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(54) **DRIVING ROD FOR THE PISTON OF A RECIPROCATING COMPRESSOR**

SCHUBSTANGE FÜR DEN KOLBEN EINES HUBKOLBENVERDICHTERS

TIGE D'ENTRAINEMENT DESTINEE AU PISTON D'UN COMPRESSEUR ALTERNATIF

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(56) References cited:
US-A- 5 525 845

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Description

Field of the invention

[0001] The present invention refers to a driving rod to be applied to a reciprocating compressor with an electric motor of the rotary or linear type, said driving rod being constructed to operatively couple a driving means to a piston to be reciprocated in the interior of a compression chamber of the compressor, according to the axis of said chamber.

Prior Art

[0002] The reciprocating compressors that are driven by a rotary or linear electric motor generally comprise a cylinder block defining, internally, a compression chamber inside which axially reciprocates a piston coupled to a driving means mounted to the cylinder block and operatively associated with the electric motor of the compressor.

[0003] The piston is coupled to the driving means so as to allow forces to be transferred therebetween and to make the piston move inside the compression chamber according to an axial direction coinciding with the axis of said compression chamber in order to minimize the transversal reaction forces of the cylinder block against the piston inside the compression chamber. As known, the transversal reaction forces of the cylinder block against the piston can provoke excessive friction between the piston and the cylinder block, leading to an increase of energy consumption, consequently reducing the efficiency of the compressor, and to an accelerated wear of the components submitted to high friction levels, reducing the useful life of the compressor.

[0004] A known reciprocating compressor with a linear electric motor, as illustrated in figure 1 of the appended drawings, comprises a cylinder block 10 defining, internally, a compression chamber 11 presenting an axis 12 and with a piston 20 axially reciprocating therewithin. The compression chamber 11 has an end that is generally closed by a valve plate 13 and by a cylinder head 14, the valve plate 13 being provided with a suction valve 13a and a discharge valve 13b of adequate construction to control the admission and discharge of gas in relation to the compression chamber 11 upon the movement of the piston 20.

[0005] In the known construction illustrated in figure 1, the piston 20 is operatively coupled to a driving means DM, which in the case of a compressor with a linear electric motor, comprises an actuator 30 in the form of a tubular structure, concentric and external to the compression chamber 11 and carrying a magnetic element 31 to be operatively impelled, with the actuator 30, upon the energization of a linear electric motor 40 mounted to the cylinder block 10 around the compression chamber 11. In this example, the driving means further comprises a set of springs 60 mounted between the cylinder block 10 and the piston 20.

[0006] To the piston 20 is directly or indirectly coupled an end of a driving rod 50 whose opposite end is coupled to the springs 60, helical springs for example, which are mounted in such a way as to exert opposite axial forces on the piston 20 upon its axial reciprocating movement in the interior of the compression chamber 11 provoked by the driving means DM comprising the actuator 30 and the springs 60. The piston 20, the actuator 30 and the springs 60 form the resonant assembly of the compressor with a linear motor.

[0007] These compressors are designed and constructed so that the axis of the axial reciprocating movement of the piston 20 coincides with the axes of both the piston 20 and the compression chamber 11, aiming at minimizing or even suppressing the transversal reaction forces between the piston 20 and the cylinder block 10. However, in use, said axes can become misaligned and thus undesirable transversal reaction forces may occur between the piston 20 and the cylinder block 10 by reason of some constructive characteristics inherent to the compressors, such as the geometrical errors in the construction of the helical springs and the transversal rigidity thereof when they are axially and elastically deformed. Besides the aspects above, one should consider the fact that misalignments commonly occur in the construction and assembly of mechanical components, as perfection is not usually reached in terms of dimensions and forms of the different components of a mechanical device.

[0008] In the construction illustrated in figure 1, the driving rod 50 has the form of a generally tubular and transversally rigid axial rod, whereby the piston-actuator assembly behaves as a single body onto which are applied magnetic axial forces of the linear motor 40 which do not produce, over the piston 20, transversal components capable of causing excessive friction between said piston 20 and the cylinder block 10.

[0009] However, the springs 60 exert over the piston-actuator assembly, not only the axial forces resulting from the compression thereof during the movement of the piston 20, but also transversal forces whose intensity varies as a function of the errors of construction and assembly of the springs 60. Such undesirable transversal forces, produced by the operational deformation of the springs, tend to misalign the piston 20 in relation to the axis of the compression chamber 11, giving rise to transversal reaction forces of the cylinder block 10, as well as a consequent higher friction between the latter and the piston 20 axially reciprocating within the compression chamber 11.

[0010] Patent US 5,525,845, from Sumpower Inc., describes a constructive solution for the problem cited above, according to which the driving rod, which can be mounted in different manners between the piston and the driving means, is constructed so as to present a required axial rigidity and also a transversal flexibility sufficient to prevent all the transversal forces acting on the piston, including the force exerted by the driving rod itself, from surpassing the centralizing transversal forces applied to the piston by a pneumatic bearing provided between the latter and the cylinder block.

[0011] This prior solution uses a single-piece driving rod dimensioned to present the necessary axial rigidity and a transversal flexibility in a degree compatible with the centralizing transversal forces produced on the piston by the pneumatic bearing. Said prior art solution do not permit an adequate flexibility in the dimensioning' of the driving rod in relation to compressors in which the axial force to be transmitted or supported by the driving rod requires a cross-section area for the latter which hinders, in the length available for the single-piece driving rod, the latter from presenting the desired transversal flexibility. The use of multiple rods is suggested (figure 8) only in a spaced-apart relationship, each rod being dimensioned to present the desired characteristics of axial rigidity and transversal flexibility. This is a complex construction, requiring the provision of the pneumatic bearing to maintain the piston adequately centralized in the compression chamber.

[0012] It should be further noted that the provision of multiple rods disposed spaced apart and symmetrical in relation to the axis of the compression chamber, as suggested in figure 8 of patent US 5,525,845, does not eliminate completely the deficiencies already discussed in relation to the single-piece driving rod. The proposed prior arrangement provides a plurality of rods spaced from each other, connecting the set of flat springs of a linear motor compressor with the structure that supports the cylinder block. These multiple rods can be dimensioned to provide, jointly, the necessary rigidity and the desired degree of flexibility in the transversal direction. However, due to the fact of being spaced apart, said prior art multiple rods do not absorb transversal forces produced by angular misalignments of the axis of the driving means in relation to the axis of the compression chamber. Such misalignments are not absorbed by the spaced-apart rods, since the latter would have to be axially deformed, partially by expansion and partially by construction. On the other hand, the required axial rigidity of the rods prevents them from being dimensioned to bend, reducing their length upon the occurrence of said angular misalignments.

[0013] As illustrated in figure 2 of the appended drawings, the reciprocating compressors with a connecting rod-crankshaft mechanism driven by a rotary motor also present problems related to geometrical and assembly errors. Such compressors also comprise a cylinder block 10 defining, internally, a compression chamber 11 with a reciprocating piston 20 axially moving therewithin. The compression chamber 11 presents an axis 12 and an end closed by a valve plate 33 provided with a suction valve 13a and a discharge valve 13b, and a cylinder head 14.

[0014] In the compressor of the type illustrated in figure 2, the piston 20 is driven by a driving means DM, in the form of a crankshaft 35, rotatively supported in the cylinder block and mounted to a rotary motor (not illustrated), the crankshaft having an end receiving the larger eye of a driving rod 50 in the form of a connecting rod, whose smaller eye is rotatively supported on the known diametrical articulating pin 21 inside the piston 20.

[0015] In the reciprocating compressors with a connecting rod-crankshaft mechanism, geometrical and assembly errors, as exaggeratedly illustrated in figure 2, can lead to the transmission of reaction forces FR transversal to the axis 12 of the compression chamber 11, a situation in which the piston 20 tends to work misaligned with said axis 12. These reaction forces FR, acting mainly in the direction of the articulating pin 21 of the piston 20, tend to produce undesirable levels of friction between the piston 20 and the cylinder block 10, increasing the consumption of energy in the operation of the compressor as well as the wear of the mutually frictional parts, reducing the reliability and the useful life of the machine. Also in this type of compressor, the solution taught by the prior art is to dimension the driving rod 50 with a cross-section which, in the length defined in the compressor project, leads to the necessary axial rigidity of the driving rod, so that the latter can withstand the transmission of forces between the driving means DM (crankshaft) and the piston 20, but which however gives to the driving rod 50, in the form of a connecting rod, a flexibility in a transversal direction which minimizes the transmission of moment to the piston 20.

[0016] While being of low cost and easy to execute, said construction, as already mentioned in relation to the driving rod of the linear motor compressors, makes the dimensioning of the cross-section a problematic task due to the length limitations of the driving rod and to the degree of transversal flexibility required to reduce the transmission of moments to the piston 20 to desirable levels.

<u>Summary of the invention</u>

[0017] Due to the dimensioning limitations of the cross-section of the driving rods of the reciprocating compressors with a linear or rotary motor, it is the object of the present invention to provide a driving rod presenting a construction that allows obtaining a flexibility, in at least one transversal direction, as well as an axial rigidity which can comply with the requirements of the compressor project regardless of the length defined for the driving rod.

[0018] The driving rod proposed by the present invention offers a simple solution that is easy to implement in the construction of reciprocating compressors, particularly those of the hermetic type used is refrigeration systems of household electric appliances in which the piston is designed to be axially displaced in a reciprocating movement inside a compression chamber, without being submitted to transversal reaction forces of the cylinder block caused by the acceptable geometrical or assembly errors of the component parts involved, but which are sufficiently relevant to cause friction that abbreviates the useful life of the compressor.

[0019] In order to attain the object cited above, the present driving rod comprises a bundle of "n" rods arranged side by side along the axis of the driving rod, each rod presenting a cross-section that is dimensioned and configured to impart to the driving rod, jointly with the other rods, an axial rigidity sufficient to transmit the reciprocating forces between the driving means and the piston, and a flexibility, in at least one transversal direction to the axis of the driving rod, sufficient to absorb, at least substantially, the forces applied to the piston, in said transversal direction, by both the driving rod and the driving means in the region of the compression chamber.

