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(54) SCREW ROTOR AND VACUUM PUMP

(75) Inventors: **Osamu Ozawa**, Saku City (JP); **Takeshi Ichikawa**, Saku City (JP); **Shinichi Matuda**, Saku City (JP)

Correspondence Address:
TRASK BRITT
P.O. BOX 2550
SALT LAKE CITY, UT 84110 (US)

(73) Assignee: **Kashiyama Industries, LTD**, Tokyo (JP)

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(52) **U.S. Cl.** **418/201.1**; 418/202

(57) **ABSTRACT**

The invention provides a low-cost screw rotor that is capable of compressing gas. As exemplified in FIG. **4**, screw rotors (**26, 27**) comprise: upstream screw section (**43***a*) defined on the upstream side of the gas travel path with screw thread (**41***a*) identically positioned at the same interval, and downstream screw section (**43***b*) connecting to the downstream side of upstream screw section (**43***a*) along the gas travel path, where threads (**41***b*) on the downstream screw section are arranged continuously with identical pitch smaller than threads (**41***a*) on the upstream screw section; and the upstream end of the downstream screw thread (**41***b*) along the gas travel path and the downstream end of upstream screw thread (**41***a*) along the gas travel path are continuously connected at a yielding point (**43***c*).

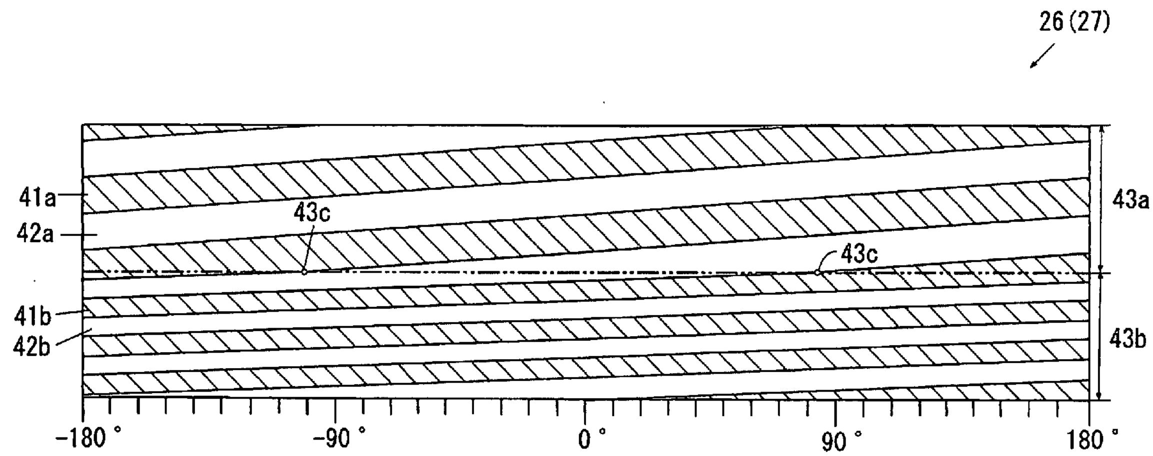
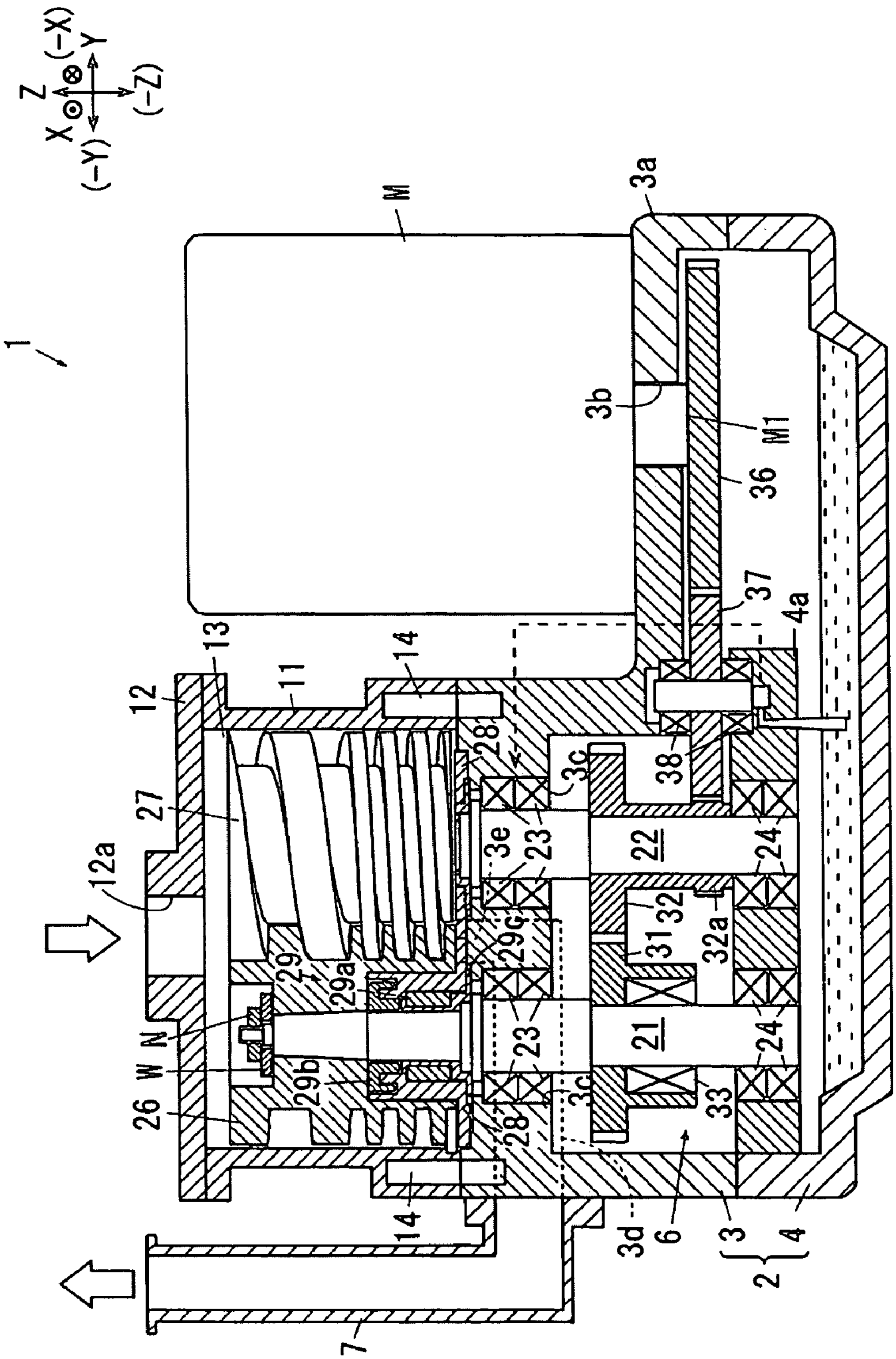


