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(54) A RECIPROCATING HERMETIC COMPRESSOR

HERMETISCHER VERDICHTER MIT HIN- UND HERGEHENDEN KOLBEN

COMPRESSEUR A PISTONS HERMETIQUE

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GB-A- 771 334

- **BEITZ & KÜTTNER 'Dubbel Taschenbuch für den Machinenbau' 1987 , SPRINGERVERLAG , BERLIN,DE 16. Auflage; Par. 3.8 Ausgeführte Verdichter see page P 41, paragraph 3.8 - page P 42; figure 33**

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Description

Field of the Invention

The present invention relates to a reciprocating compressor and particularly to a reciprocating compressor of the type comprising a housing, a cylinder block mounted inside the housing and defining a first and a second cylinder, a first piston reciprocating inside said first cylinder and being operatively mounted to an eccentric portion of a crankshaft, a second piston reciprocating inside the second cylinder and being operatively mounted to said eccentric portion, said second cylinder being disposed at 90° to the first cylinder, and further comprising a counterweight means being disposed diametrically opposite to the eccentric portion of said crankshaft and being designed such that its inertial force presents a component which is projected on a first axis parallel to the geometric axis of the first reciprocating piston and balances the inertial forces relative to said first piston and the component of inertial force of the eccentric portion projected on said first axis, and also presents a component projected on a second axis parallel to the geometric axis of the second reciprocating piston, balancing the inertial forces relative to said second piston and the corresponding component of inertial force of the eccentric portion projected on said second axis.

Background of the Invention

The known reciprocating compressors comprise a connecting rod, whose smaller eye is articulated through a wrist pin to a piston, which reciprocates inside the cylinder of the compressor and whose larger eye is mounted to an eccentric end of a crankshaft, which is orthogonal to the piston stroke and whose other end supports the rotor of an electric motor, the stator of the motor being supported by a cylinder block lodging the bearing of the crankshaft, the cylinder block being mounted to a housing through springs, said housing being covered by a lid, defining a sealed unit. To obtain a better performance of the compressor, it is important that, in mechanical terms, the parts with relative movement are perfectly balanced. It is known that the inertia and rotation forces produced by a mechanism with a single piston cause unbalance in hermetic compressors. The maximum of the inertial force in a piston occurs at the regions of the upper and lower dead points. Said force has two important components in frequency, one main or fundamental frequency in 60 Hz and a secondary one in 120 Hz, both causing vibration in the motor-compressor assembly and, consequently, in the housing where said assembly is mounted. The 60Hz frequency is the approximate frequency in which the compressor operates. These vibrations result from the non-balancing of the forces in the gas pumping unit of the compressor, more precisely in the piston-connecting rod-shaft eccentric end assembly during operation.

In these compressors, the 60Hz component is not balanced. It is, at maximum, reduced by the provision of counterweights at the crankshaft or at the rotor of the motor of said compressors, in order to balance the levels of longitudinal and transversal vibrations of the housing. These counterweights, however, rotate together with the crankshaft and produce rotary forces in the system (figure 3) that are not balanced.

In order that the vibration in the housing reaches acceptable levels, the motor-compressor assembly is mounted inside said housing through springs (figure 1).

Nevertheless, this mounting solution through springs has some inconveniences. During transportation, at the periods of the compressor stops and starts, or even occasionally during operation, the motor-compressor assembly is submitted to forces that make said assembly move inside the housing. To avoid impacts between said assembly and the housing during such movement, the dimensions of said housing are increased.

Another problem refers, principally, to the transmission of vibrations from the motor-compressor assembly to the housing, through the discharge and suction tubes, which connect, respectively, the discharge muffler and suction muffler of these compressors to the housing. To minimize the transmission of vibration, as well as to avoid the problems of material fatigue, said tubes should be sufficiently flexible.

Such flexibility is obtained by using a long discharge tube. Nevertheless, this solution causes a superheating of the suction gas, due to the heat transfer into the internal medium of the housing through said discharge tube. Plastic suction chambers and direct or semidirect connections are used to reduce the superheating, but with cost increase.

