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(54) Piston gas compressor

(57) A piston gas compressor comprising:
- a cylinder having a cylinder wall, a longitudinal axis and a cylinder cover at an end of the cylinder,
- a piston, which is reciprocable inside the cylinder, the piston comprising a piston body and at least one rider ring that extends around at least a part of the circumference of the piston body and bears against the cylinder wall, the piston delimiting a compression chamber in the cylinder, wherein the cylinder wall is provided with at least one inlet port to the compression chamber and with at least one outlet port from the compression chamber,
- a reciprocable piston rod, which is at a first end thereof connected to the piston and at a second end thereof to drive means of the compressor, preferably to a cross head which is guided in a frame of the compressor,
- a condition monitoring system comprising:
- a rider ring wear sensor and associated control unit for determination of rider ring wear by measuring a distance of the piston relative to the sensor.

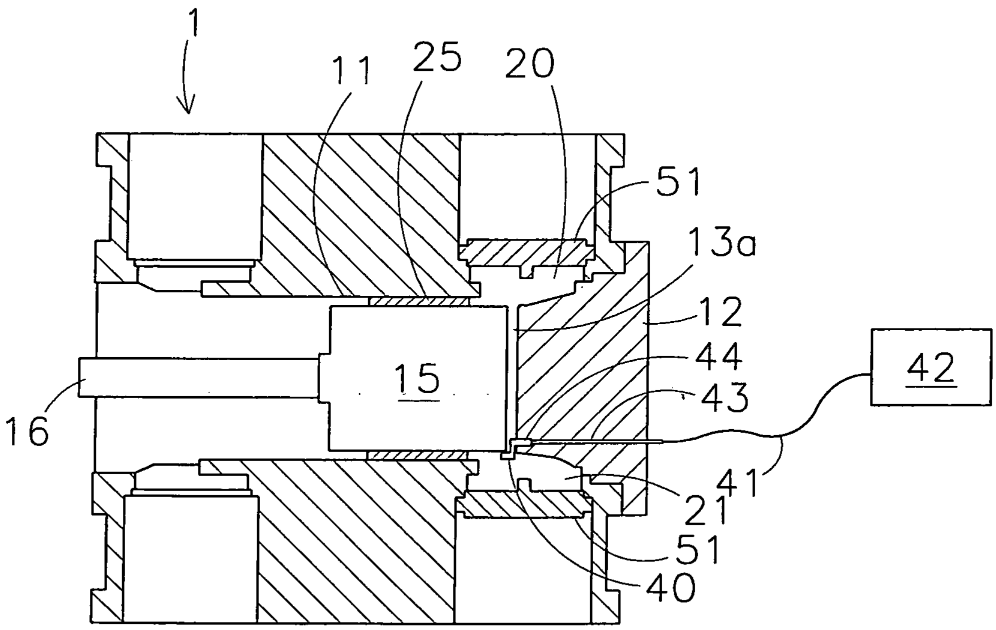

Fig 2

EP 2 012 013 A1

Description

[0001] The invention relates to a piston gas compressor according to the preamble of claim 1.

[0002] EP1416160 discloses a horizontal piston gas compressor that is provided with a condition monitoring system that is adapted to determine wear of the rider ring. In this disclosure the piston is provided with a specific reference element. The cylinder cover of the cylinder is provided with a sensor for measuring the vertical distance to the reference element in order to determine the wear of the rider rings (also known as "rider bands or wear bands") of the piston. When the rider rings suffer from wear, the piston will come to move at a lower level within the cylinder. The sensor detects the lowering of the position of the reference element, and from the change in position of the reference element over time, the rider ring wear is calculated.

[0003] A disadvantage of this known condition monitoring system is that the piston of the compressor has to be modified in order to arrange the reference element. If one would like to equip an existing gas compressor with this condition monitoring system for detecting rider ring wear, the required modifications are problematic and cause undesirable down time of the compressor.