FIG. 1



Z
X
Y
(-X)
(-Y)
(-Z)
1
M
M1
3a
3b
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37
4a
38
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12a
13
11
14
27
28
3c
3e
23
22
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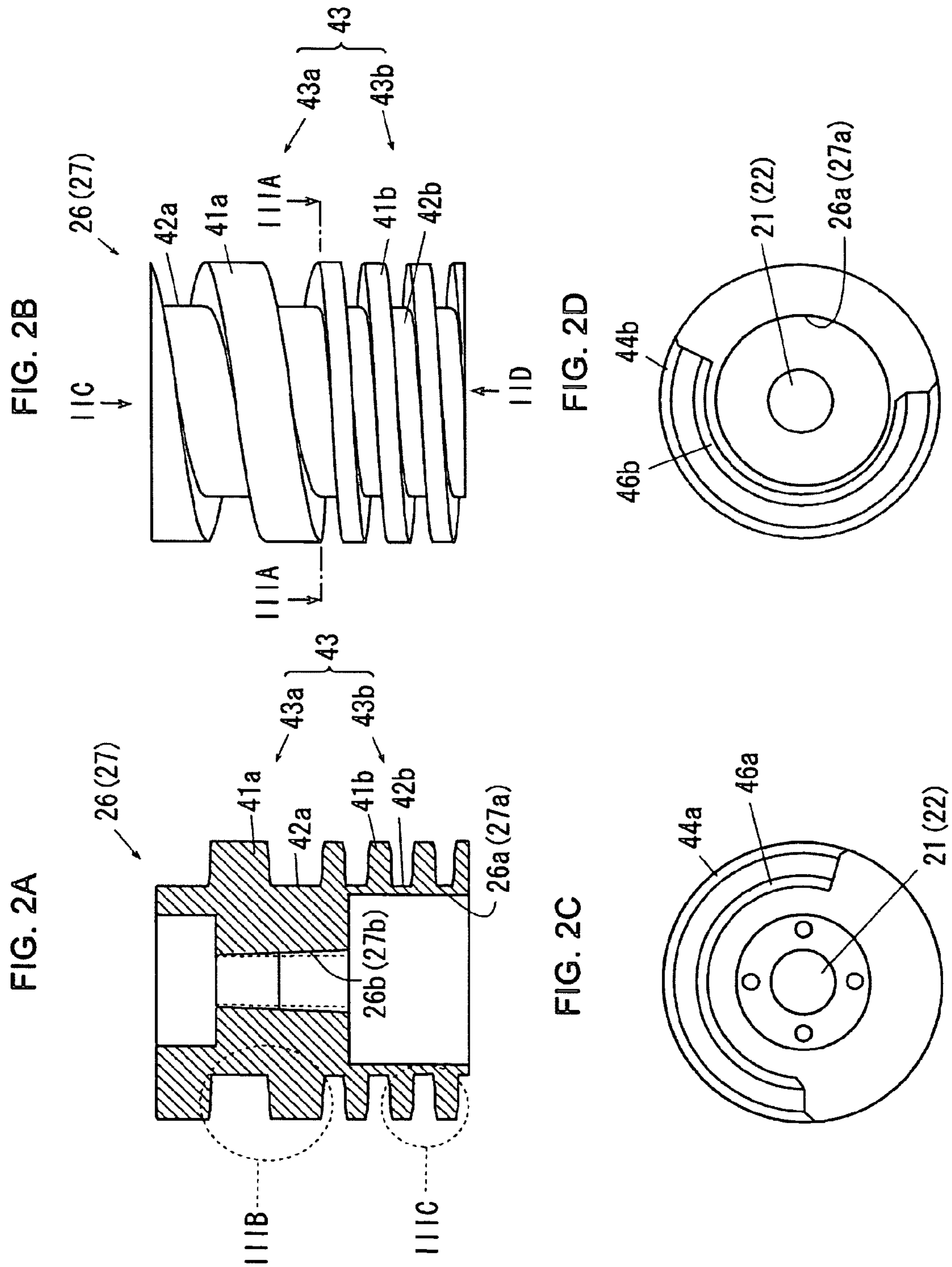