Another solution to minimize the effects of vibration in a compressor resulting from the 60 Hz component discussed above would be the use of two pistons, disposed one from the other by 180°, each piston being mounted to a respective eccentric portion of the crankshaft. However, the construction of said crankshaft with two eccentric portions would be complicated.

In "Dubbel Taschenbuch für den Maschinenbau", Springer Verlag, Berlin/Germany (16th edition), par. 3.8 "Ausgeführte Verdichter", P. 41 and 42 and figure 33, there is described a reciprocating compressor comprising two pistons, disposed from each other by 90° and both pistons being mounted to one single eccentric portion of the crankshaft. This known compressor is of the type as described in the first paragraph of this specification, but is not a hermetic compressor and includes counterweights which are fixed to the rotating mass of the crankshaft by screws. Such solution is not well applicable in small compressors, as e.g. for small refrigerating devices, as consequence of the very reduced dimensions there and of the mounting difficulties in such small devices. In this known compressor both pistons

act on the gas pumping of the compressor during compressor operation. By the particular construction of this known compressor the free mass forces of 1st order are being balanced, but the vibration components in the 60 Hz frequency being the main and fundamental frequency causing vibrations in the motor-compressor assembly, cannot be eliminated. A similar compressor construction with about the same features and function is also disclosed by GB-A-771,334.

Disclosure of the Invention

Thus, it is the object of the present invention to provide a reciprocating hermetic compressor for application also in small refrigeration devices, whose construction eliminates at least the 60 Hz component of the vibration forces, without producing the inconvenient effects cited above, and whose construction and assembly are easy to be carried out.

This and other objectives are attained in a reciprocating compressor, of the type comprising a housing, a cylinder block mounted inside the housing and defining a first and a second cylinder, a first piston, which reciprocates inside the first cylinder and which is operatively mounted to an eccentric portion of a crankshaft, a second piston reciprocating inside the second cylinder and being operatively mounted to said eccentric portion, said second cylinder being disposed at 90° to the first cylinder, and further comprising a counterweight means being disposed diametrically opposite to the eccentric portion of said crankshaft and being designed such that its inertial force presents a component, which is projected on a first axis parallel to the geometric axis of the first reciprocating piston and balances the inertial forces relative to said first piston and the component of inertial force of the crankshaft eccentric portion projected on said first axis and also presents a component projected on a second axis parallel to the geometric axis of the second reciprocating piston, balancing the inertial forces relative to said second piston and the corresponding component of inertial force of the crankshaft eccentric portion projected on said second axis, said reciprocating compressor being characterized in that the counterweight means is incorporated in the rotating mass of the crankshaft, that the housing of the compressor is hermetic and that the second cylinder and the second reciprocating piston only serve to balance the forces acting on the first cylinder-first reciprocating piston assembly during the compressor operation.

With the inventive construction of the compressor, the more intense component of the vibrations forces acting upon the motor-compressor assembly, which is the 60 Hz component, is eliminated, allowing said motor-compressor assembly to be fixedly mounted to the housing without requiring the provision of suspension springs as in the prior art constructions. The inventive compressor allows the use of a housing of small dimension, besides the use of a shorter discharge tube and a simpler and direct suction tube, and can therefore well be provided in small refrigeration devices. The inventive construction of the compressor also reduces the superheating of the suction gas as well as costs.

In the inventive compressor only the assembly which consists of the first cylinder and the first reciprocating system acts on the gas pumping of the compressor, whereas the assembly consisting of the second cylinder and the second reciprocating piston acts solely on the balance of the forces acting on the first cylinder-first reciprocating piston assembly. Thereby, the elimination of the effects of vibrations resulting from the 60 Hz frequency are eliminated.

In a preferred embodiment of the invention the second cylinder is incorporated to the cylinder. It is also advantageous if the reciprocating piston-connecting rod assemblies in an inventive compressor are designed such that they have identical inertial effects.