[0004] It is noted that in this known condition monitoring system the sensor is to be mounted in a recess in the front side of the cylinder cover. This recess forms a "dead space" in which dirt can easily accumulate, thereby inhibiting a correct operation of the sensor.

[0005] The object of the invention is to provide a piston gas compressor with an improved condition monitoring system.

[0006] This object is achieved by the piston gas compressor of claim 1.

[0007] The sensor for determining rider ring wear is arranged at the outlet port or at the inlet port of the compression chamber. Therefore, the piston does not have to be modified when the compressor is retrofitted with the sensor. In addition, the cylinder cover and/or the cylinder wall will require minimal or preferably no adaptation.

[0008] In the arrangement at a port of the compression chamber, the sensor will be exposed to the flow of gas between the respective port and the compression chamber, either the inflow or the outflow. This has the advantage that fouling of the sensor is largely avoided because dirt will be blown away from the sensor by the gas. This way, problematic dirt accumulation on the sensor is simply avoided.

[0009] Moreover, arranging the sensor at an outlet port or an inlet port of the compression chamber allows direct measurement on the piston, preferably close to a rider ring. This way, hardly any or no corrections or calculations have to be carried out on the measuring signal of the sensor in order to determine the actual position of the piston in the cylinder. This way, reliable input is provided for the determination of rider ring wear and for the monitoring of the rider ring wear in the course of time.

[0010] It is noted that it is known to determine rider ring wear using piston rod drop measurements and other indirect ways to determine the rider ring wear. In these known indirect ways of determining rider ring wear, measurement data is used as input for calculations that result in a value for the rider ring wear. In practice, the relationship between the piston rod drop and the rider ring wear is influenced by operational conditions such as the load on which the compressor is running (no load, partial load, full load), differences in gas composition that result in deviating temperatures and so on. Often, measurements are carried out at a location away from the piston. As the actual rider ring wear occurs at the piston, the measuring results have to be corrected for not measuring at the actual location where the rider ring wear occurs. When the position of the piston is measured instead of a mere variable that is related to the position of the piston, all these influences are limited or not present at all. This results in a more reliable way of condition monitoring with respect to rider ring wear.

[0011] In practice, it is advantageous to use the circumferential surface of the piston body as the surface of the piston for the sensor to look at.

[0012] Rider ring wear is commonly experienced in all non-vertical piston compressors, wherein gravity urges the piston towards the cylinder wall. This occurs for example in horizontal piston compressors wherein the longitudinal axis extends in substantially horizontal direction, or in the so-called "V-type" and "W-type" piston compressors, in which the longitudinal axis of the cylinders extend under an angle of about 45° with the vertical.

[0013] The piston is provided one or more rider rings, which bear against the cylinder wall. Because gravity draws the piston towards the cylinder wall, friction occurs between the rider rings of the piston and the cylinder wall. Due to this friction, the rider rings will wear and the surface of the piston body will become to lie closer to the cylinder wall.

[0014] By measuring directly the radial distance between the cylinder wall and the circumference of the piston body or the radial distance between a sensor that has a fixed position relative to the cylinder wall and the circumference of the piston body, the wear of the rider rings can be determined. This way, no additional elements have to be attached to the face of the piston.

[0015] The condition monitoring system can be adapted to follow the changes in said radial distance over time and/or it can be adapted to provide a warning signal when the measured distance drops below a set minimum value.

[0016] Furthermore, by arranging the sensor at an inlet port or outlet port of the compression chamber, no special groove or the like has to be made in the circumference of the piston body. Also, detecting the radial position of the circumference of the piston body and/or monitoring the changes in this position over time provides very direct information about the wear of the rider rings as effects like bending of the piston rod or thermal expansion hardly influence the measurements when the sensor is arranged according to the invention.

[0017] In an advantageous embodiment of the compressor according to the invention, the sensor is arranged perpendicular or substantially perpendicular to the longitudinal axis of the cylinder. This way, the radial position of the piston in the cylinder can be detected in the most direct way.