[0020] According to the solution proposed by the invention, the number and the cross-section of the rods that form the driving rod can be defined to impart to the latter optimized axial rigidity and transversal flexibility so that the reciprocating movement of the piston inside the compression chamber of the cylinder block occurs with little or no friction that abbreviates the useful life of the compressor.

<u>Brief description of the drawings</u>

[0021] The invention will be described below, with reference being made to the appended drawing, given by way of example of ways of carrying out the invention and in which:

Figure 1 is a schematic and simplified longitudinal sectional view of the cylinder block and the resonant assembly of a reciprocating compressor driven by a linear motor and in which the driving rod is constructed according to the prior art;

Figure 2 is a schematic and simplified longitudinal sectional view of the cylinder block of a reciprocating compressor driven by a rotary motor, by a crankshaft and by a driving rod in the form of a connecting rod constructed according to the prior art, with the piston being exaggeratedly misaligned in the interior of the compression chamber;

Figure 3 is a schematic and simplified longitudinal sectional view of the cylinder block and the resonant assembly of a reciprocating compressor driven by a linear motor and presenting a driving rod constructed according to the present invention;

Figure 4 is a perspective view of driving rod formed by a plurality of parallel rectilinear rods, with a circular cross-section and laterally seated to each other;

Figure 5 is a similar view to that of figure 4, but illustrating the rods disposed in a helical arrangement;

Figure 6 is a rather schematic perspective view of a median portion of a driving rod formed by a plurality of rods surrounded by a sleeve in the form of an elastic ring;

Figure 7 is a perspective view of the driving rod illustrated in figure 4, with the rods being surrounded by a sleeve in the form of a helical spring;

Figure 8 is a view similar to that of figure 7, but with the sleeve defined by a tube extension mounted around the rods of the driving rod;

Figure 9 is a perspective view of a driving rod with the opposite end of its rods being jointly affixed to respective terminal blocks;

Figure 10 is a longitudinal sectional view of a terminal block inside which are mounted the respective ends of the rods of a partially illustrated driving rod;

Figure 11 is an exploded perspective view of a driving rod formed by multiple rods, with two end terminal blocks;

Figure 12 is a longitudinal sectional view of the terminal block illustrated in figure 11 and inside which are secured the respective ends of the rods of the partially illustrated driving rod;

Figure 13 is a perspective exploded view of a terminal block and the respective end of a driving rod formed by multiple rods;

Figure 14 is a perspective view of a driving rod formed by a plurality of rods with a rectangular cross-section, with opposite ends being affixed to eyes to be respectively mounted to a piston and to a crankshaft of the compressor; and

Figure 15 is a cross-sectional view of the driving rod illustrated in the previous figure.

<u>Detailed Description of the Invention</u>

[0022] As already mentioned, the construction of the driving rod of the present invention is designed to be applied to reciprocating compressors driven by a linear motor or by a rotary motor.

[0023] Figure 3 illustrates, basically, the same elements that constitute a reciprocating compressor with a linear motor, contained in figure 1 and identified by the same reference numbers, constructive differences existing only in relation to the construction and assembly of the driving rod 50.

[0024] According to figure 3, the driving means DM is defined by an actuator 30 and by a pair of springs 60, the actuator 30 comprising a basic structure 30a, transversal to the axis 12 of the compression chamber 11 and incorporating an internal tubular projection 30b, rigidly secured to the piston 20, and an external tubular projection 30c that carries the magnetic element 31, the driving rod 50 being constructed so as to have an end secured to the piston 20 and an opposite end secured to a support 70 to which are mounted the adjacent ends of two springs 60, which in the illustrated construction have a helical form concentric to the axis 12 of the compression chamber 11, the opposite ends of the two springs 60 being mounted to the cylinder block 10, so that the springs 60 can exert, over the support 70, opposite axial forces to be transmitted to the piston 20 by the driving rod 50 disposed according the axis 12 of the compression chamber 11.

[0025] The support 70 can be constructed in different manners, but bearing in mind the necessity of its axial reciprocating movement, in conjunction with the piston 20 and with the adjacent ends of the springs 60, being effected with no interference of the driving means 30. In the illustrated exemplary construction, the support 70 comprises a pair of shoes 71 disposed in planes that are parallel to each other, orthogonal to the axis 12 of the compression chamber 11 and located on opposite sides of the basic structure 30a of the actuator 30, said shoes 71 being axially interconnected by spacers 72 disposed through respective windows 33 provided in the basic structure 30a of the actuator 30.

[0026] The exemplary construction illustrated in figure 3 makes the transversal forces produced by the springs 60, when the latter are elastically and axially deformed, to have the tendency to be transferred to the piston 20 through the driving rod 50.

[0027] According to the invention, in order to absorb the expected transversal forces produced by the springs 60, the driving rod 50 comprises a bundle "n" of rods 51 disposed side by side along the displacement axis of the piston 20, each rod 51 presenting a cross-section that is dimensioned and configured to impart to the driving rod 50, jointly with the other rods 51, an axial rigidity that is sufficient to transmit the axial forces to be applied to the piston 20 by the springs 60 upon movement of the actuator 30, as well as a flexibility, in at least one direction transversal to the axis of the driving rod 50, which is sufficient to absorb, at least substantially, the forces exerted over the piston 20, in said transversal direction, by the driving rod 50 and by the driving means DM in the region of the compression chamber 11. The construction of the driving rod 50 in the form of a bundle of rods 51 in an adequate material, usually steel, allows each rod 51 to be dimensioned with a cross-section area that corresponds to 1/n of a cross-section area necessary to give to the driving rod 50, in the length determined in project, an axial rigidity sufficient to withstand the required transmission of axial forces between the piston 20 and the driving means DM, which in the construction illustrated in figures 3-13, comprises the actuator 30 and the springs 60.

[0028] Besides the characteristics above, the cross-section of the rods 51 should be dimensioned and configured so that the sum of the moments of inertia of the rods 51, in the determined transversal direction, is an integer fraction of the moment of inertia, of said transversal direction, of a single piece driving rod having a cross-section area corresponding to the sum of the cross-section areas of the rods 51.

[0029] In the constructions illustrated in figures 4-13, in which the rods 51 present the same circular cross-section, the transversal flexibility of the driving rod 50 is equally achieved in any direction transversal to the axis of said driving rod 50.

[0030] In the case of rods 51 with the same circular cross-section, the sum of the moments of inertia of the rods 51, in the axial direction, corresponds to a fraction "n" of the moment of inertia, in the same axial direction, of a single-piece driving rod 50 with its cross-section area corresponding to the sum of the cross-section areas of the "n" rods 51, as explained below, considering:

- A1 as being the circular cross-section area of a single-piece driving rod;
- A2 as being the circular cross-section area of each of the rods 51 of a driving rod formed by a bundle of "n" rods 51;
- K1 e K2 as being the transversal rigidity of the single-piece driving rod and of each rod 51, respectively;
- K2 res. as being the resultant transversal rigidity of the bundle "n" of rods 51;
- R1 e R2 as being the radiuses of the single-piece driving rod and of the driving rod defined by multiple rods 51, respectively; and
- I as being the moment of inertia of each rod 51 in the transversal direction.
- Thus:

$$A_2 = \frac{A_1}{n} \Rightarrow \pi R_2^2 = \frac{\pi R_1^2}{n} \Rightarrow R_2 = \sqrt{\frac{R_1^2}{n}} \; ou \; R_2 = \frac{R_1}{\sqrt{n}}$$

[0031] Rigidity (K) proportional to the moment of inertia

$$(I) = \frac{\pi R^4}{4} = \frac{\pi D^4}{64}$$

K_1 *proportional* R_1^4

$$K_2 proportional\, R_2^4 = \left(\frac{R_1}{\sqrt{n}}\right)^4 \; for\ a\ rod$$

$$K_2 res. = \sum\nolimits_n K_2$$

$$K_2 res. = \frac{n.R_1^4}{n^2} = \frac{R_1^4}{n}$$

Resulting

[0032] Thus, the transversal rigidity (K2 res.) of the bundle of "n" rods 51 of circular section will correspond only to a fraction "n" of the transversal rigidity (K1) of a single-piece driving rod, with a cross-section area (A1) of the "n" rods 51 that form the bundle that defines the driving rod.

[0033] As illustrated in figures 4, 5, 7, 8, 11 and 13, the rods 51 are symmetrically disposed around the axis of the driving rod 50 and being usually rectilinear and parallel to each other. In the construction illustrated in figure 5, the rods 51 are provided in a helical arrangement, symmetrically disposed in relation to said axis and around the length of the driving rod 50.

[0034] In case the project of the driving rods 50 leads to a larger number "n" of thinner rods 51, i.e., with a reduced cross-section, one or more rods 51 of the bundle of rods submitted to axial forces may be deformed, provoking collapse of the driving rod. In these cases, the rods 51 of the bundle can be jointly and medianly surrounded by one or more sleeves 80, occupying part of the longitudinal extension of the driving rod 50. In figure 6, the sleeve 80 takes the form of an elastic ring 81, in a metallic of elastomeric material and dimensioned to press the rods

$$\frac{K_2 res.}{K_1} = \frac{\frac{R_1^4}{n}}{R_1^4} = \frac{1}{n} \qquad K_2 res. = \frac{K_1}{n}$$

51, one against the others. In figure 7, the sleeve 80 is defined by a helical spring 82, metallic or elastomeric and which is tightly mounted around the bundle of rods 51 of the driving rod 50. In figure 8, the sleeve is defined by a tube extension 83, also made of any adequate material to impart to the driving rod 50 a certain transversal flexibility and which is mounted, with a small clearance, around the bundle of rods 51.

[0035] As illustrated in figures 9-14, the rods 51 present opposite ends which define the ends of the driving rod 50 and which are jointly secured in respective terminal blocks 90 which may present different constructions in different metallic or non-metallic materials;

[0036] In the case of the driving rods 50 applied to the compressors driven by linear motors, the terminal blocks 90 are configured to define the mounting means of the driving rod 50 in the piston 20 and in the support 70 of the springs 60.