Brief Description of the Drawings

The invention will be described below, with reference to the attached drawings, in which:

Fig. 1 shows schematically a longitudinal sectional view of a reciprocating hermetic compressor, illustrating a piston-crankshaft assembly of the prior art;

Fig. 2 shows, schematically and partially, the forces acting on a piston, reciprocating inside the cylinder and mounted to a crankshaft eccentric portion, said piston being at the upper dead point, according to the prior art;

Fig. 3 illustrates the reciprocating piston of fig. 2, at a position intermediate to the upper and lower dead point positions, according to the prior art; and

Fig. 4 shows, schematically and partially, the forces acting on a piston-crankshaft eccentric portion assembly, according to the present invention.

Detailed Description of the Drawings

According to figure 1, a motor-compressor assembly is suspended inside a hermetically sealed housing 1, through springs 2. A cylinder block 3 of said motor-compressor assembly serves as a support for a stator 4 of the electric motor and presents a bearing 5, for supporting a crankshaft 6 which, in this construction, carries at the lower part thereof, the rotor 7 of said motor. Said cylinder block 3 further lodges a cylinder 8, in which inside reciprocates a piston 9, driven by the rotation of the crankshaft 6, which is mounted by means of a connecting rod 10 to a crankshaft eccentric portion 11, which is provided at an upper end portion 6a of said crankshaft 6 and which has a free upper end 12.

In order that during operation there occurs balance

between the levels of longitudinal and transversal vibrations, resulting from the presence of rotational and inertial forces in the motor-compressor assembly, in this prior art construction there are provided counterweight regions 13 at the crankshaft-rotor assembly, said regions being generally indicated as a region defined at the upper portion 6a of said crankshaft 6, radially opposite to the region where the crankshaft eccentric portion 11 is disposed, and as a region located close to the rotor 7, such as illustrated in figure 1, for example.

The counterweight 13 is calculated, in such a way that, in the upper and lower dead point conditions, the force produced by said counterweight 13 acts in a system of forces including the piston 9 and the crankshaft eccentric portion 11, in order to balance the inertial forces relative to said elements.

When the reciprocating piston 9 is at the upper dead point position (fig. 2), the inertial forces of the movement acting on the piston-crankshaft eccentric portion assembly are balanced, meaning that a centrifugal force F_{cw} of the counterweight 13 counterbalances the summing of the centrifugal force F_e of the crankshaft eccentric portion and of the inertial force F_p of the piston, i.e., $F_{cw} = F_e + F_p$.

When not in the upper and lower dead point conditions, the system of forces is unbalanced (fig. 3), since the force F_{cw}, due to the counterweight 13, is superior to the summing of the forces F_e, due to the crankshaft eccentric portion, and F_p, due to the piston.

This unbalance results from the fact that the inertial force F_p relative to the piston varies during the operational cycle of the latter. The situations of higher unbalance occur between the upper and lower dead point conditions, more precisely when the reciprocating piston is at the positions corresponding to 1/4 and 3/4 of the cycle.

In these positions, the force relative to the piston is null, but the force relative to the crankshaft eccentric portion has an intensity equivalent to the sum of the forces associated to both the crankshaft eccentric portion and piston when aligned. Such conditions of unbalance between the forces allow the occurrence of vibrations in the system, as discussed above.

The hermetic compressor of the present invention, illustrated in figure 4, has a cylinder block 20, lodging a first cylinder 21 and a second cylinder 22, each of said cylinders respectively lodging first and second reciprocating pistons 31, 32, both driven by the crankshaft eccentric portion 11 mounted to the crankshaft 6. The cylinders 21,22 are disposed one from the other by 90°, each piston being driven by the crankshaft eccentric portion 11 through a respective connecting rod 23, 24. The force balance condition is achieved by using reciprocating piston-connecting rod assemblies having identical inertial effects, obtained, in the illustrated construction, with identical reciprocating piston-connecting rod assemblies.

During operation of the compressor, only the assembly consisting of the first cylinder 21 and first reciprocating piston 31 acts on the gas pumping of the compressor, whereas the assembly consisting of the second cylinder 22 and second reciprocating piston 32 acts solely on the balance of the forces acting on the first cylinder 21-first reciprocating piston 31 assembly, more particularly to eliminate the components of the 60 Hz forces discussed above.