[0018] In an advantageous embodiment, the sensor is arranged below the longitudinal axis of the cylinder. This way, the measurements are not affected by the effects of thermal expansion of the piston.

[0019] In general, the at least one outlet port and the at least one inlet port of the compression chamber will be arranged radially with respect to the cylinder. In a compressor according to the present invention, it is advantageous if the inlet port or outlet port at which the sensor is arranged, is arranged perpendicular to the longitudinal axis at the top or at the bottom of the cylinder. As an alternative, the inlet port or outlet port in which the sensor is arranged, is arranged in a plane perpendicular to the longitudinal axis of the cylinder and at an angle to this longitudinal axis. Preferably, this angle is 55° or less, more preferably 45° or less, to the vertical. This way, the sensor can be aligned or substantially aligned with the inlet port or outlet port respectively and with the direction of the gas flow. Aligning with the inlet port or the outlet port respectively has the advantage of easy mounting, while aligning with the gas flow has the advantage of lower forces being exerted on the sensor and the creation of less turbulence in the gas flow. In the cases where the sensor is arranged at the location in which the minimum radial distance between the surface of the piston body and the cylinder wall occurs, preferably calculations are performed, for example by the control unit of the condition monitoring system, in order to determine this minimal radial distance.

[0020] Because of the reciprocating movement of the piston, in most cases the sensor, which is arranged at least substantially stationary, generally cannot measure the distance to the piston over the piston's entire stroke. It is advantageous if the sensor is arranged near one of the end points of the stroke, as in that case the sensor has more time to measure the distance to the piston body's circumference.

[0021] It is advantageous if the sensor is arranged close to the piston in order to reduce the measuring errors. In practice, a distance of less than 10 mm has proven to be advantageous. More preferably, the distance between the circumference of the piston and the sensor is less than 5 mm at the time the piston passes the sensor.

[0022] It is envisaged that the sensor for determining the rider ring wear also comprises an additional measuring element for measuring another parameter, such as temperature and/or pressure.

[0023] In many reciprocating compressors an inlet valve and outlet valve are arranged in the inlet port and the outlet port respectively. Such a valve is adapted to open and close the respective inlet port or outlet port. In an advantageous embodiment, the sensor is arranged on the valve. The valve provides a solid basis for mounting the sensor on.

[0024] In many existing design the valve has a valve body with a central member, usually a central bolt. In an advantageous embodiment, the sensor is arranged on that bolt.

[0025] The sensor can be connected to the control unit by means of one or more wires. This wire can for example extend through a central bore in the valve body, through a bore in the side wall of the valve housing or through a bore in the valve gland.

[0026] If the sensor is supported from the cylinder cover, either at the inlet port or the outlet port, it is envisaged that the wire extends through a bore in the cylinder cover. Alternatively, the wire could extend through a bore in the cylinder wall.

[0027] In a preferred embodiment, the sensor is adapted for contact free measurement. This way, wear of the sensor by contact with the piston is avoided. The contact free sensor can for example be a sensor which is adapted to detect changes in an electromagnetic field or an optical sensor.

[0028] Preferably, the sensor is at least partially shielded from the environment inside the compressor. If the sensor is arranged in an outlet port of the compression chamber, it is advantageous if at least the face of the sensor that is directed to the piston of the compressor is shielded from the environment inside the compressor, because that face will be exhibited most intensively to the gas flow.

[0029] The shield can for example be a foil, such as a plastic or metal foil or a membrane, that shields the sensor from aggressive substances in the gas that is or will be compressed. The foil can for example be attached to the sensor by means of laser welding.

[0030] It is advantageous to apply the invention in a piston gas compressor that is not provided with a lube oil system for lubricating the piston in the cylinder. In such a compressor, which is sometimes in the art also indicated as "oil free cylinder compressor", "non-lubricated compressor", "compressor with non-lubricated piston", "dry (gas) lubricated compressor" or "dry-running compressor", the piston is not lubricated by oil or an other liquid (such as water) in the cylinder, but a gas film or -usually solid- lubricants in the rider rings themselves are applied to reduce the friction coefficient between the rider ring or rider rings and the cylinder wall. A compressor that uses a gas film to lubricate the piston inside the cylinder is known from EP0839280.