[0037] In the embodiment illustrated in figures 9 and 10, each terminal block 90 comprises a tubular body 91 that is usually externally threaded and incorporates an enlarged end head 91a, preferably in the form of a hexagonal end nut turned to the rods 51 and presenting, internally, a housing 91b axially defined through the enlarged end head 91a and through at least part of the length of the tubular body 91. This constructive arrangement, also illustrated in figure 3, allows the terminal blocks 90 to have the tubular body 91 thereof threaded in a corresponding threaded orifice 23, 73 provided in the piston 20 and in the support 70, respectively (figure 3). In the constructive arrangement illustrated in figure 10, the ends of the bundle of rods 51 are preferably tightly fitted and affixed by processes such as interference, welding, gluing, mechanical riveting or any other adequate process in the interior of the housing 91b of the respective tubular body 91.

[0038] In the embodiment of figures 11 and 12, the terminal blocks 90 comprise an elongated body 92 externally threaded and incorporating an enlarged end head 92a. However, in this construction, the ends 52 of the rods 51 are laterally curved, so that the terminal blocks 90 can be molded or injected in aluminum, plastic or any other adequate material, directly on said ends 52, guaranteeing the necessary mechanical anchorage between the driving rod 50 and the terminal blocks 90. In the embodiment illustrated in figure 13, each terminal block is formed by a pair of plates 93 to be secured to each other, sandwiching a respective end of the rods 51. One or both the plates 93 are internally provided with a recess 93a configured to receive and fit a respective cross-section portion of an extension of the adjacent end of the bundle of rods 51, said extension being laterally curved or bent to facilitate locking the end of the driving rod 50 in each terminal block 90.

[0039] The plates 93 of each pair are preferably provided with orifices 93b for the passage of tightening screws (not illustrated).

[0040] As already mentioned above and illustrated in figures 14 and 15, the driving rod 50 can be designed in the form of a connecting rod to operate in a reciprocating compressor of the type in which the piston 20 is driven by a driving means DM in the form of a crankshaft 35 (see figure 2). In this type of construction, the terminal blocks 90 of the driving rod 50 are defined by eyes 94 to be respectively rotatively supported around the articulating pin 21 of both the piston 20 and the crankshaft 35.

[0041] In the assemblies in which the actuator 30 is defined by a crankshaft 35, the driving rod 50 comprises a number "n" of rectilinear parallel rods 51 which are laterally seated in relation to each other, each rod 51 having a rectangular cross-section with a dimension L corresponding to a dimension "L" of the rectangular cross-section of a single-piece driving rod and with the other dimension "h" corresponding to the fraction "n" of the other dimension "H" of the cross-section of said single-piece driving rod. Thus, the same rectangular cross-section area of each rod 51 corresponds to the fraction "n" of the cross-section area of said single-piece driving rod. The same ratio is applied to the relation between the moment of inertia, in the axial direction of each rod 51 and the moment of inertia in the axial direction of the single-piece driving rod. The sum of the cross-section areas of the rods 51 corresponds to the cross-section area of said reference single-piece driving rod. Thus, the driving rod 50 with "n" rods 51 has an axial rigidity equivalent to that obtained with the driving rod formed by only one rod having a cross-section area corresponding to the sum of the cross-section areas of the "n" rods 51 of the driving rod 50 with multiple rods.

[0042] In the construction of figures 14 and 15, in which the rods 51 have a rectangular section, the moment of inertia of each rod 51 in the transversal direction, parallel to the larger dimension "L", corresponds to the moment of inertia, in the same direction, of a single-piece driving rod with the same cross-section dimension "L". It should be noted that the driving rod 50 is mounted so that said transversal direction is orthogonal to the axis of the articulating pin 21 of the piston 20. The articulation of the driving rod 50 to the piston 20 allows the latter to stay in a coaxially aligned position in the compression chamber 11, independently of the relative angular positioning of the driving rod 50.

[0043] However, in the direction of the other dimension "h" of the rectangular cross-section of the rods 51, which direction is parallel and coplanar to the axis of the articulating pin 21 of the piston 20, the sum of the moments of inertia of the rods 51 in said other direction, orthogonal to the anterior direction, corresponds to a fraction "n2" of the moment of inertia, in the same transversal direction, of a single-piece driving rod, with the corresponding cross-section dimension "L", in the same direction, being equal to the sum of the dimensions "h" of the rods 51 in the same direction, as exposed below, and further considering:

- A1 as being the rectangular cross-section area of a single-piece driving rod;
- A2 as being the rectangular cross-section area of each one of the rods 51 of a driving rod formed by a bundle of "n" rods 51;
- K1 e K2 as being the transversal rigidity of the single-piece driving rod and of each rod 51 of the driving rod with "n" rods 51, respectively;
- K2res. as being the resultant rigidity of the bundle of "n" rods 51, in said transversal direction; and
- I1 e I2 as being the moments of inertia of the single-piece driving rod and of each rod 51, in said transversal direction, respectively.

[0044] Thus:

$$A_2 = \frac{A_1}{n} = L \, . \frac{H}{n} \quad e \quad h = \frac{H}{n}$$

[0045] Considering that the single-piece driving rod and the rods 51 of the driving rod 50 with multiple rods present the same dimension "L" for the larger side of the rectangular cross-section.

$$Rigidity(K) proportional\ I = \frac{L \, . h^3}{12}$$

$$I_1 = \frac{L \, . \, H^3}{12} \quad e \quad I_2 = \frac{L \, . \, h^3}{12} = \frac{L}{12} \, . \, \frac{H^3}{n^3}$$

$$K_2 res. = \sum_n K_2 \ proportion\,al \ n \, . \, I_2 = n \, . \, \frac{L}{12} \, . \, \frac{H^3}{n^3}$$

resulting

$$\frac{K_2 res.}{K_1} = \frac{\frac{L}{12} \, . \, \frac{H^3}{n^2}}{\frac{L}{12} \, . \, H^3} = \frac{1}{n^2}$$

$$K_2 \ res. = \frac{K_1}{n^2}$$

[0046] Thus, the transversal rigidity (K2res.) of the bundle of "n' rods 51 with a rectangular section will correspond only to a fraction "n2" of the transversal rigidity (K1) of a single-piece driving rod presenting a cross-section area (A1) corresponding to the sum of the cross-section areas (A2) of the "n" rods 51 that form the bundle that defines the driving rod 50 of the invention, as well as a cross-section dimension "H", in said direction, corresponding to the sum of the corresponding cross-section dimensions (h) of the rods 51 that form the driving rod 50.

[0047] It should be understood that the bundle of rods 51 of the driving rod 50 illustrated in figures 14 and 15 could be surrounded by at least one sleeve 80 constructed according to any one of the forms described in relation to figures 6, 7 and 8.

Claims

1. A driving rod for the piston of a reciprocating compressor of the type that comprises: a cylinder block (10) defining, therewithin, a compression chamber (11); a piston (20) axially reciprocating within the compression chamber (11) according to the axis of the latter; a driving means (DM) mounted in the cylinder block (10) to apply reciprocating forces to the piston (20); and a driving rod (50) coupled to the piston (20) and to the driving means (DM), **characterized in that** the driving rod (50) comprises a bundle of "n" rods (51) disposed side by side along the axis of the driving rod (50), each rod (51) presenting a cross-section that is dimensioned and configured to impart to the driving rod (50), jointly with the other rods (51), an axial rigidity sufficient to transmit the reciprocating forces to be applied to the piston (20), as well as a flexibility, in at least one direction transversal to the axis of the driving rod (50), which is sufficient to absorb, at least substantially, the forces exerted on the piston (20), in said transversal direction, by the driving rod (50) and by the driving means (DM) in the region of the compression chamber (11).

2. The driving rod as set forth in claim 1, **characterized in that** each one of the rods (51) present a cross-section area corresponding to 1/n the cross-section area needed to impart to the driving rod (50) the sufficient axial rigidity, the cross-section of the rods (51) being dimensioned and configured so that the sum of the moments of inertia of the rods (51), in said transversal direction, is a fraction of the moment of inertia, in said transversal direction, of a single-piece driving rod having a cross-section area corresponding to the sum of the cross-section areas of the rods (51).

3. The driving rod as set forth in claim 2, **characterized in that** the sum of the moments of inertia of the rods (51) corresponds to a fraction "n" of the moment of inertia of a single-piece driving rod (50) with a cross-section area corresponding to the sum of the cross-section areas of the rods (51).

4. The driving rod as set forth in claim 2, **characterized in that** the sum of the moments of inertia of the rods (51) corresponds to a fraction "n2" of the moment of inertia of a single-piece driving rod (50) with a cross-section area corresponding to the sum of the cross-section areas of the rods (51).

5. The driving rod as set forth in claim 2, **characterized in that** the rods (51) are symmetrically disposed around the displacement axis of the piston (20) and laterally seated to each other.

6. The driving rod as set forth in claim 5, **characterized in that** the rods (51) are rectilinear and parallel to each other.

7. The driving rod as set forth in claim 5, **characterized in that** the rods (51) are disposed in a helical arrangement.

8. The driving rod as set forth in claim 5, **characterized in that** the rods (51) present a circular cross-section with equal flexibility in any transversal direction.

9. The driving rod as set forth in claim 2, **characterized in that** the rods (51) are rectilinear, parallel and laterally seated to each other, each rod (51) having a rectangular cross-section with a dimension corresponding to a dimension (L) of the rectangular cross-section of a single-piece driving rod, and with the other dimension (h) corresponding to the fraction "n" of the other dimension (H) of the cross-section of said single-piece driving rod, the cross-section of the latter corresponding to the sum of the cross-section areas of the "n" rods (51) of the driving rod with multiple rods (51).

10. The driving rod as set forth in claim 2, **characterized in that** the rods (51) are jointly and medianly surrounded by at least one sleeve (80) occupying part of the longitudinal extension of the driving rod (50).

11. The driving rod as set forth in claim 10, **characterized in that** the sleeve (80) is defined by an elastic ring (81) pressing the rods (51) against each other.

12. The driving rod as set forth in claim 10, **characterized in that** the sleeve (80) is defined by a helical spring (82) tightly mounted around the rods (51) of the driving rod (50).

13. The driving rod as set forth in claim 10, **characterized in that** the sleeve (80) is defined by a tube extension (83) mounted with a small clearance around the rods (51) of the driving rod (50).

