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ROTARY TYPE FLUID MACHINE

The present invention relates generally to a rotary machine, and more specifically to a rotary type fluid machine such as a compressor, a pump, ~~an expander~~, etc.

(ii) Description of the Prior Art

The typical construction of a scroll-type compressor, for example, generally known in art of the fluid compressor machine as shown in FIG. 1, a schematic view showing generally the principle of operation, is such that there are provided two spiral elements having the same sectional shape, one spiral element 2 being fixed in position onto the surface of a sealing end plate shown having a central delivery opening 4, the other element 1 fixed in position upon the surface of the opposite end plate. Stating further to this construction, these two elements are rotated relatively 180 degrees with each other and are shifted in relative location by a distance $2p$ ($=$ the pitch of a spiral pattern $-2 \times$ thickness of a spiral element plate) so as to be nested with each other in such a manner as typically shown in the drawing figure that they may be located in their relative position to come mutually in contact at four points 51, 52 and 51', 52'. In this construction, it is further noted such that one spiral element 2 is disposed stationary in position, and the other element 1

is arranged to move in revolution or in solar orbital motion with a radius of $\rho = 00'$ about the center 0 of the spiral element 2, without moving in rotation or in planetary motion on its own axis, by using a crank mechanism having a radius ρ .

With such construction, there are defined small chamber or spaces 3, 3 being tightly closed between the abutting points 51, 52 and 51', 52' of the spiral elements 1, 2, respectively, the volumes of which chambers 3, 3 vary gradually with the revolving or solar motion of the spiral element 1.

Reviewing more specifically, it is notable that when the spiral element 1 is firstly caused to be revolved 90 degrees starting with the state shown in FIG. 1 (A), it turns now over to the position as shown in FIG. 1 (B), when it is revolved 180 degrees, then it turns to be the state as shown in FIG. 1 (C), and when it is further revolved 270 degrees, it turns then to be the state as shown in FIG. 1 (D). As the spiral element 1 moves in revolution, the volume of the small chambers 3, 3 decrease gradually, and eventually, these chambers come to intercommunicate with each other and merge into one tightly closed small chamber 53. Now, when it moves further in revolution 90 degrees from the state shown in FIG. 1 (D), it turns back to the state of position shown in FIG. 1 (A), and the small

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chamber 53 would then be reduced in its volume as it turns from the state shown in FIG. 1 (B) to that shown in FIG. 1 (C), and eventually, it would exhibit to be a smallest volume intermediate the states shown in FIGS. 1(C) and (D).

5 During this stage of motion, outer spaces beginning to be opened as seen in FIG. 1 (B) get grown to be greater as the element 1 turns from the state of FIG. 1 (C) through the state of FIG. 1 (D) to the state of FIG. 1 (A), thus taking another volume of a gas into the tightly closed
10 small chamber to be eventually defined together from these outer spaces, and then repeating this cycle of revolution so that the gas taken into the outer spaces of the spiral elements may accordingly be compressed, thus being delivered out of the delivery opening 4.

15 The foregoing description is directed to the principle of operation of the scroll-type compressor, and now, referring more in practice to the construction of this scroll-type compressor by way of FIG. 2 showing in longitudinal cross-section the general construction of the
20 compressor, it is seen that a housing 10 is comprised of a front end plate 11, a rear end plate 12 and a cylinder plate 13. The rear end plate 12 is provided with an intake port 14 and a delivery port 15 extending outwardly therefrom, and further mounted securely with a stationary scroll
25 member 25, comprised of a spiral or helical fin 252 and



a disc 251. The front end plate 11 is adapted to pivotally mount a spindle 17 having a crank pin 23. As typically shown in FIG. 3 which is a transversal cross-sectional view taken along the plate defined by the line III-III in FIG. 2, in corporative relationship with the crank pin 23 there is provided a movable scroll member 24 including a spiral element 242 and a disc 241, through a non-rotary or stationary mechanism, which comprises a radial needle bearing 26, a boss 243 of the movable scroll member 24, a square sleeve member 271, a slider element 291, a ring member 292 and a stopper lug 293.

On the other hand, there are provided such members as a radial needle bearing 16 for the shaft 17, a movable thrust plate 27 formed integrally with a square sleeve member 271, a backing plate 21, and thrust bearings 20 and 22, which are adapted all together to receive and stop a thrust to be rendered thereupon during the operation.

According to the general construction of this type compressor, however, there is adopted the non-rotary mechanism of the so-called Scotch yoke type, and this mechanism would inevitably bring such drawbacks noted as follows.

They are:

- (1) There are relatively many components incorporated.
- (2) There is the essential requirement that the gaps

existing between the sliding engagement elements be worked to a high precision, which would bring a greater cost burden in the manufacture of the fluid machine.