[0031] In such piston gas compressors without a lubricating liquid to lubricate the piston, it is advantageous to monitor the rider ring wear in a reliable way for several reasons. Reasons are that the rider rings tend to wear faster in this kind of compressors than in compressors with oil lubricated pistons and that the life span of the rider rings is unpredictable. Another reason is that in case of rider ring failure, the system has no emergency running properties, so a lot of damage to the piston and the cylinder wall rapidly occurs.

[0032] Of course, the sensor can also be applied in piston gas compressors that are provided with a system for lubricating the piston by means of a liquid (such as oil or water) in the cylinder.

[0033] Preferably, the compressor according to the invention is suitable for a pressure up to about 350 bars. In that case, the sensor is adapted to be able to resist at least 350 bars.

[0034] Preferably, the compressor according to the invention is suitable for compressing gases containing aggressive, corrosive and/or sour components, such as H_2S, CO_2, HCl, water and/or O_2 or combinations thereof.

[0035] The piston gas compressor according to the invention is provided with a condition monitoring system, which condition monitoring system at least monitors the wear of the at least one rider ring of the piston. Of course, other parameters could be monitored in addition.

[0036] The invention will be described in more detail below under reference to the drawing, in which in a non-limiting manner exemplary embodiments of the invention will be shown.

[0037] The drawing shows in:

- fig. 1 - an overview of an exemplary oil free compressor which is suitable for use in combination with the invention,
- fig. 2 - a part of a compressor according to a first embodiment of the invention,
- fig. 3 - a variant to the embodiment of fig. 2,
- fig. 4 - a part of a compressor according to a second embodiment of the invention,
- fig. 5 - a detail of the sensor mounting in the second embodiment of the invention,
- fig. 6 - an alternative to the sensor mounting of fig. 5,
- fig. 7 - a part of a compressor according to a third embodiment of the invention,
- fig. 8 - a part of a compressor according to a fourth embodiment of the invention,
- fig. 9 - some possible alternative piston configurations.

[0038] Fig. 1 shows an example of a piston gas compressor 1. The piston in the exemplary compressor of fig. 1 is dry-running and is not lubricated by a liquid such as oil or water in the cylinder. The piston gas compressor of fig. 1 could be a horizontal piston gas compressor of the type according to EP0839280 wherein a gas film is used to reduce the friction between the rider rings of the piston and the cylinder wall, but the skilled person will understand that also other types of piston gas compressors can be used for this invention, regardless of whether the piston is lubricated in the cylinder or not.

[0039] It will be also clear for the skilled person that the application of this invention is not limited to horizontal piston gas compressors (that is: piston gas compressors wherein the cylinder is arranged such that the longitudinal axis extends substantially horizontal). It can also be applied in for example V-type and in W-type compressors, in which the longitudinal axis of the cylinder generally extends under an angle (for example 45°) with the vertical.

[0040] The compressor 1 of fig. 1 is provided with a cylinder 10, which has a cylinder wall 11 and a cylinder cover 12. The cylinder 10 here is arranged such that its longitudinal axis extends horizontally.

[0041] Inside the cylinder 10, a piston is arranged. The piston comprises a piston body 15, that is provided with rider rings 25a,b that bear against the cylinder wall 11. In this example, the rider rings 25a,b extend around the piston body 15. The piston, the cylinder wall 11 and the cylinder cover 12 enclose a first compression chamber 13a in which the gas is compressed. The first compression chamber 13a is provided with a gas inlet port 20a and a gas outlet port 21a. In the example of fig. 1, the gas compressor 1 is of the double-acting type. This means that, apart from the first compression chamber 13a, a second compression chamber 13b is present on the other side of the piston. This second compression chamber 13b is provided with its own gas inlet port 20b and its own gas outlet port 21b. The skilled person will understand that the invention can be used for single acting compressors as well as for double-acting compressors.