14. The driving rod as set forth in claim 2, **characterized in that** the rods (51) present opposite ends defining the ends of the driving rod (50), said rods (51) having each of the opposite ends jointly affixed to a terminal block (90).

15. The driving rod as set forth in claim 14, **characterized in that** each terminal block (90) comprises a tubular body (91) incorporating an enlarged end head (91a) turned to the rods (51) and presenting, internally, a housing (91b) axially defined through the enlarged end head (91a) and through at least part of the extension of the tubular body (91).

16. The driving rod as set forth in claim 15, **characterized in that** the tubular body (91) is externally threaded, the enlarged end head (91a) being in the form of a hexagonal nut.

17. The driving rod as set forth in claim 14, **characterized in that** the opposite ends (52) of the rods (51) are laterally curved, defining an anchorage deformation, each terminal block (90) being molded over one of the opposite ends (52) of the rods (51).

18. The driving rod as set forth in claim 17, **characterized in that** each terminal block (90) comprises an elongated body (92) incorporating an enlarged end head (92a) turned to the rods (51).

19. The driving rod as set forth in claim 18, **characterized in that** the elongated body (92) is externally threaded, the enlarged end head (92a) being in the form of a hexagonal nut.

20. The driving rod as set forth in claim 14, **characterized in that** the terminal blocks (90) are each formed by a pair of plates (93) to be affixed to each other, sandwiching a respective end of the rods (51).

21. The driving rod as set forth in claim 14, **characterized in that** the terminal blocks (90) are defined by eyes (94) of a driving rod (50) in the form of a connecting rod of a reciprocating compressor.

Patentansprüche

1. Eine Schubstange für den Kolben eines Hubkolbenverdichters der Art, die folgendes umfaßt: einen Zylinderblock

(10), der in seinem Inneren eine Verdichtungskammer (11) festlegt; einen Kolben (20), der in der Verdichtungskammer (11) axial entsprechend der Achse der letzteren hin- und herläuft; Antriebsmittel (DM), die im Zylinderblock (10) montiert sind, um hin- und hergehende Kräfte auf den Kolben (20) auszuüben; und eine Schubstange (50), die an den Kolben (20) und an die Antriebsmittel (DM) angeschlossen ist, **dadurch gekennzeichnet, daß** die Schubstange (50) ein Bündel von n-Stangen (51) umfaßt, die Seite an Seite entlang der Achse der Schubstange (50) vorgesehen sind, wobei jede Stange (51) einen Querschnitt aufweist, der so ausgelegt und gestaltet ist, daß er, gemeinsam mit den anderen Stangen (51), der Schubstange (50) eine axiale Steifigkeit verleiht, die ausreicht, um die hin- und hergehenden Kräfte zur Anwendung auf den Kolben (20) zu übertragen, ebenso wie eine Flexibilität in wenigstens einer Richtung quer zur Achse der Schubstange (50), die ausreichend ist, um zumindest im wesentlichen die Kräfte zu absorbieren, welche auf den Kolben (20) in dieser Querrichtung durch die Schubstange (50) und durch die Antriebsmittel (DM) im Bereich der Verdichtungskammer (11) ausgeübt werden.

2. Die Schubstange nach Anspruch 1, **dadurch gekennzeichnet, daß** jede einzelne der Stangen (51) eine Querschnittsfläche entsprechend dem 1/n-fachen der Querschnittsfläche aufweist, die erforderlich ist, um der Schubstange (50) die ausreichende axiale Steifigkeit zu verleihen, wobei der Querschnitt der Stangen (51) so bemessen und ausgelegt ist, daß die Summe der Trägheitsmomente der Stangen (51), in dieser Querrichtung, ein Bruchteil des Trägheitsmomentes, in dieser Querrichtung, einer einstückigen Schubstange ist, die eine Querschnittsfläche aufweist entsprechend der Summe der Querschnittsflächen der Stangen (51).

3. Die Schubstange nach Anspruch 2, **dadurch gekennzeichnet, daß** die Summe der Trägheitsmomente der Stangen (51) einem Bruchteil n des Trägheitsmomentes einer einstückigen Schubstange (50) mit einer Querschnittsfläche entsprechend der Summe der Querschnittsflächen der Stangen (51) entspricht.

4. Die Schubstange nach Anspruch 2, **dadurch gekennzeichnet, daß** die Summe der Trägheitsmomente der Stangen (51) einem Bruchteil n2 des Trägheitsmomentes einer einstückigen Schubstange (50) mit einer Querschnittsfläche entsprechend der Summe der Querschnittsflächen der Stangen (51) entspricht.

5. Die Schubstange nach Anspruch 2, **dadurch gekennzeichnet, daß** die Stangen (51) symmetrisch um die Verschiebeachse des Kolbens (20) und seitlich zu einander versetzt vorgesehen sind.

6. Die Schubstange nach Anspruch 5, **dadurch gekennzeichnet, daß** die Stangen (51) geradlinig und parallel zueinander vorgesehen sind.

7. Die Schubstange nach Anspruch 5, **dadurch gekennzeichnet, daß** die Stangen (51) in einer schraubenförmigen Anordnung vorgesehen sind.

8. Die Schubstange nach Anspruch 5, **dadurch gekennzeichnet, daß** die Stangen (51) einen kreisförmigen Querschnitt mit gleicher Flexibilität in jeder Querrichtung aufweisen.

9. Die Schubstange nach Anspruch 2, **dadurch gekennzeichnet, daß** die Stangen (51) geradlinig, parallel und seitlich zueinander versetzt vorgesehen sind, wobei jede Stange (51) einen rechteckigen Querschnitt aufweist mit einer Abmessung entsprechend einer Abmessung (L) des rechteckigen Querschnitts einer einstückigen Schubstange, und mit der anderen Abmessung (h) entsprechend dem Bruchteil n der anderen Abmessung (H) des Querschnitts dieser einstückigen Schubstange, wobei der Querschnitt der letzteren der Summe der Querschnittsflächen der n-Stangen (51) der Schubstange mit mehreren Stangen (51) entspricht.

10. Die Schubstange nach Anspruch 2, **dadurch gekennzeichnet, daß** die Stangen (51) gemeinsam und in der Mitte liegend von wenigstens einer Hülse (80) umgeben werden, die einen Teil der Längserstreckung der Schubstangen (50) belegt.

11. Die Schubstange nach Anspruch 10, **dadurch gekennzeichnet, daß** die Hülse (80) von einem elastischen Ring (81) festgelegt wird, der die Stangen (51) gegeneinander drückt.

12. Die Schubstange nach Anspruch 10, **dadurch gekennzeichnet, daß** die Hülse (80) von einer Schraubenfeder (82) festgelegt wird, die fest um die Stangen (51) der Schubstange (50) herum montiert ist.

13. Die Schubstange nach Anspruch 10, **dadurch gekennzeichnet, daß** die Hülse (80) von einem Rohrabschnitt (83) festgelegt wird, der mit einem kleinen Spiel um die Stangen (51) der Schubstange (50) herum montiert ist.

14. Die Schubstange nach Anspruch 2, **dadurch gekennzeichnet, daß** die Stangen (51) einander gegenüberliegende Enden aufweisen, welche die Enden der Schubstange (50) festlegen, wobei die Stangen (51) mit jedem der einander gegenüberliegenden Enden gemeinsam an einem Anschlußblock (90) befestigt sind.

15. Die Schubstange nach Anspruch 14, **dadurch gekennzeichnet, daß** jeder Anschlußblock (90) einen rohrförmigen Körper (91) umfaßt, der einen vergrößerten Endkopf (91a) enthält, welcher den Stangen (51) zugewandt ist und in seinem Inneren ein Gehäuse (91b) aufweist, das axial durch den vergrößerten Endkopf (91a) und durch zumindest einen Teil der Erstreckung des rohrförmigen Körpers (91) hindurch festgelegt ist.

16. Die Schubstange nach Anspruch 15, **dadurch gekennzeichnet, daß** der rohrförmige Körper (91) an seiner Außenseite mit einem Gewinde versehen ist, wobei der vergrößerte Endkopf (91a) in Form einer Sechskantmutter ausgebildet ist.

17. Die Schubstange nach Anspruch 14, **dadurch gekennzeichnet, daß** die einander gegenüberliegenden Enden (52) der Stangen (51) seitlich gekrümmt ausgebildet sind, wobei sie eine Verankerungsverformung festlegen, und wobei jeder Anschlußblock (90) über eines der einander gegenüberliegenden Enden (52) der Stangen (51) aufgeformt ist.

18. Die Schubstange nach Anspruch 17, **dadurch gekennzeichnet, daß** jeder Anschlußblock (90) einen länglichen Körper (92) umfaßt, der einen vergrößerten Endkopf (92a) aufweist, welcher zu den Stangen (51) hin gewendet ist.

19. Die Schubstange nach Anspruch 18, **dadurch gekennzeichnet, daß** der längliche Körper (92) an seiner Außenseite mit einem Gewinde versehen ist, wobei der längliche Endkopf (92a) in Form einer Sechskantmutter ausgebildet ist.

20. Die Schubstange nach Anspruch 14, **dadurch gekennzeichnet, daß** jeder der Anschlußblöcke (90) von einem Paar von Platten (93) zur Befestigung aneinander ausgebildet ist, wobei sie ein entsprechendes Ende der Stangen (51) zwischen sich festhalten.

21. Die Schubstange nach Anspruch 14, **dadurch gekennzeichnet, daß** die Anschlußblöcke (90) von Augen (94) einer Schubstange (50) in Form einer Pleuelstange eines Kolbenverdichters festgelegt werden.