FIG. 2B

FIG. 2D

FIG. 2A

FIG. 2C

FIG. 3B

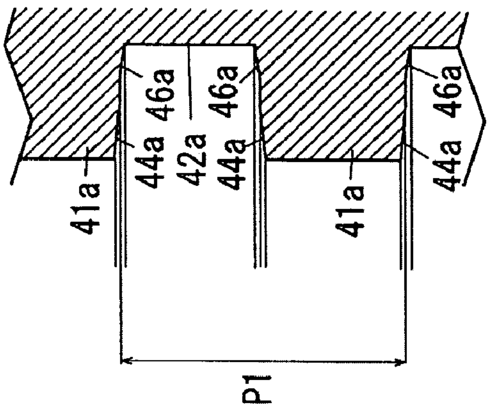


FIG. 3A

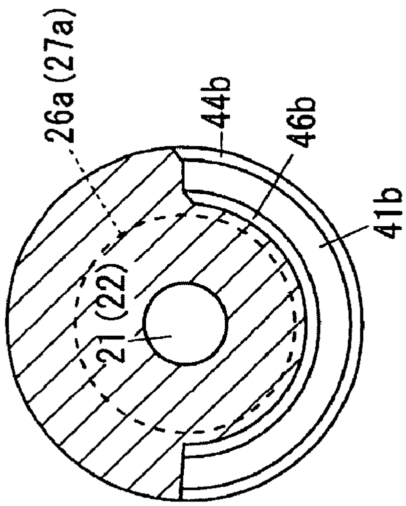


FIG. 3C

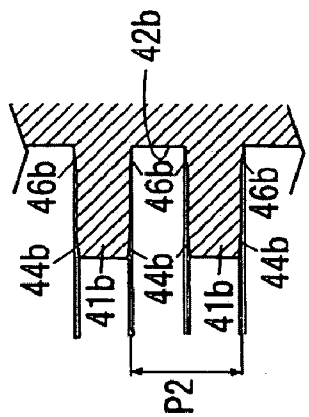


FIG. 4

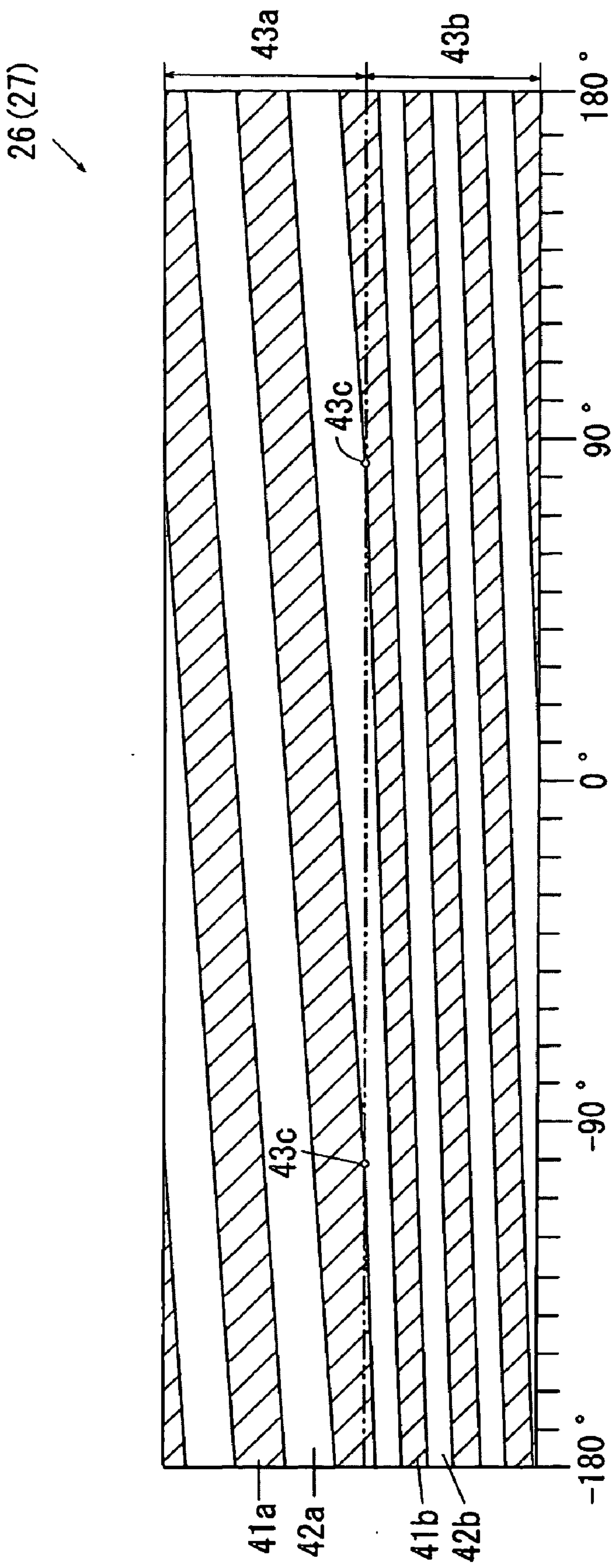
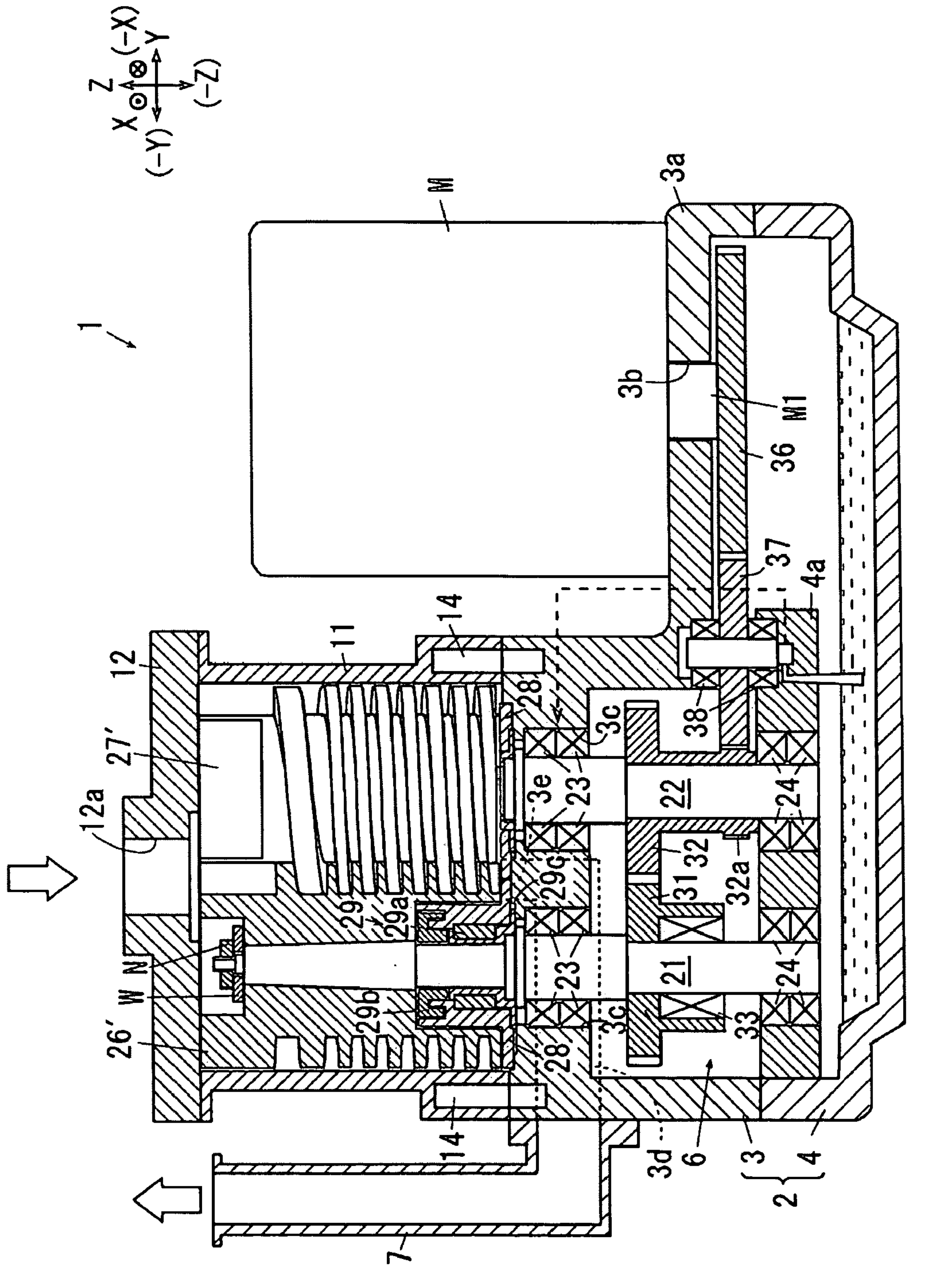