[0042] The piston is further provided with piston rings 26, that provide an at least substantially gas tight seal between the piston and the cylinder wall 11. The piston rings extend around the piston body 15 of the piston.

[0043] To the piston, a piston rod 16 is connected, here opposite the cover 12. The end of the piston rod 16 remote from the piston is connected to a cross head 34. The cross head 34 is connected to a drive unit 30. The drive unit 30 comprises a crank 31, which is part of the crank shaft 32. Connecting rod 33 connects the crank 31 to the cross head 34 and transforms the rotating movement R of the crank 31 into a translating movement T of the cross head 34. The cross head 34 is guided in frame 36 by means of guides 35.

[0044] In an alternative, also advantageous embodiment, which is not shown, the compressor 1 is provided with a gas lubrication unit, which in operation provides a gas film between the rider rings 25a,b and the cylinder wall 11 for reducing the friction between the rider rings and the cylinder wall 11. Examples of suitable gas lubrication units are described in EP0839280.

[0045] Fig. 2 shows a part of a compressor 1 according to a first embodiment of the invention. For illustrative purpose parts similar to parts of the compressor of figure 1 have been given the same reference numeral.

[0046] In the embodiment of fig. 2, the piston is provided with a single rider ring 25, which rider ring 25 bears against the cylinder wall 11 and extends around the piston body 15. A sensor 40 is provided to determine the wear of the rider ring 25. The piston is attached to the piston rod 16.

[0047] The compression chamber 13a is provided with an inlet port 20 and an outlet port 21. Both the inlet port 20 and the outlet port 21 are provided with an associated valve, each valve being schematically depicted here and each valve having a valve body 51. In the example of fig. 2, the sensor 40 is arranged in the outlet port 21. The sensor is arranged below the path of the reciprocating piston in such a way that it can measure the distance to the circumference of the piston body 15 when the piston 15 is near or at the dead end of its stroke.

[0048] The sensor 40 is held in place by sensor holder 44. The sensor 40 and the sensor holder 44 can be two separate elements, but advantageously they are integrated into a single element. The sensor holder 44 has a suitable shape in order to make sure that the sensor 40 is positioned in the right way with respect to the piston body 15, for example the Z-like shape shown in fig. 2. As is clear from fig. 2, the piston is not provided with a special feature such as a dedicated reference element for the sensor 40. Instead, the sensor 40 measures the distance to the normal circumference of the piston body 15.

[0049] In a possible embodiment, the sensor 40 is adapted not only to measure the distance to the piston body 15, but to also measure one or more other parameters, such as temperature and/or pressure.

[0050] The sensor 40 here is provided with one or more wires 41 to transmit its sensor signal to a control unit 42. The control unit 42 processes the signal from the sensor 40 in order to determine the wear of the rider ring 25. The changes in distance from the sensor 40 to the circumference of the piston body 15 over time are a direct indication of the wear of the rider ring 25. As the sensor 40 is arranged below the piston 40, the thermal expansion of the piston body 15 hardly influences the measurements of the sensor 40. If necessary, the sensor 40 can have more wires 41, for example when the sensor 40 is adapted to measure multiple parameters.

[0051] The sensor holder 44 here is secured in the cylinder cover 12. In the cylinder cover 12, a bore 43 is present. Through this bore 43, the wire 41 (or wires) extend through the bore 43 so they can be connected to the control unit 42 outside the compressor 1. The control unit can be integrated in the overall control system of the compressor.

[0052] As can be seen in fig. 2, the sensor 40 operates contact free with respect to the piston body 15. This can for example be achieved by applying an optical sensor or a sensor that measures distance by detecting changes in an electromagnetic field.