Revendications

1. Tige d'entraînement pour le piston d'un compresseur alternatif du type qui comprend : un bloc cylindres (10) définissant, à l'intérieur, une chambre de compression (11) ; un piston (20) effectuant un mouvement alternatif axial à l'intérieur de la chambre de compression (11) selon l'axe de celle-ci ; un moyen d'entraînement (DM) monté dans le bloc cylindres (10) pour appliquer des forces alternatives sur le piston (20) ; et une tige d'entraînement (50) couplée au piston (20) et au moyen d'entraînement (DM), **caractérisée en ce que** la tige d'entraînement (50) comprend un faisceau de « n » tiges (51) disposées côte à côte le long de l'axe de la tige de piston (50), chaque tige (51) présentant une section transversale qui est dimensionnée et configurée pour conférer à la tige d'entraînement (50), conjointement avec les autres tiges (51), une rigidité axiale suffisante pour transmettre les forces alternatives à appliquer au piston (20), ainsi qu'une flexibilité, dans au moins une direction transversale à l'axe de la tige de piston (50), qui est suffisante pour absorber, au moins en grande partie, les forces exercées sur le piston (20), dans ladite direction transversale, par la tige d'entraînement (50) et par le moyen d'entraînement (DM) dans la région de la chambre de compression (11).

2. Tige d'entraînement selon la revendication 1, **caractérisée en ce que** chacune des tiges (51) présente une aire de section transversale correspondant à 1/n de l'aire de section transversale nécessaire pour conférer à la tige d'entraînement (50) la rigidité axiale suffisante, la section transversale des tiges (51) étant dimensionnée et configurée de manière à ce que la somme des couples d'inertie des tiges (51), dans ladite direction transversale, soit une fraction du couple d'inertie, dans ladite direction transversale, d'une tige d'entraînement monopièce ayant une aire de section transversale correspondant à la somme des aires de section transversale des tiges (51).

3. Tige d'entraînement selon la revendication 2, **caractérisée en ce que** la somme des couples d'inertie des tiges (51) correspond à une fraction « n » du couple d'inertie d'une tige d'entraînement monopièce (50) ayant une aire de section transversale correspondant à la somme des aires de section transversale des tiges (51).

4. Tige d'entraînement selon la revendication 2, **caractérisée en ce que** la somme des couples d'inertie des tiges

(51) correspond à une fraction « n2 » du couple d'inertie d'une tige d'entraînement monopièce (50) ayant une aire de section transversale correspondant à la somme des aires de section transversale des tiges (51).

5. Tige d'entraînement selon la revendication 2, **caractérisée en ce que** les tiges (51) sont disposées symétriquement autour de l'axe de déplacement du piston (20) et placées latéralement les unes par rapport aux autres.

6. Tige d'entraînement selon la revendication 5, **caractérisée en ce que** les tiges (51) sont rectilignes et parallèles les unes par rapport aux autres.

7. Tige d'entraînement selon la revendication 5, **caractérisée en ce que** les tiges (51) sont disposées selon un agencement hélicoïdal.

8. Tige d'entraînement selon la revendication 5, **caractérisée en ce que** les tiges (51) présentent une section transversale circulaire ayant une flexibilité égale dans toute direction transversale.

9. Tige d'entraînement selon la revendication 2, **caractérisée en ce que** les tiges (51) sont placées de manière rectiligne, parallèle et latérale les unes par rapport aux autres, chaque tige (51) ayant une section transversale rectangulaire avec une dimension correspondant à une dimension (L) de la section transversale rectangulaire d'une tige d'entraînement monopièce, et avec l'autre dimension (h) correspondant à la fraction « n » de l'autre dimension (H) de la section transversale de ladite tige d'entraînement monopièce, la section transversale de celle-ci correspondant à la somme des aires de section transversale des « n » tiges (51) de la tige d'entraînement ayant de multiples tiges (51).

10. Tige d'entraînement selon la revendication 2, **caractérisée en ce que** les tiges (51) sont entourées de manière conjointe et médiane par au moins un manchon (80) occupant une partie de l'extension longitudinale de la tige d'entraînement (50).

11. Tige d'entraînement selon la revendication 10, **caractérisée en ce que** le manchon (80) est défini par une bague élastique (81) appuyant les tiges (51) les unes contre les autres.

12. Tige d'entraînement selon la revendication 10, **caractérisée en ce que** le manchon (80) est défini par un ressort hélicoïdal (82) monté serré autour des tiges (51) de la tige d'entraînement (50).

13. Tige d'entraînement selon la revendication 10, **caractérisée en ce que** le manchon (80) est défini par une extension en tube (83) montée avec un faible jeu autour des tiges (51) de la tige d'entraînement (50).

14. Tige d'entraînement selon la revendication 2, **caractérisée en ce que** les tiges (51) présentent des extrémités opposées définissant les extrémités de la tige d'entraînement (50), lesdites tiges (51) ayant chacune des extrémités opposées fixées conjointement à un bloc terminal (90).

15. Tige d'entraînement selon la revendication 14, **caractérisée en ce que** chaque bloc terminal (90) comprend un corps tubulaire (91) incorporant une tête à extrémité agrandie (91 a) tournée vers les tiges (51) et présentant, en interne, un logement (91 b) défini axialement à travers la tête à extrémité agrandie (91 a) et à travers au moins une partie de l'extension du corps tubulaire (91).

16. Tige d'entraînement selon la revendication 15, **caractérisée en ce que** le corps tubulaire (91) a un filetage externe, la tête à extrémité agrandie (91a) ayant la forme d'un écrou hexagonal.

17. Tige d'entraînement selon la revendication 14, **caractérisée en ce que** les extrémités opposées (52) des tiges (51) sont courbées latéralement, définissant une déformation d'ancrage, chaque bloc terminal (90) étant moulé sur l'une des extrémités opposées (52) des tiges (51).

18. Tige d'entraînement selon la revendication 17, **caractérisée en ce que** chaque bloc terminal (90) comprend un corps allongé (92) incorporant une tête à extrémité agrandie (92a) tournée vers les tiges (51).

19. Tige d'entraînement selon la revendication 18, **caractérisée en ce que** le corps allongé (92) a un filetage externe, la tête à extrémité agrandie (92a) ayant la forme d'un écrou hexagonal.

20. Tige d'entraînement selon la revendication 14, **caractérisée en ce que** les blocs terminaux (90) sont chacun formés par une paire de plaques (93) à fixer l'une à l'autre, prenant en sandwich une extrémité respective des tiges (51).

21. Tige d'entraînement selon la revendication 14, **caractérisée en ce que** les blocs terminaux (90) sont définis par des orifices (94) d'une tige d'entraînement (50) ayant la forme d'une tige de connexion d'un compresseur alternatif.