FIG. 5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M1
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3
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3b
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3d
3e
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23
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26'
27'
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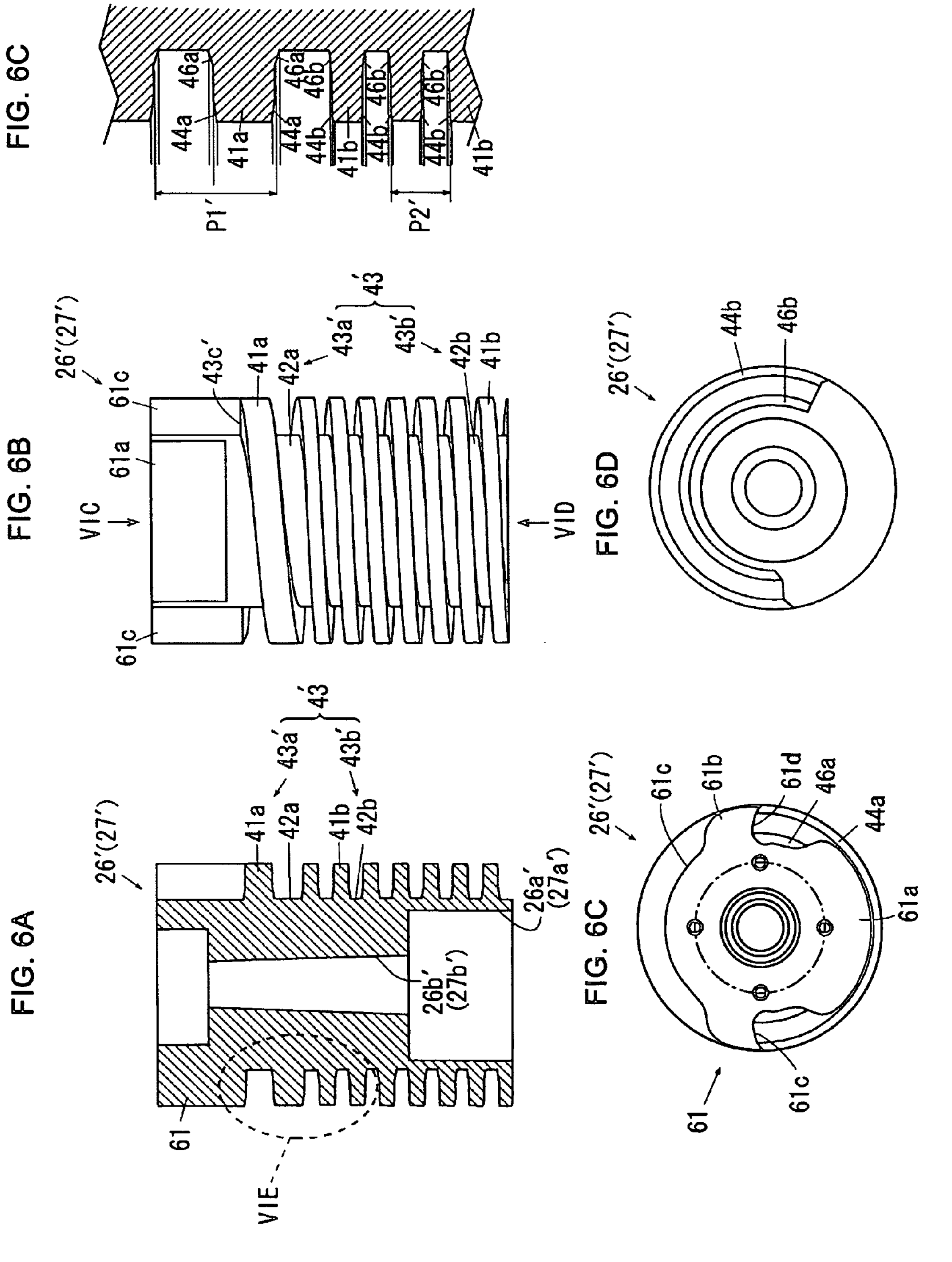