[0053] Fig. 3 shows a variant of the embodiment of fig. 2. In this variant, two sensors 40, 40* are present. Just like in the embodiment of fig. 2, sensor 40 is arranged in the outlet port 21, below the piston 15. In the variant of fig. 3, an additional sensor 40* is arranged in the inlet port 20, above the piston. Sensor 40* is retained by sensor holder 44*, and its wire 41* extends through bore 43* to the control unit 21.

[0054] When using data from the sensor 40* that is arranged above the piston, the measurements have to be corrected at least for the thermal expansion of the piston body 15.

[0055] The data originating from the two sensors 40, 40* can be combined in an algorithm to calculate the rider ring wear, and/or the sensors 40, 40* can be used as back up for each other. In that case however, the different effects between when using a sensor arranged above the piston and when using a sensor that is arranged below the piston, such as differences in measured distance due to the thermal expansion of the piston body 15, have to be taken into account.

[0056] Fig. 4 shows a part of a compressor according to a second embodiment of the invention, with the piston at the dead end of its stroke.

[0057] In fig. 4, the sensor 40 is arranged at the valve body 51 in the outlet port 21. The valve body 51 comprises a central bolt 52, onto which the sensor holder 44 is arranged. The sensor holder 44 holds the sensor 40.

[0058] In the embodiment of fig. 4, a bore 54 is provided through the valve body 51. The sensor wire 41 extends through this bore to the control unit 42.

[0059] Fig. 5 and fig. 6 show possible ways of mounting the sensor 40 on the central bolt 52. The sensor holder 44 is arranged over the central bolt 52. Again, the sensor holder 44 can be integral with the sensor 40, or they can be separate elements. The sensor 40 is arranged in a recess in the sensor holder 44. In fig. 5, the sensor 40 is provided with a shield 55 that is attached to the sensor 40 by means of a circumferential weld 56.

[0060] In the variant of fig. 6, the shield 55 has the form of a cap, that is arranged over the sensor holder. In the example of fig. 6, the cap is provided with a click-fit connection to the sensor holder 44. The sensor holder 44 has a groove 57 for receiving a rim 58 of the cap. The groove 57 and the rim 58 operate together to provide the click-fit connection between the cap and the sensor holder 44.

[0061] Fig. 7 shows a part of a compressor according to a third embodiment of the invention. In this embodiment, like in the embodiment of fig. 4, the sensor 40 is arranged at the central bolt 52 of the valve body 51. In the embodiment of fig. 7 however, the bore 54 extends through the valve body 51 sideways, and leaves the compressor via the valve housing.

[0062] Fig. 8 shows a part of a compressor according to a fourth embodiment of the invention. In this embodiment, like in the embodiments of fig. 4 and fig. 7, the sensor 40 is arranged at the central bolt 52 of the valve body 51. In the embodiment of fig. 8 however, the bore 54 extends through the valve body 51 sideways, and leaves the compressor via the valve gland 53.

[0063] The embodiments shown in the figures 2,3,4,7 and 8 all have pistons with a piston body 15 and a single rider ring 25. However, in all these embodiments, also pistons with multiple rider rings 25 and/or piston rings 26 can be used instead of the piston with the single rider ring 25. Fig. 9 shows some possible alternative piston configurations that could be used in the embodiments shown in the figures 2,3,4,7 and 8. It will be clear to the skilled person that also other configurations are possible.

Claims

1. Piston gas compressor comprising:

- a cylinder having a cylinder wall, a longitudinal axis and a cylinder cover at an end of the cylinder,
- a piston, which is reciprocable inside the cylinder, the piston comprising a piston body and at least one rider ring that extends around at least a part of the circumference of the piston body and bears against the cylinder wall, the piston delimiting a compression chamber in the cylinder, wherein the cylinder wall is provided with at least one inlet port to the compression chamber and with at least one outlet port from the compression chamber,
- a reciprocable piston rod, which is at a first end thereof connected to the piston and at a second end thereof to drive means of the compressor, preferably to a cross head which is guided in a frame of the compressor,
- a condition monitoring system comprising:

  - a rider ring wear sensor and associated control unit for determination of rider ring wear by measuring a distance of the piston relative to the sensor,

characterised in that,
the rider ring wear sensor is arranged at the outlet port or at the inlet port of the compression chamber.