Nevertheless, said assembly consisting of the second cylinder 22 and second piston 32 may be formed in such a way as to be able to receive a larger eye from each of said connecting rods 23, 24.

With this construction, when the first reciprocating piston 21 is at the upper dead point condition, the second reciprocating piston 22 will be at one of the 1/4 and 3/4 positions of the piston cycle, said positions being a relative function between the respective cylinders.

The elimination of the 60 Hz component from the inertial forces acting on the piston-crankshaft eccentric portion assembly occurs with the provision of one or more couterweights in the crankshaft-rotor assembly, diametrically opposite to the crankshaft eccentric portion 11, so that the force resultant, relative to said couterweights, balances the inertial forces acting on the pistons and eccentric portions, during each operative cycle of said piston, as described ahead.

When the first reciprocating piston 31 is at the upper dead point condition, the inertial forces acting upon the piston-crankshaft eccentric portion assembly are balanced, i.e., the summing of the inertial force F_{p1} of the first piston 31, with the component F_{ex} of the inertial force F_e of the crankshaft eccentric portion projected on an axis X, parallel to the geometric axis of the first cylinder 21 is equivalent to the component F_{cwx} of the inertial force F_{cw} of a counterweight 33 on said axis X, whereas the summing of the inertial force F_{p2} of the second reciprocating piston 32 with the component F_{ey} of the inertial force F_e of the crankshaft eccentric portion, projected on an axis Y, parallel to the geometric axis of the second cylinder 22, is equivalent to the component F_{cwy} of the centrifugal force F_{cw} of the counterweight 33 onto said axis Y. This balance means that, mathematically, the following equations should be simultaneously obeyed:

$$F_{p1} + F_{ex} = F_{cwx} \text{ and } F_{p2} + F_{ey} = F_{cwy}$$

In order that this condition of balance be maintained in any phase of the gas pumping operative cycle of the compressor, the only thing to do is to determine through the equations above described the intensity of the force relative to the counterweight 33, when any one of the pistons from the piston-crankshaft eccentric portion assembly is at one of the upper or lower dead point conditions. Since the pistons are equal and the respective cycles of movements thereof are displaced at 90°, a reduction in the intensity of the force relative to one of said

pistons is compensated by a corresponding increase of intensity at the other of said pistons and vice-versa. The resultant of the force relative to the counterweight is therefore a well determined constant.

Claims

1. A reciprocating compressor of the type comprising a housing, a cylinder block mounted inside the housing and defining a first and a second cylinder (21, 22), a first piston (31) reciprocating inside said first cylinder (21) and being operatively mounted to an eccentric portion (11) of a crankshaft (6), a second piston (32) reciprocating inside the second cylinder (22) and being operatively mounted to said eccentric portion (11), said second cylinder (22) being disposed at 90° to the first cylinder (21), and further comprising a counterweight means (13) being disposed diametrically opposite to the eccentric portion (11) of said crankshaft and being designed such that its inertial force presents a component which is projected on a first axis (X) parallel to the geometric axis of the first reciprocating piston (31) and balances the inertial forces relative to said first piston (31) and the component of inertial force of the eccentric portion projected on said first axis (X), and also presents a component projected on a second axis (Y) parallel to the geometric axis of the second reciprocating piston (32), balancing the inertial forces relative to said second piston (32) and the corresponding component of inertial force of the eccentric portion (11) projected on said second axis (Y), **characterized in that** the counterweight means (13) is incorporated in the rotating mass of the crankshaft (6), that the housing of the compressor is hermetic and that the second cylinder (22) and the second reciprocating piston (32) only serve to balance the forces acting on the first cylinder (21)-first reciprocating piston (31) assembly during the compressor operation.

2. Compressor as claimed in claim 1 characterized in that the second cylinder (31) is incorporated to the cylinder block.