FIG. 6A

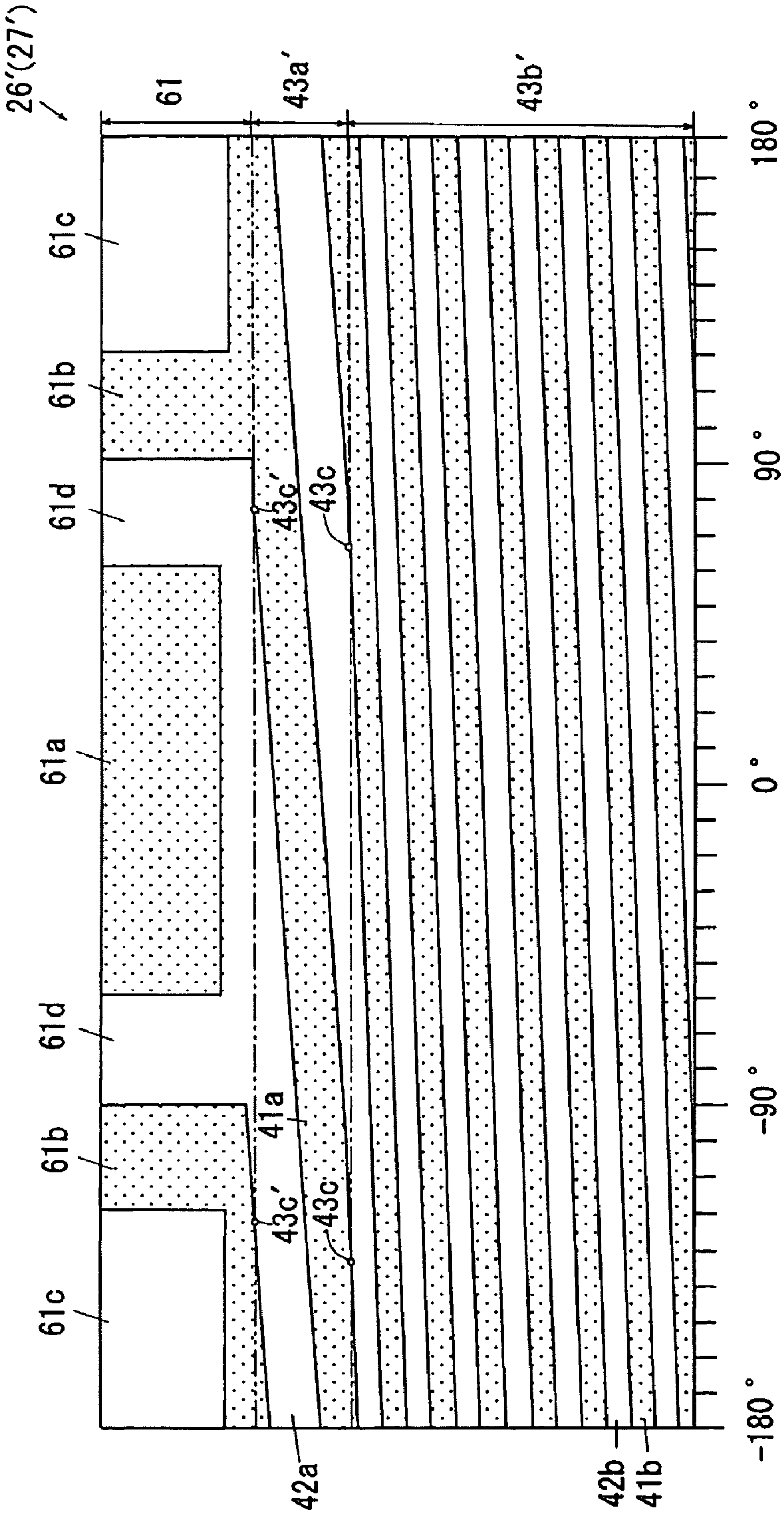
FIG. 6B

FIG. 6C

FIG. 6C

FIG. 6D

FIG. 7


26′(27′)
61
43a′
43b′
61c
61b
61d
61a
61d
61b
61c
43c′
43c
41a
43c′
43c
42a
42b
41b
180°
90°
0°
−90°
−180°

SCREW ROTOR AND VACUUM PUMP

TECHNICAL FIELD

[0001] The invention relates to a screw rotor having a threaded outer periphery and a screw-type vacuum pump equipped with a pair of the screw rotors. In particular, the invention relates to a screw rotor that is capable of compressing gas during transportation of gas, and a vacuum pump equipped with the screw rotors.

BACKGROUND

[0002] With respect to a vacuum pump that discharges gas from a vacuum chamber, a screw type vacuum pump that transports and discharges gas by means of rotation of jogged screw rotors having threaded outer periphery is well known. As an example, the herein described screw type dry vacuum pump applying traditional technology (J01) is well-known. (J01) Prior art is described in Patent document 1 (Japanese Patent Laid-open Publication No. 2000-45976)

[0003] As described in Patent document 1, a screw-type dry vacuum pump comprises a pair of screw rotors having square thread on the outer periphery with identical lead (distance that a screw thread advances axially in one turn—on a single threaded screw, the lead and pitch are identical). (Japanese Patent Publication No. 2000-45976, paragraph 0022, FIG. 1)

[0004] In the case of the screw pump applying traditional technology described in the prior art (J01), the screw rotors are designed to have identical lead (pitch) so that gas is discharged out of a discharge outlet from the upstream side without being compressed.

[0005] Regarding compression of gas during gas transportation when screw rotors are used, a continuously variable pitch design of the screw rotor is considered wherein the pitch size at the suction side is maximum, and minimum at the discharge outlet. However, in the case of continuously variable pitch design, a high cost due to complicated machining is regarded as a problem.

[0006] In addition, a small clearance is defined between threads of the two intermeshed screw rotors of the screw-type vacuum pump. When the threads have a rectangular tooth shape, they make interference (contact) on the surface of intermeshed threads as they rotate. As a result, the thread profile (interference prevention section) is machined to have a tapering (narrowing) end in order to prevent interference between threads in the case of the conventional screw type vacuum pump. However, since the intermesh interference between the threads becomes large with large lead size, it is required that the profile shape changes continuously with continuously variable pitch. In the case of continuously variable pitch of a thread, failure to carry out thread machining with one end-mill resulting in difficult machining and high cost.

[0007] In addition, in order to compress the transported gas when screw rotors are used, in practical applications, the rotor of a large thread lead (large pitch) and the rotor of a small thread lead (pitch) are placed at a certain interval along the same revolving shaft. However, the discontinuous change of discharge volume between the rotor of a large thread lead and the rotor of a small thread lead results in low discharge efficiency. Moreover, because the two rotors are arranged at an interval, axial length of rotor (rotor length) tends to be increased. If the rotor length is increased, the dimension of the whole unit is forced to increase, together with the need for bearings to be mounted to support the revolving shaft at both ends as well as at the vacuum side. If bearings are mounted at the vacuum side, it becomes necessary to provide lubricant for the bearings; furthermore, measures should be taken to prevent pollution to the vacuum chamber resulting in a complicated structure and high cost.

SUMMARY OF INVENTION

[0008] The invention provides a screw rotor at low cost that is capable of compressing air. The invention also increases discharge efficiency of a screw rotor and shortens the rotor length.

[0009] In aspect **1** of the invention, a screw rotor is designed to be in possession of the following features. The screw rotor having threaded outer periphery rotates around the revolving shaft to transport gas. The screw rotor comprises two sections: an upstream screw section on the upstream side and a downstream screw section connecting the downstream side of the upstream screw section along the gas travel path.

[0010] The threads on the upstream screw section are arranged at an identical pitch and the threads on the downstream screw section are arranged continuously at identical pitch smaller than that on the upstream screw section. The downstream end of the upstream screw threading along the gas travel path and the upstream end of the downstream screw threading along the gas travel path are continuously connected through inflexion points.

[0011] The screw rotor further has threads on its outer periphery to rotate around a revolving shaft so as to transport gas. On the upstream side along the gas travel path, upstream threads are formed at identical intervals. On the downstream screw section connected with the downstream end of the upstream screw section along the gas travel path, the threads are formed continuously at identical interval smaller than that on the upstream screw section. Besides, in the downstream screw section, the downstream end of the upstream thread along the gas travel path and the upstream end of the downstream thread along gas travel path are continuously connected through inflexion points.

[0012] Accordingly, both the upstream and downstream screw sections of the screw rotor in aspect **1** are formed at identical pitch, resulting in easy manufacture and low cost compared with the case of continuously variable pitch.

[0013] Furthermore, because the pitch of the downstream screw section is smaller than that of the upstream section on the screw rotor in aspect **1**, gas is compressed as it travels from the upstream section to the downstream section. In the meantime, the downstream end of the upstream screw section and the upstream end of the downstream screw section are continuously connected at a yielding point, therefore, the gas discharge volume changes continuously near the yielding point. Compared to the screw rotor of variable pitch design whose gas discharge volume is not continuous, the screw rotor of the invention increases discharge efficiency and shortens the rotor length. In addition, the design of a shortened rotor length makes it easy to apply a stay bracket of bearings on one end of the revolving shaft.

[0014] In Form **1** of aspect **1**, the screw rotor possesses the following features: it comprises an upstream interference prevention section on the upstream screw section and a downstream interference prevention section on the downstream screw section. The upstream interference prevention section on the upstream screw section is designed with tapering end of tread on upstream thread profile, and thread shape of the downstream interference prevention section on downstream thread profile of the downstream screw section is different from that of upstream interference prevention section.

