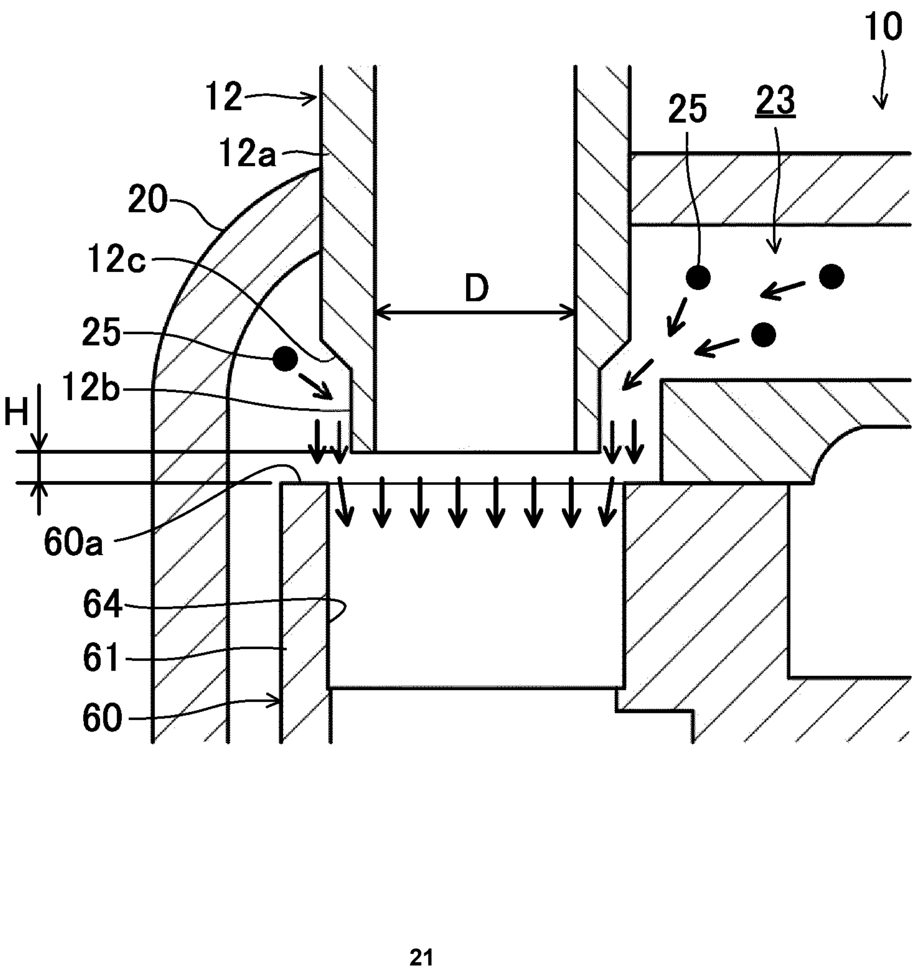
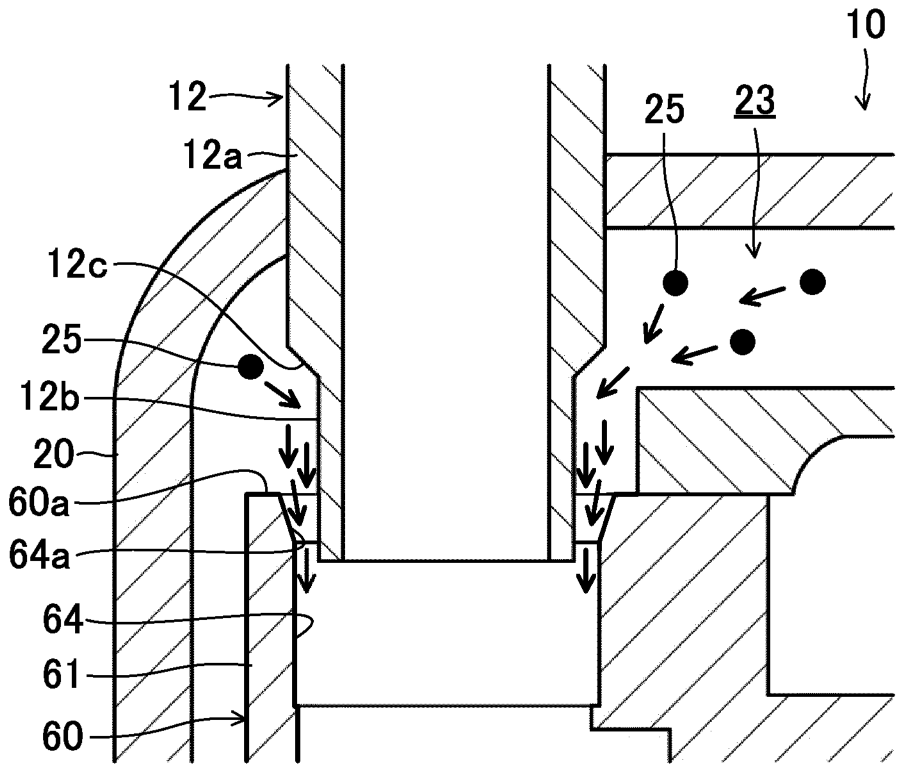