3. Compressor as claimed in claim 2, characterized in that the reciprocating piston-connecting rod assemblies (22,32) are designed such that they have identical inertial effects.

Patentansprüche

1. Verdichter mit hin- und hergehenden Kolben der Art mit einem Gehäuse, einem Zylinderblock, der innerhalb des Gehäuses angeordnet ist und einen ersten und einen zweiten Zylinder (21,22) festlegt, mit einem ersten Kolben (31), der innerhalb des ersten Zylinders (21) hin- und herläuft und zu seiner Betätigung an einem exzentrischen Abschnitt (11) einer Kurbelwelle (6) befestigt ist, mit einem zweiten Kolben (32), der innerhalb des zweiten Zylinders (22) hin- und herläuft und zu seiner Betätigung mit dem exzentrischen Abschnitt (11) verbunden ist, wobei der zweite Zylinder (22) unter 90° zum ersten Zylinder (21) angeordnet ist, und ferner mit Gegengewichtsmitteln (13), die direkt gegenüber dem exzentrischen Abschnitt (11) der Kurbelwelle angebracht und so ausgebildet sind, daß ihre Trägheitskraft eine Komponente aufweist, die auf einer ersten Achse (X) parallel zu der geometrischen Achse des ersten hin- und hergehenden Kolbens (31) liegt und die Trägheitskräfte relativ zu diesem ersten Kolben (31) sowie die Komponente der Trägheitskraft des exzentrischen Abschnitts, die auf dieser ersten Achse (X) liegt, ausgleicht, und die auch eine Komponente aufweisen, die auf einer zweiten Achse (Y) parallel zur geometrischen Achse des zweiten hin- und hergehenden Kolbens (32) liegt und die Trägheitskräfte relativ zu diesem zweiten Kolben (32) sowie die zugeordnete Komponente der Trägheitskraft des exzentrischen Abschnitts (11) auf dieser zweiten Achse (Y) ausgleicht, **dadurch gekennzeichnet,** daß die Gegengewichtsmittel (13) in die rotierende Masse der Kurbelwelle (6) eingelassen sind, daß das Gehäuse des Verdichters hermetisch ausgebildet ist, und daß der zweite Zylinder (22) und der zweite hin- und hergehende Kolben (32) nur zum Ausgleich der Kräfte dienen, die auf die Baueinheit erster Zylinder (21) - erster hin- und hergehender Kolben (31) während des Kompressionsvorganges wirken.

2. Verdichter nach Anspruch 1, dadurch gekennzeichnet, daß der zweite Zylinder (22) in den Zylinderblock eingelassen ist.

3. Verdichter nach Anspruch 2, dadurch gekennzeichnet, daß die Baueinheiten hin- und hergehender Kolben - Kolbenstange (22,32) so ausgebildet sind, daß sie identische Trägheitseffekte aufweisen.

Revendications

1. Un compresseur à pistons du type comprenant un carter, un bloc-cylindres monté dans le carter et définissant un premier et un second cylindre (21, 22), un premier piston (31) qui se déplace en va-et-vient à l'intérieur dudit premier cylindre (21) et qui est monté fonctionnellement sur une partie excentrée (11) d'un vilebrequin (6), un second piston (32) qui se déplace en va-et-vient à l'intérieur du second cylindre (22) et qui est monté fonctionnellement sur ladite partie excentrée (11), ledit second cylindre

(22) étant positionné à 90° par rapport au premier cylindre (21), et comprenant en outre un moyen formant contrepoids (13) placé dans une position diamétralement opposée à la partie excentrée (11) dudit vilebrequin et conçu de telle sorte que sa force d'inertie présente une composante qui est projetée sur un premier axe (X) parallèle à l'axe géométrique du premier piston (31) à mouvement de va-et-vient et équilibre les forces d'inertie dudit premier piston (31) ainsi que la composante de force d'inertie de la partie excentrée projetée sur ledit premier axe (X), et présente également une composante projetée sur un second axe (Y), parallèle à l'axe géométrique du second piston (32) à mouvement de va-et-vient, qui équilibre les forces d'inertie dudit second piston (32) ainsi que la composante correspondante de la force d'inertie de la partie excentrée (11) projetée sur ledit second axe (Y), caractérisé en ce que le moyen formant contrepoids (13) est intégré dans la masse tournante du vilebrequin (6), en ce que le carter du compresseur est hermétique et en ce que le second cylindre (22) et le second piston (32) à mouvement de va-et-vient ne servent qu'à équilibrer les forces s'exerçant sur l'ensemble constitué par le premier cylindre (21) et le premier piston (31) à mouvement de va-et-vient, pendant le fonctionnement du compresseur.