[0015] With respect to the screw rotor described in form **1** of aspect **1**, an upstream interference prevention section is designed on the thread profile of the upstream screw section with tapering end of thread, and similarly, a downstream interference prevention section is formed on the downstream thread profile of the downstream screw section that has thread shape different from that of upstream interference prevention section. Therefore, interference prevention areas are formed in order to prevent interference between intermeshed screw rotors.

[0016] In aspect **2** of the invention, a vacuum pump is characterized by including the screw rotor in aspect **1** or form **1** of aspect **1**. Since the vacuum pump comprising the components in aspect **2** has the same screw rotors as that in aspect **1** or form **1** of aspect **1**, it has the same effect as aspect **1** or form **1** of aspect **1**.

[0017] The foregoing described invention makes it possible to provide a screw rotor that is capable of compressing gas at low cost. Moreover, it is capable of increasing the discharge efficiency as well as shortening the rotor length.

DESCRIPTION OF THE FIGURES

[0018] FIG. **1** is an overall illustration of screw type dry vacuum pump.

[0019] FIG. **2** is an illustration of the screw rotor in embodiment **1**. FIG. **2**A is the sectional view, and FIG. **2**B the side view, FIG. **2**C illustrates the view taken from the direction of arrow IIC in FIG. **2**B, FIG. **2**D illustrates the view taken from the direction of arrow IED in FIG. **2**B.

[0020] FIG. **3** illustrates the main part of the screw rotor. FIG. **3**A is a sectional view along line IIIA-IIIA of FIG. **2**B, FIG. **3**B shows an enlarged illustration of IIIA section in FIG. **2**A, and FIG. **3**C shows an enlarged illustration of IIIC section in FIG. **2**A.

[0021] FIG. **4** is the expanded view of the screw rotor profile in embodiment 1.

[0022] FIG. **5** is an overall illustration of a screw type vacuum pump in embodiment 2, corresponding to FIG. **1** of embodiment 1.

[0023] FIG. **6** illustrates a screw rotor in embodiment 2 corresponding to FIG. **2** in embodiment 1. FIG. **6**A is a sectional view, FIG. **6**B is a side view, FIG. **6**C is a sectional view taken from arrow VIC of FIG. **6**B, FIG. **6**D is a sectional view taken from arrow VID of FIG. **6**B. FIG. **6**E shows an enlarged illustration of VIE section in FIG. **6**A.

[0024] FIG. **7** is an expanded view of the screw rotor profile in embodiment 2, corresponding to FIG. **4** in embodiment 1.

DETAILED DESCRIPTION OF THE INVENTION

[0025] Various embodiments of application of the invention are illustrated in the accompanying drawings. It should be understood that applications of the invention are not limited to the following embodiments.

[0026] Symbols used throughout in the Specification and the FIGS are explained as follows:

[0027] **1**. . . vacuum pump,

[0028] **21**, **22**. . . revolving shafts,

[0029] **26**, **27**, **26**', **27**'. . . screw rotor

[0030] **41***a* . . . upstream thread

[0031] **41***b* . . . downstream thread

[0032] **43** . . . screw

[0033] **43***a*, **43***a*' . . . upstream screw section

[0034] **43***b*, **43***b*' . . . downstream screw section

[0035] **43***c* . . . yielding point

[0036] **44***a* . . . upstream interference prevention section

[0037] **44***b* . . . downstream interference prevention section

[0038] In order to make the illustration easily understood, the following definition is made to specify directions. X axis: the longitudinal (forward and aft), Y axis: the lateral (inward and outward) and Z axis: the vertical (up and down); and arrow marks X, -X, Y, -Y, Z,and -Z stand, respectively, for forward, aft, right, left, up and down in the drawings. In addition, the symbol ⌈□⌋ in ⌈○⌋ represents an arrow directing out of the paper, and ⌈x ⌋ in ⌈○⌋ represents an arrow directing into the paper.

[0039] Embodiment 1 of the invention is further explained as follows. FIG. **1** is an overall illustration of a screw type dry vacuum pump. It shows in FIG. **1** that there is a base **2** mounted in the screw type dry vacuum pump **1** in the invention. The upper base **3** and lower base **4** are mounted on base **2**, with a gear room **6** designed within base **3** and base **4**. On the right side of base **2**, motor stand **3***a* to support pump motor M is mounted. A motor shaft through-hole **3***b* is drilled on motor stand **3***a* for motor shaft M**1** to go through. On the left side of the upper end of upper base **3**, a pair of upper bearing saddles **3***c* is mounted. On the left side of upper base **3**, discharge duct **7** is fixed, with which the downstream end of discharge passage **3***d* formed within base **3** is connected. Discharge outlet **3***e* is formed on the upstream end of discharge passage **3***d*. On the upper end of the left side of lower base **4**, lower bearing saddle **4***a* is mounted. Lubricant for bearing lubrication is stored at the bottom of lower base **4**.

[0040] To the left of the upper end of upper base **3**, a cylinder casing **11** is mounted. The top of casing **11** is blocked by cover **12**. On cover **12**, a suction inlet **12***a* while not shown in the drawings is connected with the vacuum chamber. Therefore, pump chamber **13** is defined in the internal space generated by the upper surface of upper base **3**, casing **11** and cover **12**, where suction inlet **12***a* is formed on the top and exhaust outlet **3***e* at the bottom. At the bottom of said casing **11** as well as around the outer periphery of upper base **13**, a doughnut-shaped cooling circuit **14** is mounted in which cooling water runs for cooling pump chamber **13**.

[**0041**] Within base **2** as well as casing **11**, a pair of rotor axles (revolving shaft) **21**, **22** are mounted at both left and right sides going through pump chamber **13** and gear room **6**. Rotor axles **21** and **22** are supported by upper bearing saddles **3***c* and lower bearing saddle **4***a* in gear room to rotate by means of bearings **23** and **24**. Within pump chamber **13** where rotor axles **21** and **22** are mounted, the intermeshed left and right screw rotors **26** and **27** are fixed. Within the bottom of screw rotors **26** and **27**, seal recesses **26***a* and **27***a* (referring to FIG. **2**) are designed. On the top of seal recesses **26***a* and **27***a*, tapering axial through-holes **26***b* and **27***b* are made, and the tapering top of rotor axles **21** and **22** go through axial through-holes **26***b* and **27***b*. At the top end of rotor axles **21** and **22**, screw threads are drilled and screwed tightly with nut N through washer W; therefore, rotor axles **21** and **22** are fixed together with screw rotors **26** and **27** thereby rotating integrally.

[**0042**] Housing **28** for seal installation is fixed on the top of the upper bearing **23**. In seal recess **26***a*, oil seal **29***a* fixed on seal installation housing **28**, together with the two flingers **29***b* and **29***c* that rotate with rotor axles **21** and **22**, comprises the seal system **29** functioning on prevention of leakage and reverse flow of gas and lubricant, etc.