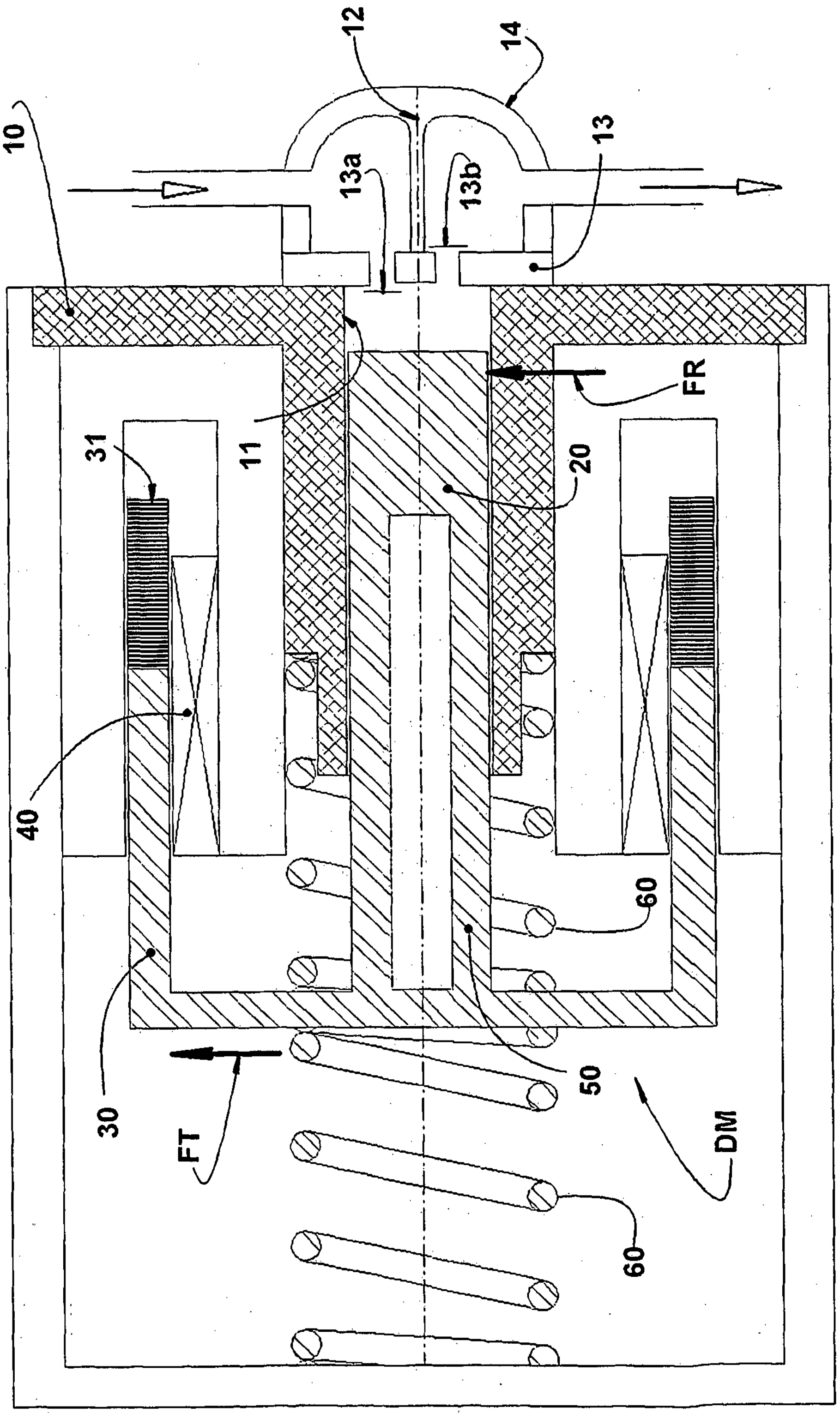


FIG. 1
PRIOR ART

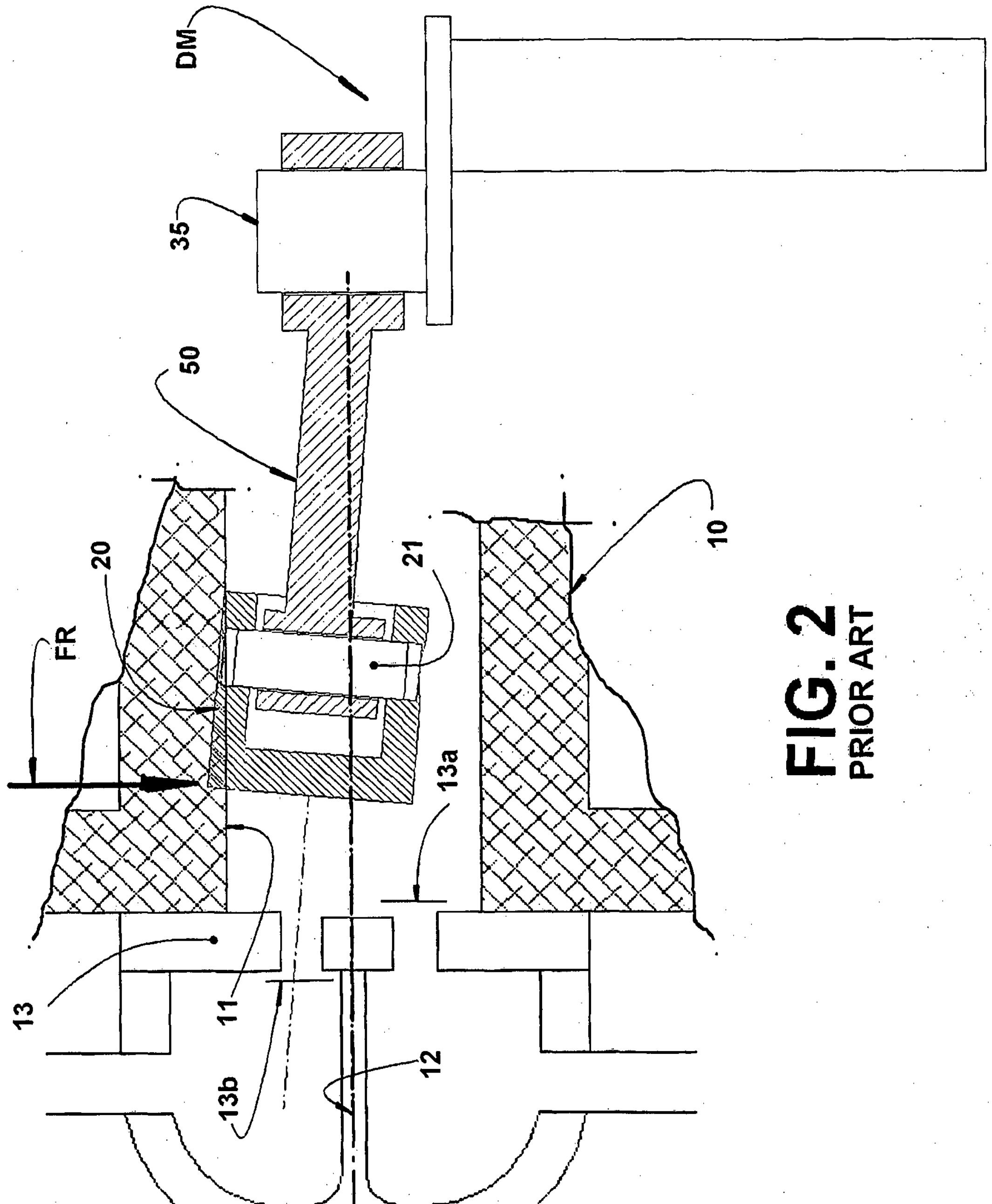
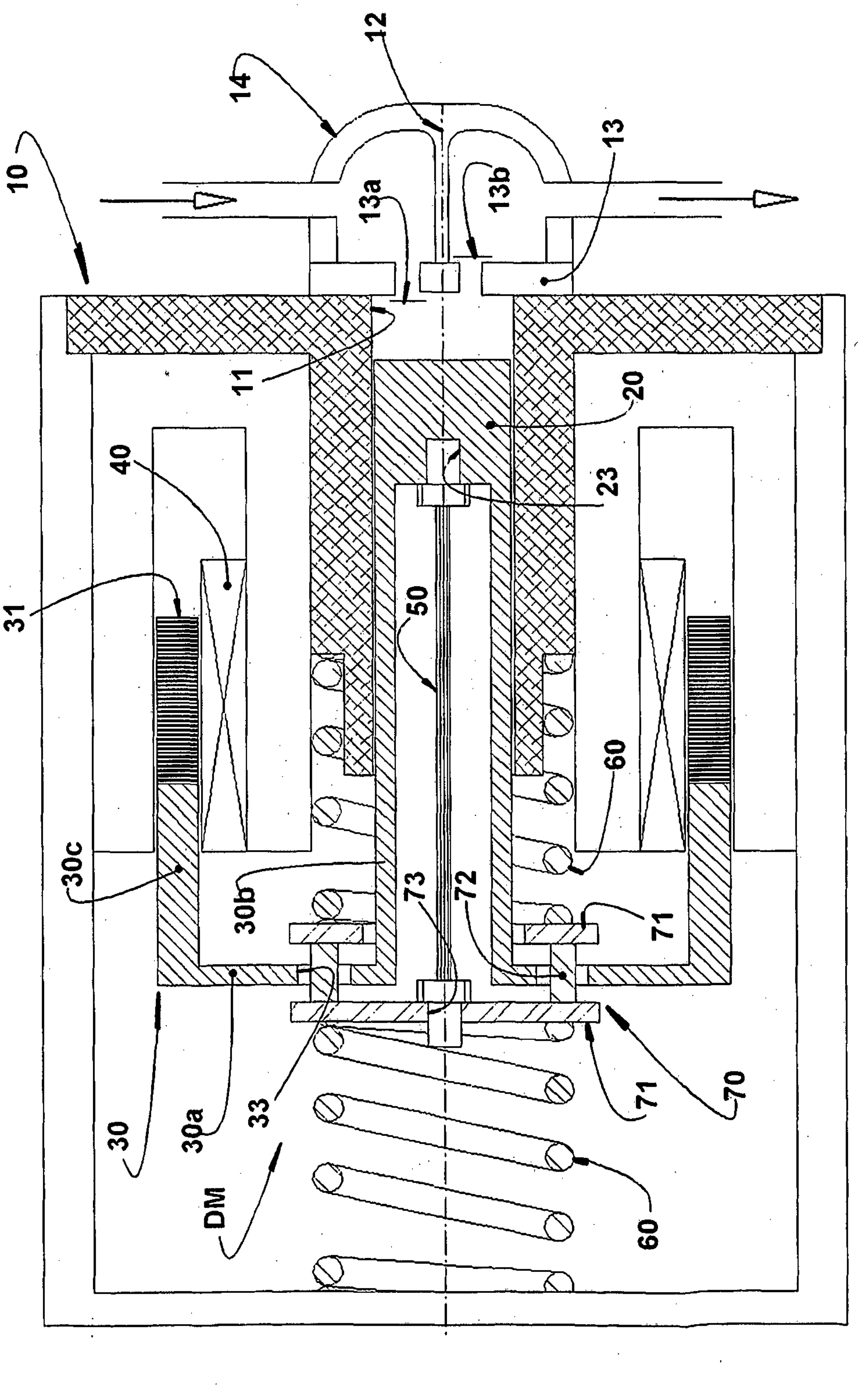


FIG. 2
PRIOR ART


10
14
12
13a
13b
13
11
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40
31
50
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30c
30b
73
72
71
70
30
30a
33
DM