2. Piston gas compressor according to claim 1, wherein the rider ring wear sensor is adapted to determine a distance in the radial direction of the cylinder to the circumferential surface of the piston body when the piston is at an end point of its stroke.

3. Piston gas compressor according to any of the preceding claims, wherein the rider ring wear sensor is arranged at a radial distance of 10 mm or less, preferably at 5 mm or less, from the circumferential surface of the piston body.

4. Piston gas compressor according to any of the preceding claims, wherein the outlet port or the inlet port of the compression chamber at which the sensor is arranged is provided with an associated valve, and wherein the rider ring wear sensor is arranged on the valve.

5. Piston gas compressor according to claim 4, wherein the valve has a valve body which comprises a central member, e.g. a central bolt, and wherein the rider ring wear sensor is arranged on the central member.

6. Piston gas compressor according to any of the preceding claims, wherein the rider ring wear sensor is adapted for contact free measurement of the distance to the piston.

7. Piston gas compressor according to claim 6, wherein the rider ring wear sensor is adapted to measure said distance based on the detection of changes in an electromagnetic field.

8. Piston gas compressor according to any of the preceding claims 1-6, wherein the rider ring wear sensor is an optical sensor.

9. Piston gas compressor according to any of the preceding claims, wherein the rider ring wear sensor comprises at least one surface that is directed to the circumferential surface of the piston, which surface is provided with a shield.

10. Piston gas compressor according to claim 9, wherein the shield is a foil, which preferably is attached to the sensor by means of laser welding.

11. Piston gas compressor according to any of the preceding claims, wherein the rider ring wear sensor is mounted on the cylinder cover at either the inlet port or the outlet port, and wherein said sensor is preferably connected to the control unit by means of a wire, which wire may extend through a bore in the cylinder cover.

12. Piston gas compressor according to claim 4 or 5, wherein the rider ring wear sensor is connected to the control unit by means of a suitable wire, which wire extends through the valve, preferably through the central member of the valve.

13. Piston gas compressor according to claim 4, wherein the rider ring wear sensor is connected to the control unit by means of a wire, which wire extends through a bore in a side wall of the valve housing.

14. Piston gas compressor according to claim 4, wherein the rider ring wear sensor is connected to the control unit by means of a wire, which wire extends through a bore in a valve gland.

15. Piston gas compressor according to any of the preceding claims, wherein the piston is lubricated in the cylinder by a gas film or by a solid lubricant.

16. Condition monitoring system for a piston gas compressor, the compressor comprising:

- a cylinder having a cylinder wall, a longitudinal axis and a cylinder cover at an end of the cylinder,
- a piston, which is reciprocable inside the cylinder, the piston comprising a piston body and at least one rider ring that extends around at least a part of the circumference of the piston body and bears against the cylinder wall, the piston delimiting a compression chamber in the cylinder, wherein the cylinder wall is provided with at least one inlet port to the compression chamber and with at least one outlet port from the compression chamber,
- a reciprocable piston rod, which is at a first end thereof connected to the piston and at a second end thereof to drive means of the compressor, preferably to a cross head which is guided in a frame of the compressor,
- a condition monitoring system comprising:

    - a rider ring wear sensor and associated control unit for determination of rider ring wear by measuring a distance of the piston relative to the sensor,

characterised in that,
the rider ring wear sensor of the condition monitoring system is adapted to be arranged at an outlet port or at an inlet port of the compression chamber.