[**0043**] In gear room **6**, timing gears **31** and **32** are fixed to rotor axles **21** and **22** in an intermeshed state to transmit the driving power. In addition, in the vacuum pump described in embodiment 1, a rotation transmission gear **32***a* is fixed at the bottom of right timing gear **32**, and the right timing gear **32** is fixed rotationally with right rotor axle **22** integrally through the key and key groove that are not shown in the drawings. Furthermore, left timing gear **31** is connected with left rotor axle **21** through joint **33**. By means of joint **33**, the intermesh of gears **31** and **32** as well as that of screw rotors **26** and **27** is easily obtained.

[**0044**] Drive gear **36** is fixed on the driving shaft M1 of pump motor M. Rotation is transmitted to timing gears **31** and **32** through drive gear **36** together with the mid-gear **37** that is intermeshed with rotation transmission gear **32***a*. In addition, bearing **38** that rotationally supports mid-gear **37**, together with other bearings **23** and **24**, are lubricated by the lubricant stored in lower base **4** through a lubricant supply device that is not shown in drawings.

[**0045**] FIG. **2** is an illustration of the screw rotor in embodiment 1. FIG. **2**A is the sectional view. FIG. **2**B is a side view. FIG. **2**C illustrates the view taken from the direction of arrow IIC in FIG. **2**B. FIG. **2**D illustrates the view taken from the direction of arrow IID in FIG. **2**B.

[**0046**] FIG. **3** illustrates the main part of the screw rotor. FIG. **3**A is a sectional view taken along line IIIA-IIIA of FIG. **2**B. FIG. **3**B shows an enlarged illustration of IIIA section in FIG. **2**A. FIG. **3**C shows an enlarged illustration of IIIC section in FIG. **2**A.

[**0047**] FIG. **4** is the expanded view of the screw rotor profile in embodiment 1. As show from FIG. **2** to FIG. **4**, one screw **43** with screw thread **41** and valley **42** is formed on the outer periphery of screw rotors **26** and **27** in embodiment 1. Screw **43** comprises upper upstream screw section **43***a* on the upstream side of the gas travel path and lower downstream strew section **43***b* on the downstream side of the gas travel path.

[**0048**] In FIG. **3**B and FIG. **4**, adjacent upstream threads **41***a* are designed with identical distance (pitch p1, referring to FIG. **3**B), with equal width of upstream screw valley **42***a* on upstream screw **43***a*. In FIG. **3**C and FIG. **4**, adjacent downstream threads **42***a* are designed with identical distance (pitch p2, referring to FIG. **3**C), with equal width of upstream screw valley **42***b* on downstream screw **43***b*. Moreover, pitch p2 (referring to FIG. **3**C) is designed to be narrower in width compared with that of upstream screw **43***a*.

[**0049**] The downstream end of upstream screw section **43***a* and the upstream end of the downstream screw section **43***b* are continuously connected at yielding points **43***c* and **43***c* in FIG. **4**. Accordingly, near the yielding points **43***c* and **43***c*, the gas discharge volume changes smoothly in a continuous way, thus gas discharge volume changes continuously from upstream screw section **43***a* to the downstream screw section **43***b*.

[**0050**] In FIG. **2**C, FIG. **2**D, FIG. **3**B and FIG. **3**C, on the end of thread profile of screw threads **41***a* and **42***a*, interference prevention sections **44***a* and **44***b* are designed through cutting (chamfering machining) in order to remove interference when rotors **26** and **27** have rectangular teeth (which did not undergo chamfering). Moreover, with respect to interference prevention sections **44***a* and **44***b*, since the shape of upstream interference prevention section **44***a* is different from that of the downstream interference prevention section **44***b*, interference on the upstream side with a large lead tends to be large. Correspondingly, more cutting is required on the upstream interference prevention section **44***a* than on the downstream interference prevention section **44***b*.

[**0051**] In addition, on the surface near the root of screw threads **41***a* and **42***a*, gap filling sections **46***a* and **46***b* are generated to fill the space between interference prevention sections **44***a* and **44***b* and the thread surface of screw threads **41***a* and **42***a* corresponding to the cutting of interference prevention sections **44***a* and **44***b*. The existence of space between interference prevention sections **44***a* and **44***b* and the thread surface of screw threads **41***a* and **42***a* while rotors **26** and **27** are in intermeshed state will cause gas leaks and reverse flow; accordingly, discharge efficiency will decrease. Therefore, in embodiment 1, by means of clearance filling section **46***a* and **46***b*, intermeshing is realized when rotors **26** and **27** are in intermeshed state; when the intermesh is released, interference generated is removed by interference prevention sections **44***a* and **44***b*.

[**0052**] In vacuum pump **1** having the structure described in embodiment 1, rotation is transmitted by gears **31**, **32**, **36** and **37** when pump motor M1 starts; then rotor axles **21** and **22** start to rotate; furthermore, screw rotors **26** and **27** start to rotate. Accompanying the rotation of the screw rotors **26** and **27**, gas is transported by means of screw **43**. The gas inhaled from suction inlet **12***a* is discharged from discharge outlet **13**.

[**0053**] On the screw rotors **26** and **27** defined in embodiment 1, upstream screw section **43***a* of a large lead (large pitch) on the upstream side is designed while downstream screw section **43**b of a small lead (small pitch) on the downstream side is designed. Therefore, gas passing through upstream screw section **43**a is compressed by means of a smaller gas discharge volume upon the arrival at downstream screw section **43**b. Besides, the fact that upstream screw section **43**a and downstream screw section **43**b are connected continuously at yielding point **43**c leads to a continuously changeable gas discharge volume, in addition to the fact that the upstream screw section and downstream screw section are arranged with no space in between; therefore, gas discharge efficiency is superior compared with the case when the gas discharge volume changes in discontinuity.

[**0054**] Furthermore, since the upstream screw section and downstream screw section are arranged with no space in between, rotor length can be shortened. Accordingly, the design of a stay bracket without the arrangement of a bearing on the vacuum side (on the side of suction inlet **12**a) is applicable, as shown in FIG. **1**.

[**0055**] Moreover, corresponding to the degree of interference, interference prevention sections **44**a and **44**b are arranged on screw rotors **26** and **27** to remove interference when rotors are released from intermesh. In addition, the advantage that space is filled by means of gap filling sections **46**a and **46**b leads to reduction of gas leakage and increase of discharge efficiency.

[**0056**] In addition, for screw rotors **26** and **27** defined in embodiment 1, it is possible to make screw rotors **26** and **27** as follows: the screw thread higher than the yielding point **43**c is machined by a large lead cutting tool, and the screw thread lower than the yielding point **43**c is machined by a small lead cutting tool. Therefore, compared with the case that the pitch of the screw thread is continuously variable, machining of screw rotors **26** and **27** is easier. In addition, compared with the case of continuously variable shape, it is easy to make interference prevention sections **44**a and **44**b since they have two different shapes, resulting in low cost.