(3) When the gaps fail in meeting the high precision requirement, there would possibly occur tapping noises in the engagement between the sliding elements, thereby producing abnormal noises of the entire machine, under which condition there would very possibly bring the risks of abnormal wears of the sliding elements, thus eventually cutting the service life of the machine substantially shorter.

In coping with these drawbacks particular to the conventional rotary fluid machines incorporating the non-rotary mechanism as raised above, the present inventors have previously proposed the provision of the rotary type fluid machine construction which omitted the non-rotary type mechanisms by way of the Japanese Patent Applications Nos. 205,413/1982; 149,092/1982 (publication Nos. 96493/1984 and 39987/1984); and the Japanese Utility Model Application No. 130,551/1982.

Referring firstly to the Japanese Patent Application No. 205,413/1982, the general construction is of such as shown schematically in FIG. 4 that one spiral element (stationary spiral element) 500 is located securely to a sealing end plate having a generally central delivery port (not shown), and the other spiral element (movable spiral

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element) 501 is placed fixedly against an opposite end plate in such a relationship that they may come mutually in contact with each other abutting at points 502, 503 and 502', 503', respectively, when installed together.

5 Reviewing further in detail, these spiral elements are operatively arranged in such a manner that while maintaining constant a distance " l " between the center p' of the driving pin (not shown) adapted to generate the revolutionary motion of the movable spiral element 501 with the radius of motion of ρ and a point p of reciprocating motion along an arc qq' having a radius r , the movable spiral element 501 is caused to be moved in revolutionary motion about the center O' of the drive shaft with a radius of revolution ρ (the distance across the drive shaft center O' and the driving pin center p').

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15 More specifically, the revolutionary motion of these spiral elements is defined in such a relationship that the point p' may move in rotating motion along the circle having the radius ρ , and the point p moves in reciprocating motion along the arc qq' having the radius r around the point O'' , while maintaining the relationship of $pp' = l$.

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 With such structural arrangement, there are defined small tightly closed spaces or chambers 504, 504' between the points of contact 502, 503 and 502', 503' where these two spiral elements 500, 501 meet in contact with each other, and it is seen that these small closed chambers 504,

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504' reduce gradually in continuation in their volumes, as the movable spiral element 501 moves in revolution during the operation of the rotary machine.

Now, when the movable spiral element 501 is started in
5 revolutionary motion 45 degrees apart from the position shown in FIG. 4(A), it will turn to the position as shown in FIG. 4(B); when it is moved in revolution 90 degrees further, it will then turn to the position as shown in FIG. 4(C) and so on, then with its eventual revolutionary
10 motion by 315 degrees reaching the position shown in FIG. 4(H).

During this cycle of revolutionary motion of the movable spiral element 501, it is noted that the small chambers 504, 504' will gradually grow smaller, and with
15 a further revolutionary motion of the element 501 by 45 degrees from the position shown in FIG. 4(H), it will again turn back to the position shown in FIG. 4(A), and the small chambers 504, 504' will turn to be similar small chambers 505, 505', whereupon these two small chambers 505,
20 505' will now come to be in communication with each other.

With a further cycle of revolutionary motion of the element 501, it will follow the same patterns of positioning from FIG. 4(A) through FIG. 4(B) and so on, and at the moment that the element 501 reaches the position shown
25 in FIG. 4(H), the small chambers reduce in their volumes

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to a minimum. Along with such a cycle of positional shift of the element 501, the outer spaces defined between the outer extensions of the two elements 500, 501 will grow greater from the point to start opening at the position shown in FIG. 4 (A), passing through the positions of FIG. 4 (B) through FIG. 4 (C) and so on to the end of cycle shown in FIG. 4 (H), and at the beginning of a subsequent cycle of revolutionary motion shown in FIG. 4 (A), there is captured another body of gas by a pair of small chambers defined over again. With the subsequent cycles of revolutionary motion of the element 501, a body of gas taken from the outer openings defined between the outer extensions of the two elements is to be compressed by the continuously reducing volumes of the small chambers, finally being delivered outwardly from a delivery opening (not shown) disposed generally at the center of the stationary spiral element 500.

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A practical example of a conventional scroll type fluid machine is shown in FIG. 5. A movable spiral member or scroll member 101 is shown having a disc portion 101b and a spiral 101a. Also shown is a stationary spiral member or scroll member 102, having a disc portion 102b and a spiral element 102a. It is seen that the spiral elements of the movable and stationary scroll members 101, 102 are nested in an opposed relationship with each other, thus forming a fluid pocket 103 therebetween. The stationary scroll member 102 is fixed securely to a frame 106, and the movable scroll member 101 is interlocked with a crank portion 107a of a crank shaft 107 through a bearing 106b, and also with the frame 106 by way of a rotation preventing mechanism 108 comprising an Oldam's coupling. The crank shaft 107 is rotated by a motor 109, and the movable scroll member 101 is caused to move in orbital (solar) motion with a radius of crank p while being prevented from planetary motion (rotation) by the mechanism 108, and concurrently, sucking the fluid into the fluid pocket 103 so as to have it compressed and then directed to a delivery opening 104 provided in the disc portion 102b of the stationary scroll member 102.