10
12
12a
25
23
20
12c
D
25
12b
H
60a
64
61
60

FIG.11



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2020/024527

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F04C29/12(2006.01)i, F04C18/02(2006.01)i
FI: F04C29/12A, F04C18/02311P

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. F04C29/12, F04C18/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2001-165069 A (DAIKIN INDUSTRIES, LTD.) 19.06.2001 (2001-06-19), paragraph [0061], fig. 1, 2	1, 7 2-6
Y	JP 4-228895 A (DAIKIN INDUSTRIES, LTD.) 18.08.1992 (1992-08-18), fig. 3, 4	2-6
A	JP 2008-31920 A (DAIKIN INDUSTRIES, LTD.) 14.02.2008 (2008-02-14), paragraph [0089], fig. 1, 2	1-7
A	JP 2015-36514 A (DAIKIN INDUSTRIES, LTD.) 23.02.2015 (2015-02-23), fig. 1-4	1-7
A	JP 6-330867 A (DAIKIN INDUSTRIES, LTD.) 29.11.1994 (1994-11-29), fig. 4	1-7

☒ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

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Date of the actual completion of the international search 19.08.2020	Date of mailing of the international search report 08.09.2020
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/024527

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 64-63678 A (TOSHIBA CORPORATION) 09.03.1989 (1989-03-09), fig. 1, 2	1-7
A	JP 2013-221485 A (DAIKIN INDUSTRIES, LTD.) 28.10.2013 (2013-10-28), paragraphs [0068], [0069], fig. 1-3	1-7
A	JP 2017-89504 A (DAIKIN INDUSTRIES, LTD.) 25.05.2017 (2017-05-25) fig. 16	1-7

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/024527

JP 2001-165069 A	19.06.2001	US 6607367 B1 column 8, lines 31-41, fig. 1, 2 WO 2001/042658 A1 EP 1158166 A1 EP 2055957 A1 CN 1339088 A KR 10-2001-0093314 A
JP 4-228895 A	18.08.1992	(Family: none)
JP 2008-31920 A	14.02.2008	(Family: none)
JP 2015-36514 A	23.02.2015	(Family: none)
JP 6-330867 A	29.11.1994	(Family: none)
JP 64-63678 A	09.03.1989	(Family: none)
JP 2013-221485 A	28.10.2013	(Family: none)
JP 2017-89504 A	25.05.2017	US 2018/0298900 A1 fig. 16 WO 2017/081845 A1 EP 3339647 A1 CN 108138779 A

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2016160816 A **[0003]**