[**0057**] Embodiment 2 of the invention is further explained as follows. FIG. **5** is an overall illustration of screw type vacuum pump in embodiment 2, corresponding to FIG. **1** embodiment 1. FIG. **6** illustrates screw rotor in embodiment 2 corresponding to FIG. **2** of embodiment 1. FIG. **6**A is a sectional view. FIG. **6**B is a side view. FIG. **6**C is a sectional view taken from arrow VIC FIG. **6**B. FIG. **6**D is a sectional view taken from arrow VID of FIG. **6**B. FIG. **6**E shows an enlarged illustration of VIE section in FIG. **6**A.

[**0058**] FIG. **7** is the expanded view of the screw rotor profile in embodiment 2, corresponding to FIG. **4** in embodiment 1. Additionally, regarding the illustration of embodiment 2, same symbols for the corresponding components are used as in embodiment 1 whith specific explanation of the symbols omitted. Regarding the components of embodiment 2, it is the same as those of embodiment 1 except the following features.

[**0059**] As shown in FIG. **5** to FIG. **7**, screw type vacuum pump **1** of embodiment 2 is equipped with screw rotors **26'** and **27'** which are different from the screw rotors **26** and **27** of the embodiment 1. In screw rotors **26'** and **27'** of the embodiment 2, an innite lead section **61** is formed continuously, on the upstream side of gas travel path, further up than upstream screw section **43**a (the side of suction inlet **12**a), with a length corresponding to thread lead infinitely great. Infinite lead section **61** comprises small circle section **61**a and large circle section **61**b. On large circle section **61**b, a circular excision **61**c is formed. In addition, gas compression section **61**d is formed between small circle section **61**a and large circle section **61**b. As described in patent document 1 (referring to rotor extensions **7** and **8** in patent document 1), being normally well-known, infinite lead section **61** is applied to discharge gas by a discharge mechanism depicted in FIG. **3** of Patent document 1, therefore, detailed illustration is omitted. Additionally, in the structure described in patent document 1, the center of gravity of infinite rotor section **61** deviates. It becomes ill-balanced as screw rotors **26'** and **27'** rotate. In embodiment 2 of the invention, excision **61**c is applied on infinite rotor section **61** to keep screw rotors **26'** and **27'** in a balanced state.

[**0060**] In FIG. **6** and FIG. **7**, the downstream end of upstream screw section **43**a' is continuously connected with the upstream end of downstream screw section **43**b' at yielding points **43**c and **43**c; in addition, the upstream end of upstream screw **43**a' is continuously connected with the downstream end (lower end) of infinite lead section **61** at yielding point **43**c' and **43**c' in screw rotors **26'** and **27'**.

[**0061**] Furthermore, in screw rotors **26'** and **27'**of the embodiment 2, more thread turns of downstream screw section **43**b' (7 turns) are designed compared with that in the case of embodiment 1.

[**0062**] In the screw type vacuum pump **1** that has the structure defined in embodiment 2, gas is compressed as it travels from infinite lead section **61** to upstream screw section **43**a' as well as from upstream screw section **43**a' to downstream screw section **43**a'. Therefore, compression ratio is increased.

[**0063**] In addition, in screw rotors **26'** and **27'**of the embodiment 2, the fact that infinite lead section **61** is continuously connected with upstream end of upstream screw section **43**a' at yielding point **43**c' with no space in between, together with the fact that the upstream screw section **43**a' and downstream screw section **43**b' are continuously connected at yielding point **43**c, make it possible for the rotor length of screw rotors **26** and **27** to be shortened. Consequently, application of stay bracket is easy to accomplish. Furthermore, continuous connection enables continuously changeable discharge volume resulting in increased discharge efficiency.

[**0064**] Furthermore, with respect to screw rotors **26'** and **27'**of the embodiment 2, more thread turns of downstream screw section **43**b' of small lead are designed so that transported gas is separated into more parts. Accordingly, it can reduce leakage from discharge outlet **3**e to suction inlet.

[**0065**] Apart from the foregoing description, vacuum pump **1** of embodiment 2 has similar effect to that of embodiment 1. Some embodiments of the invention have been the described in detail, but it is to be understood that the invention is not limited exclusively to the described embodiments, within the scope of the claims of the invention, variations can be made Variations (H01) to (H06) of the invention are illustrated below.

[**0066**] (H01) In the embodiments, it is possible to install additional one or more screw threads on the upstream side of upstream screw sections **43**a and **43**a' or the downstream side of downstream screw sections **43***b* and **43***b*'. That is, it is possible to design a screw rotor with more than three screw sections instead of 2.

[**0067**] (H02) In the embodiments, it is preferred that screw **43** comprises one thread; however, screw **43** may comprise more than two threads.

[**0068**] (H03) In various embodiments, the specific numbers of thread turns of screws and the length of lead, p**1**, p**2**, p**1**' and p**2**', as well as the rotor length, can be varied based on specific designs.

[**0069**] (H04) In the embodiments, it is possible to install roots rotor instead of infinite lead **61** as described in patent document 1.

[**0070**] (H05) In the embodiments, the threads are designed to be curved and continuously connected at yielding point **43***c* and **43***c*'. In addition, it should be understood that it is also possible to cut off the curved angle so as to connect smoothly near the yielding point.

[**0071**] (H06) In the embodiments, the driving force of pump motor M that is supported by motor stand **3***a* is transmitted to rotor axles **21** and **22** through gear **36** and mid-gear **37**; however, it is not limited to the present structure. Either of rotor axles **21** and **22** can support the motor rotor with a motor starter located around the rotor; that is to say, a built-in motor structure can be applied. Incorporation of the built-in motor results in a compact structure and reduced cost.

What is claimed is:

1. A screw rotor having a threaded outer periphery for transporting gas while rotating around a revolving shaft, comprising

an upstream screw section on an upstream side and a downstream screw section that is connected to the downstream side of said upstream screw section along the gas travel path,

wherein the threads on the upstream screw section are arranged at a first identical pitch and the threads on the downstream screw section are arranged continuously at a second identical pitch that is smaller than that on said upstream screw section, and

wherein the downstream end of said upstream screw threading along the gas travel path and the upstream end of said downstream screw threading along gas travel path are continuously connected at a yielding point.

2. The screw rotor of claim 1, wherein an upstream interference prevention section comprising a tapering end on the upstream thread profile is formed on said upstream screw section; a downstream interference prevention section is formed on said downstream screw section; and the shape of the upstream interference prevention section is different from that of the downstream interference prevention section.

3. A vacuum pump comprising the screw rotor of claim 1.

4. A vacuum pump comprising the screw rotor of claim 2.

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