According to this construction of the scroll type fluid machine, if the origin or center of the movable

scroll member 101 does not move in constant revolutionary motion with the radius of crank p around the origin or center O of the stationary scroll member 102, while maintaining the proper relative relationship of the spiral configuration with respect to the stationary scroll member 102, the spiral elements 102a, 101a of the stationary scroll member 102 and the movable scroll member 101 would occasionally engage, or be spaced too far apart, thus allowing the fluid to escape from the pocket 103, with the eventual reduction in the performance of the scroll type fluid machine.

In the conventional arrangement, as noted above, an Oldam's coupling is used as the rotation preventing mechanism 108, and with such a construction, typically shown in FIG. ⁶~~5~~, one key 108b of the Oldam ring 108a slides freely in the keyway of the movable scroll member 101, and the other key 108c slides freely in the keyway of the frame 106, respectively. In addition, as the stationary scroll member 102 is fixed to the frame 106, the relative relationship of spiral configurations of the movable scroll member 101 and the stationary scroll member 102 may duly be determined with respect to the frame 106.

As a consequence, in order to attain a proper relative relationship of spiral configuration between the movable scroll member 101 and the stationary scroll member 102, it is essential to predetermine the relative

relationship in the spiral configurations between the frame 106 and the stationary scroll member 102. A positioning pin could for example be provided between these two, but this was expensive. It is generally difficult to set the two scroll members 101,102 precisely, and often poor setting results in a reduction of performance of the fluid machine.

The Invention

The present invention provides rotary type fluid machines as set forth in Claim 1 or 9. The remaining Claims set forth optional features of the invention.

The present invention can solve the problems discussed above, and can provide ready setting of the relationship between the spiral elements, the setting being efficiently and permanently effected. This can improve the performance of the machine and substantially reduce production costs.

Due to the invention, the previously required precise setting of the relative positions of the scroll members with respect to the front end plate, the housing, etc. is no longer required, which reduces costs. As the relationship between the spiral elements is determined by the construction of the spiral elements per se and by the rotation preventing mechanism (the limit means) incorporated between the movable and stationary members, the positioning is precise and there is no risk of leakage from the gap defined between the



spiral elements, substantially improving the performance of the machine, and more particularly avoiding reduction in performance.

The Drawings

The prior art and the invention are particularly described with reference to the accompanying drawings, the invention being described purely by way of example. In the drawings:

FIG. 1 is a series of schematic views showing the principle of operation of a known scroll-type compressor;

FIG. 2 is a longitudinal cross-sectional view showing the general construction of the known scroll-type compressor;

FIG. 3 is a transversal cross-sectional view taken along the line III-III in FIG. 2;

FIG. 4 is a series of schematic views showing the principle of operation of the rotary-type fluid machine disclosed in Japanese Patent Application No. 205,413/1982;

FIG. 5 is a longitudinal cross-sectional view showing the general construction of a known scroll-type compressor;

FIG. 6 is an enlarged top plan view showing in detail the rotation preventing mechanism of the scroll-type compressor shown in FIG. 5;

FIGS. 7 to 9 are schematic views showing the construction of a first embodiment of the present

invention, in which FIG. 7 is a fragmentary longitudinal cross-sectional view, FIG. 8 is a fragmentary perspective view showing a cross-type key according to the present invention, and FIGS. 9 (A) and (B) are plan views showing the configuration of keyways formed in the movable and stationary scroll members;

FIGS. 10 and 11 are perspective views showing the cross-type key according to two further embodiments of the present invention, respectively; and

FIG. 12 is a fragmentary longitudinal cross-sectional view showing still another embodiment of the present invention.

FIGS. 7 to 9 show a first embodiment of the invention. As typically shown in FIG. 7, there is a plurality of keyways 301 extending in the same direction in the surface of the disc portion 102b of the stationary scroll member 102 facing the movable scroll member 101, though only two keyways are visible in the Figure. There is a corresponding number of keyways 302 in the surface of the disc portion 101b of the movable scroll member 101 facing the stationary scroll member 102, in such a relationship that the keyways 302 extend generally at the right angles to the keyways 301. There is a number of cross-shaped keys 300 as schematically shown in FIG. 8, spaced around the axes or origins of the movable and stationary scroll members 101, 102; each key 300 has one key element 303 slidably engaged in the



respective keyway 301 and another key element 304 slidably engaged in the respective keyway 302, the key elements 303, 304 projecting in opposite axial directions. As the other details are similar in construction to those shown in FIG. 5, like parts are designated with like reference numerals.