FIG. 3

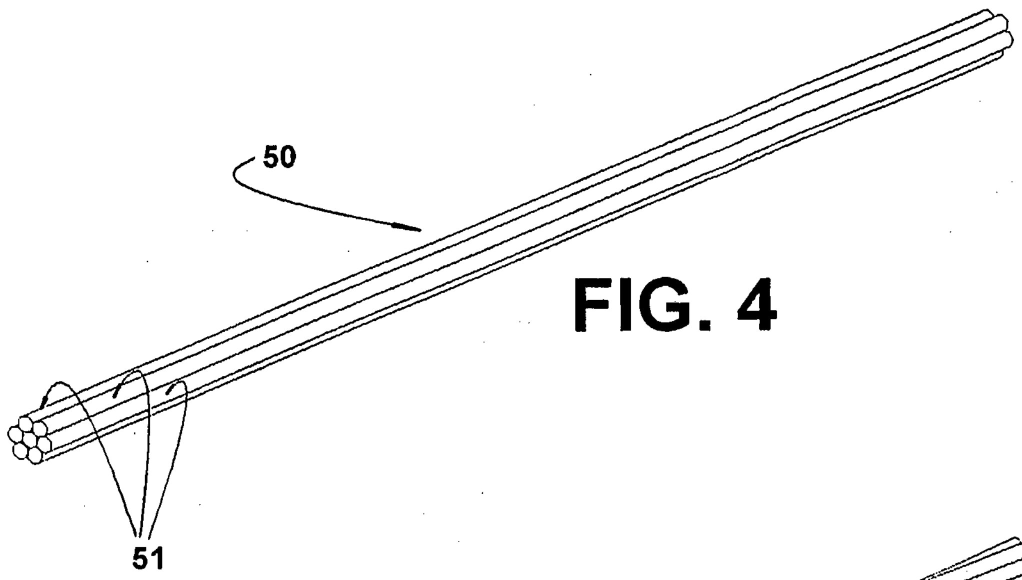

FIG. 4

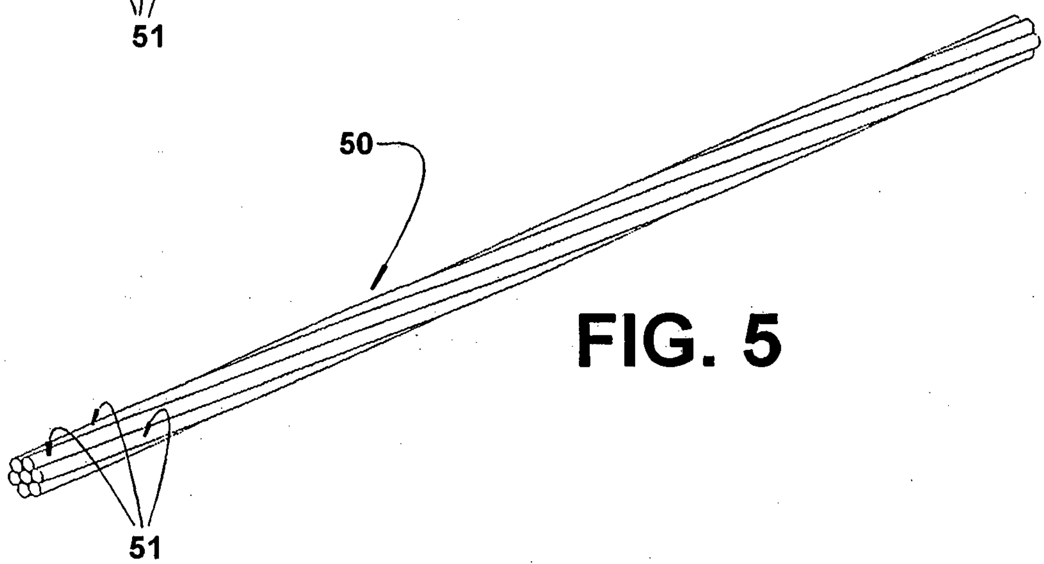

FIG. 5

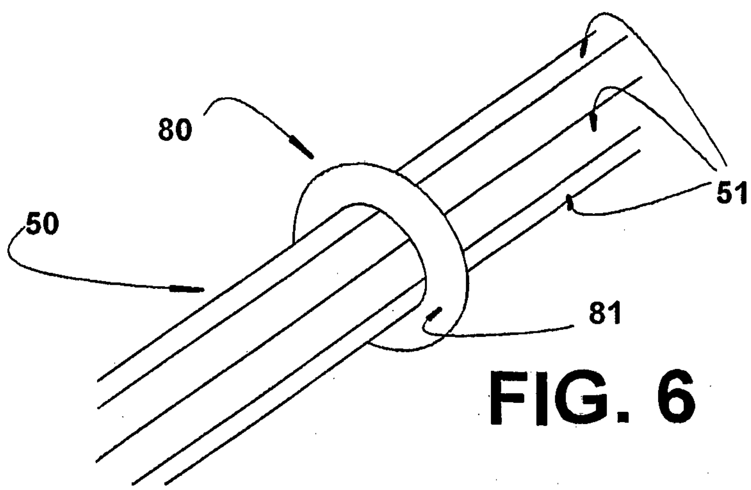

FIG. 6

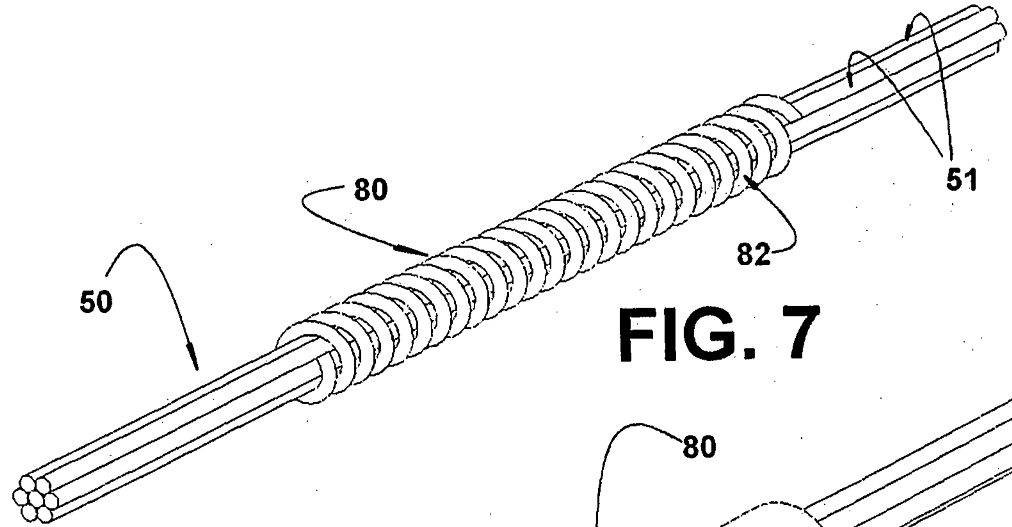

FIG. 7

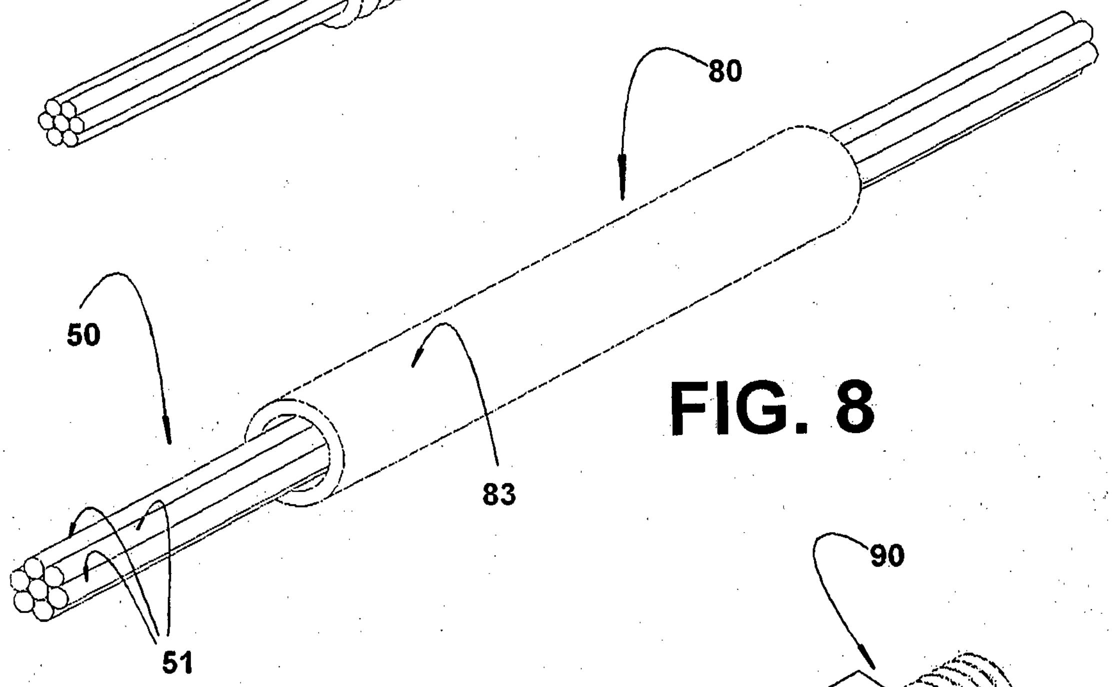

FIG. 8

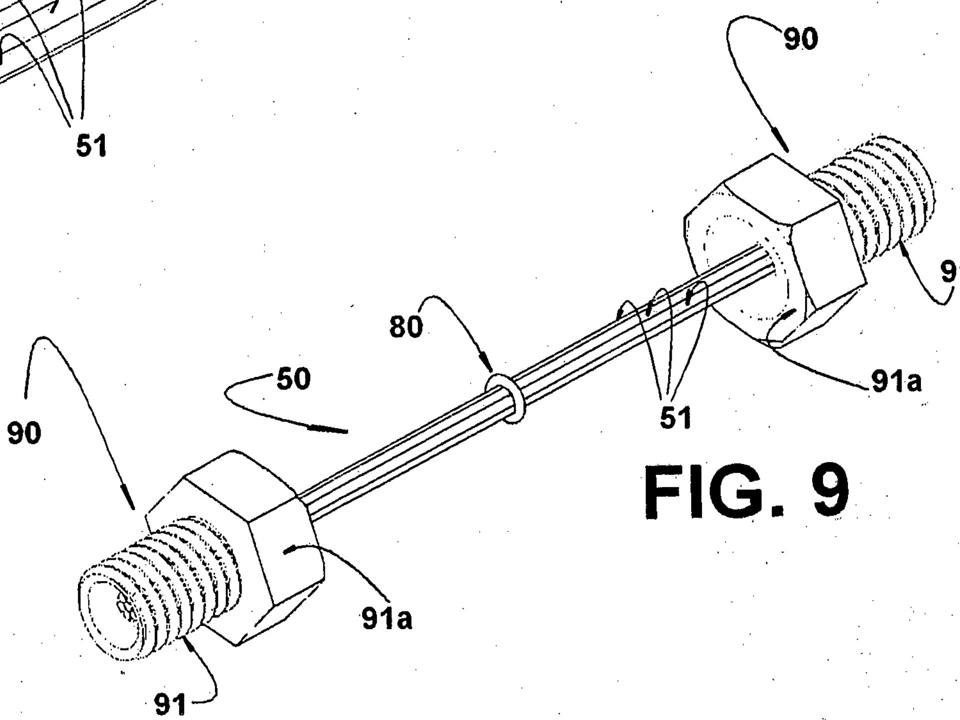

FIG. 9

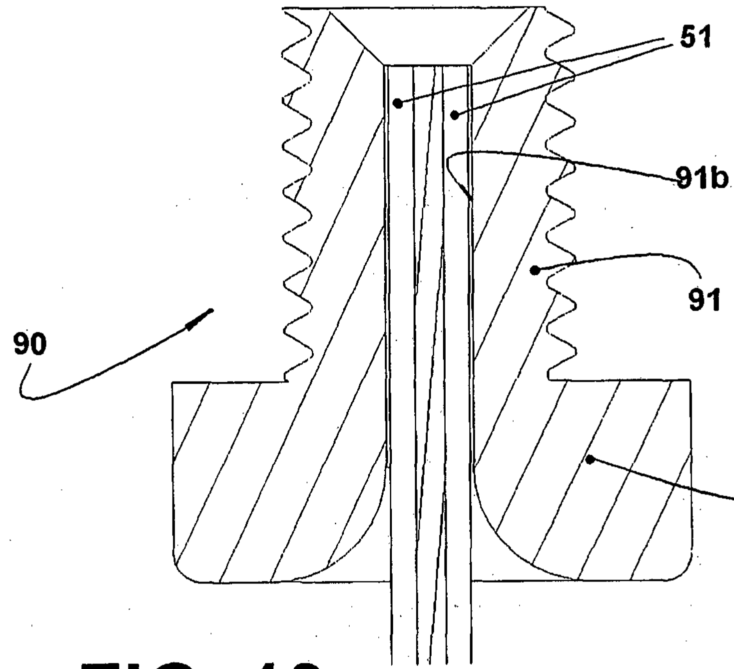