2. Compresseur selon la revendication 1, caractérisé en ce que le second cylindre (22) est intégré dans le bloc-cylindres.

3. Compresseur selon la revendication 2, caractérisé en ce que les ensembles piston à mouvement de va-et-vient/bielle (22, 32) sont conçus de telle sorte qu'ils aient des effets inertiels identiques.

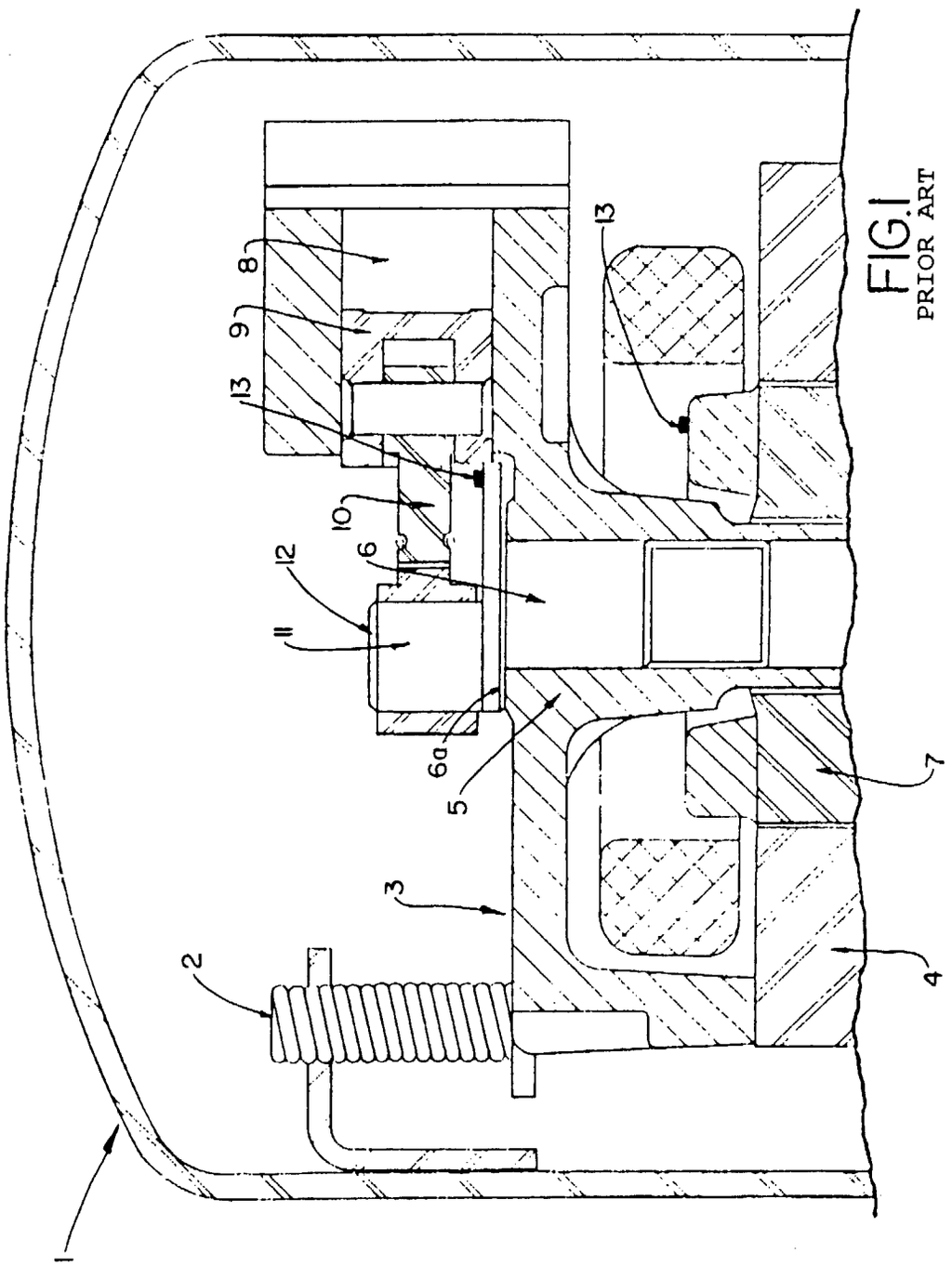


FIG.1
PRIOR ART

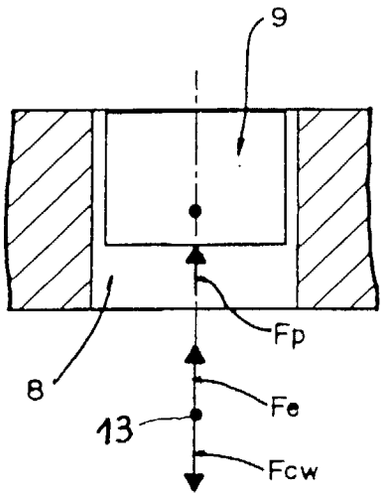


FIG.2
PRIOR ART

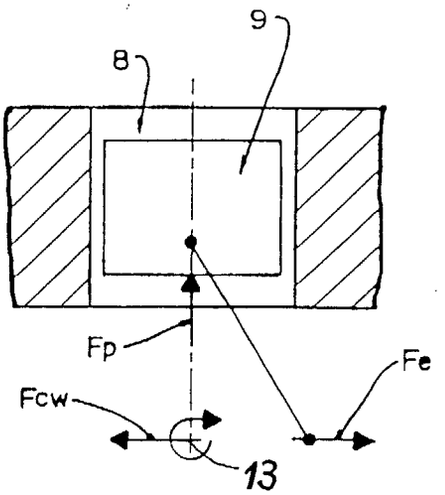


FIG.3
PRIOR ART

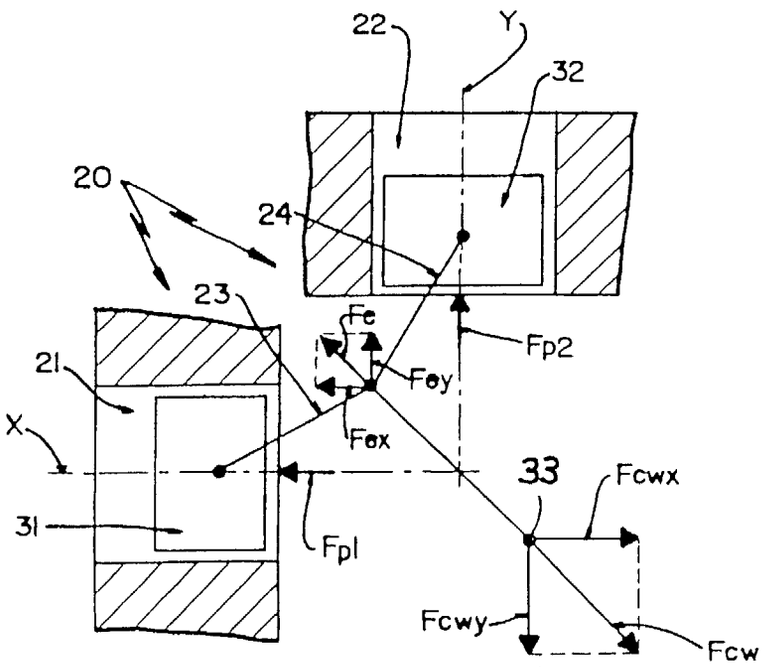


FIG.4