Now, as shown typically in FIG. 9, the keyways 301 and 302 are formed in the disc portions 102b and 101b of the stationary scroll member 102 and the movable scroll member 101, respectively, with the cross key 300 engaged with the keyways 301, 302 in such a manner that the key element 303 may slide in reciprocating motion along the keyway 301 of the stationary scroll member 102, as shown by the double-headed arrow in FIG. ⁹~~3~~⁹B, and that the key element 304 may slide in reciprocating motion along the keyway 302 of the movable scroll member 101, as shown by the double-headed arrow in FIG. ⁹~~3~~⁹A. As the key 300 permits the two reciprocating motions in combination with each other, the movable scroll member 101 may have an orbital motion whilst its rotation is prevented. The cross-type key 300 is of a very simple construction, making it feasible substantially to reduce the production cost of the fluid machine.

At the same time, as the relative relationship between both scroll members 101, 102 may be predetermined exclusively by the precision of machining of the keyways 301, 302 and the cross-type key 300, the strict

positioning of the stationary scroll member 102 with respect to the machine frame, that has hitherto been essential during installation, is no longer necessary. In addition, with the elimination of the specific mechanism required hitherto for such positioning, it is possible to reduce the time required for assembly.

While the relative relationship between both the scroll members 101, 102 is predetermined by the precision of machining of the rotation preventing mechanism and also by the precision of installation of the stationary scroll member 102 with respect to the frame of the machine, this relative relationship will now depend upon the precision of machining of the rotation preventing mechanism exclusively of the precision of installation of these members. From this advantageous feature, it is now possible in practice to predetermine the relative relationship between the both scroll members, thus substantially avoiding reduction in performance when assembled.

As shown in FIG. 10, it is possible in practice to employ a modified cross-type key 400 having key elements 402 and 403 extending generally at right angles to each other on opposite sides of a disc portion 401 thereof. This construction enables the strength of the key elements 402, 403 to be increased, but a recess must be made in the disc portion 101b or 102b of the movable scroll member 101 or of the stationary scroll member 102



to permit the shifting motion of the disc portion 401.

FIG. 11 shows a modification using a cross-type key 450 having key means each formed by spaced pins 452, 453, instead of the continuous keys; the pins 452, 453 are formed integrally with, or inserted by way of screw-in or press-fitting into, a disc portion 451.

In addition, as typically shown in FIG. 12, there may also be an oil groove 361 in the movable scroll member 101 so that the keyway 302 may properly be supplied with the lubricating oil, and the engaging surfaces of the cross-type key 300 and the keyways 301, 302 be lubricated accordingly.

The material and the surface treatment for the cross-type key may be specified appropriately. It may be made of an iron casting or of any other metal material such as aluminium, or else of another material like a plastic resin, and its surface may be treated by for instance a phosphoric acid film treatment, or in general by metal plating, polytetrafluoroethylene coating, etc., as desired.

While the typical preferred embodiments of the present invention has been described fully hereinbefore, it is to be understood that the present invention is not intended to be restricted to the details of the specific constructions shown in the preferred embodiments, but on the contrary many changes and modifications may be made in the foregoing teaching.



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Claims

1. A rotary type fluid machine having:

two members each having a spiral element nested in the spiral element of the other member, one member being stationary and the other member being movable; and

a plurality of limit means immediately between parts of both the members and spaced around the axes of the members, for limiting the motion of the movable member, each limit means comprising two key means extending at right angles to each other, ^{and engaged} ~~for engagement~~ in respective keyway means extending at right angles to each other.

2. The machine of Claim 1, wherein the keyway means are in the respective said members.

3. The machine of Claim 2, wherein each limit means has two keys in the form of a cross.

4. The machine of Claim 2, wherein each limit means comprises disc means with the key means projecting from opposite sides of the disc means.

5. The machine of Claim 1, 2 or 4, wherein the key means are long-shaped keys.



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6. The machine of Claim 1, 2 or 4, wherein each key means is formed by spaced pins.

7. The machine of any of the preceding Claims, wherein respective keyway means are formed in a surface of a first said member which faces the other said member and all extending in the same direction, and respective keyway means are formed in a surface of a disc portion of said other member which faces said first member and all extending in a direction at right angles to the first direction.

8. The machine of any of the preceding Claims, wherein the movable member has oil groove means for providing its keyway means with lubricating oil.

9. A rotary scroll-type fluid-handling machine, substantially as herein described with reference to Figures 7 to 9B of the accompanying drawings.

10. The machine of Claim 1, wherein the limit means are substantially as herein described with reference to Figure 10 or Figure 11 of the accompanying drawings.

11. The machine of Claim 1, wherein the limit means are lubricated substantially as herein described with reference to Figure 12 of the accompanying drawings.