FIG. 10

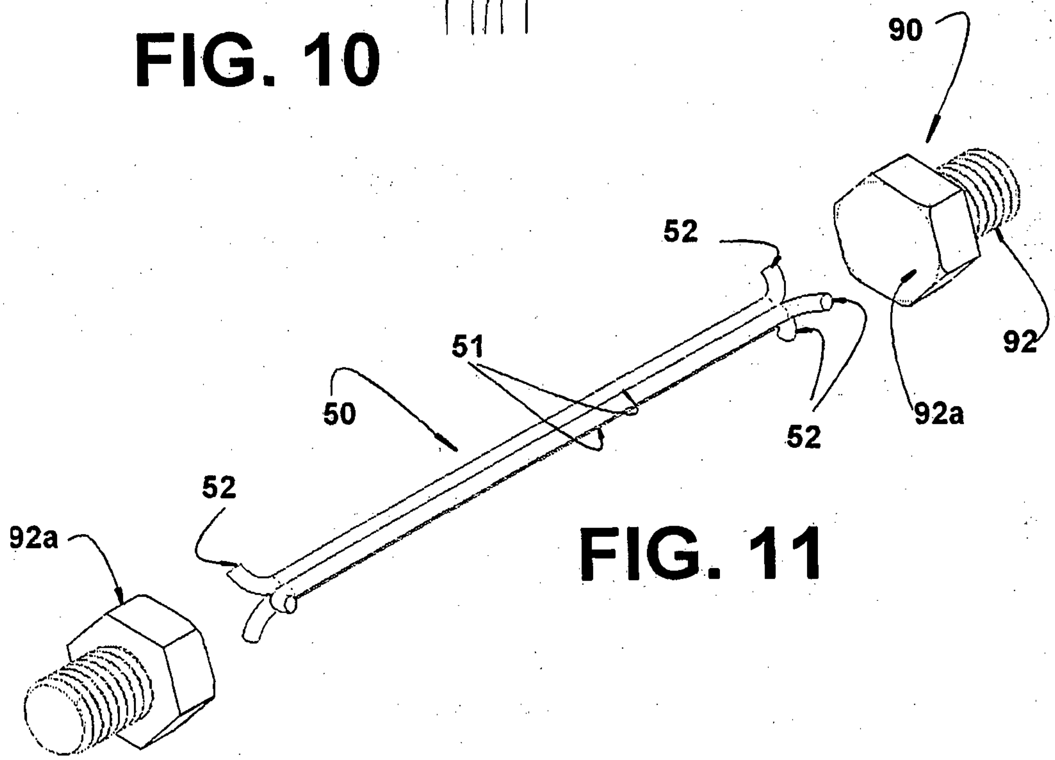

FIG. 11

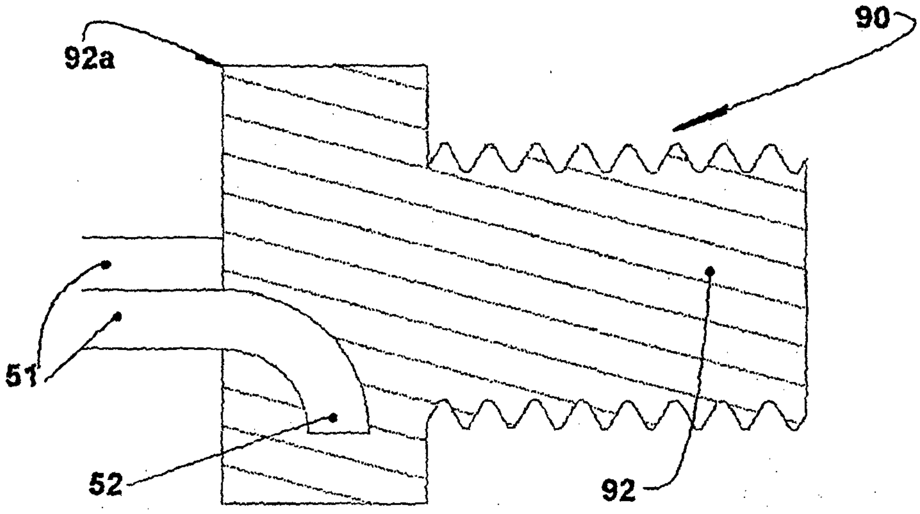

FIG. 12

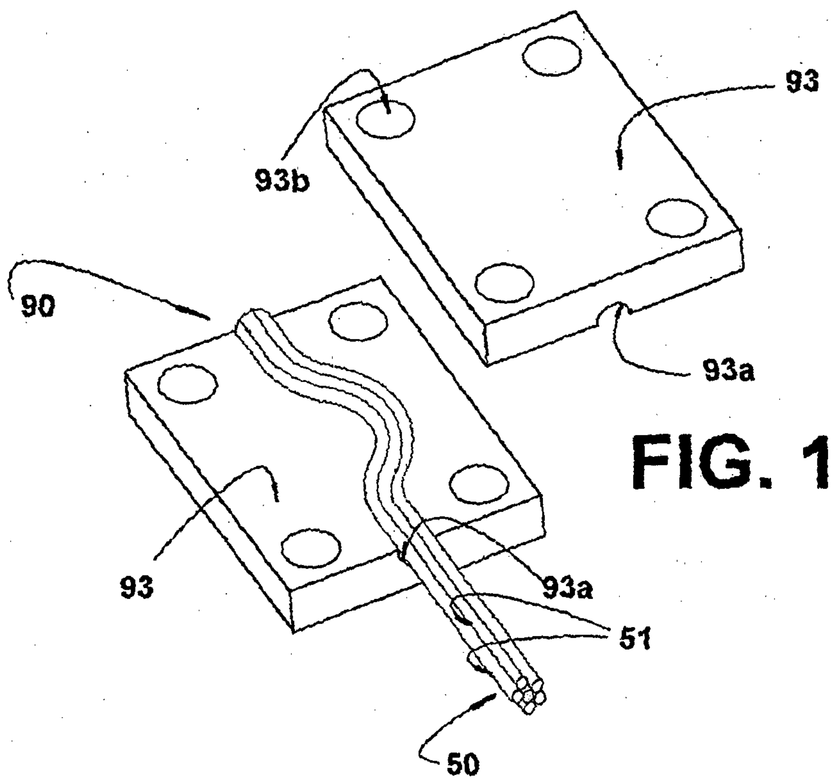

FIG. 13

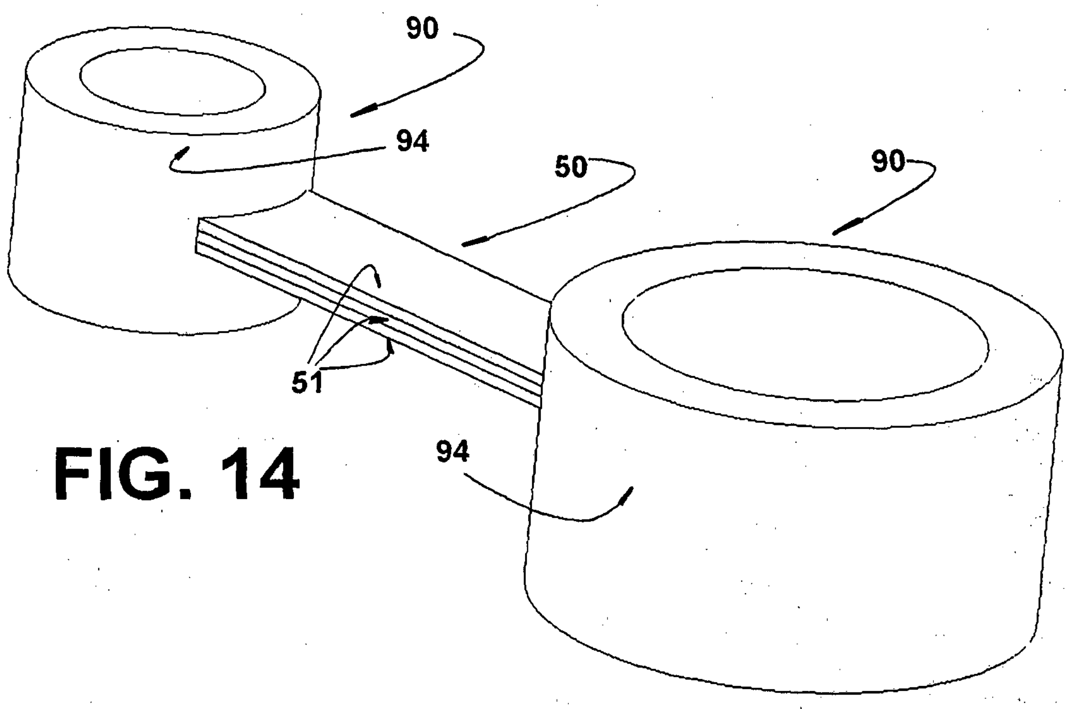

FIG. 14

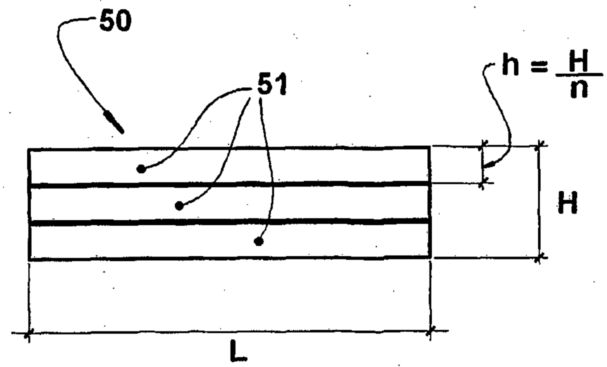

FIG. 15

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5525845 A **[0010] [0012]**