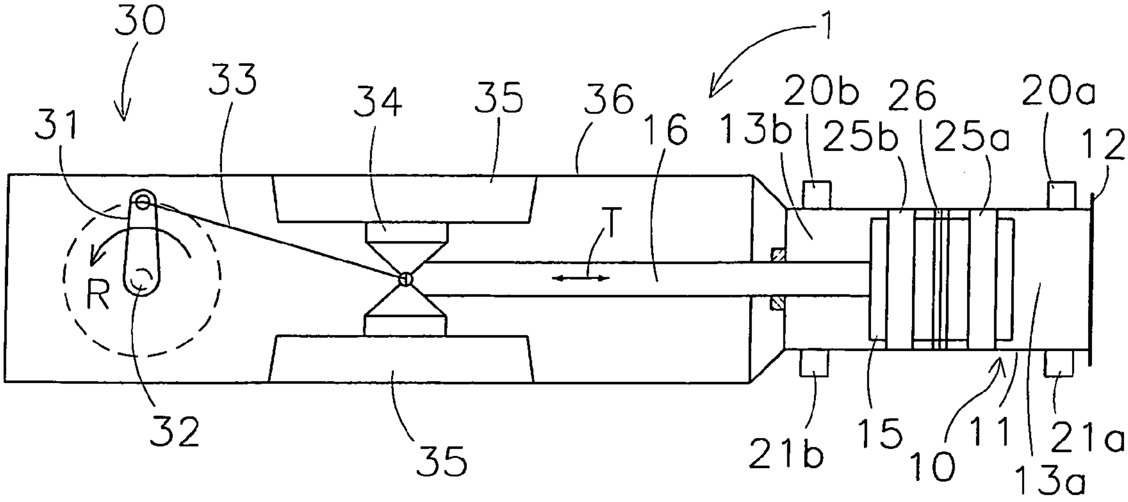
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Fig 1

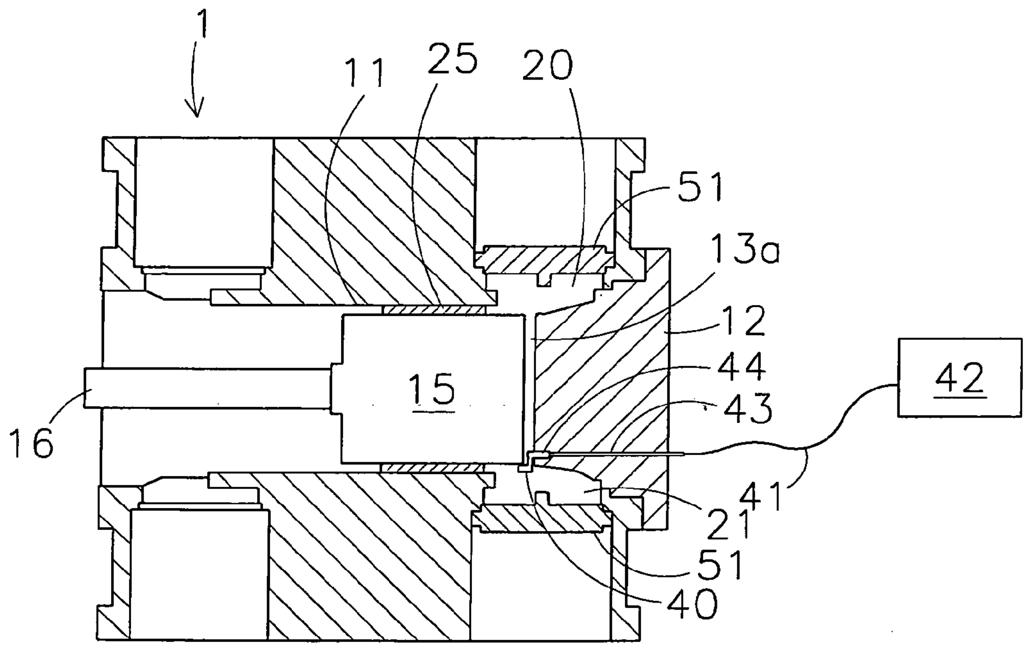
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Fig 2

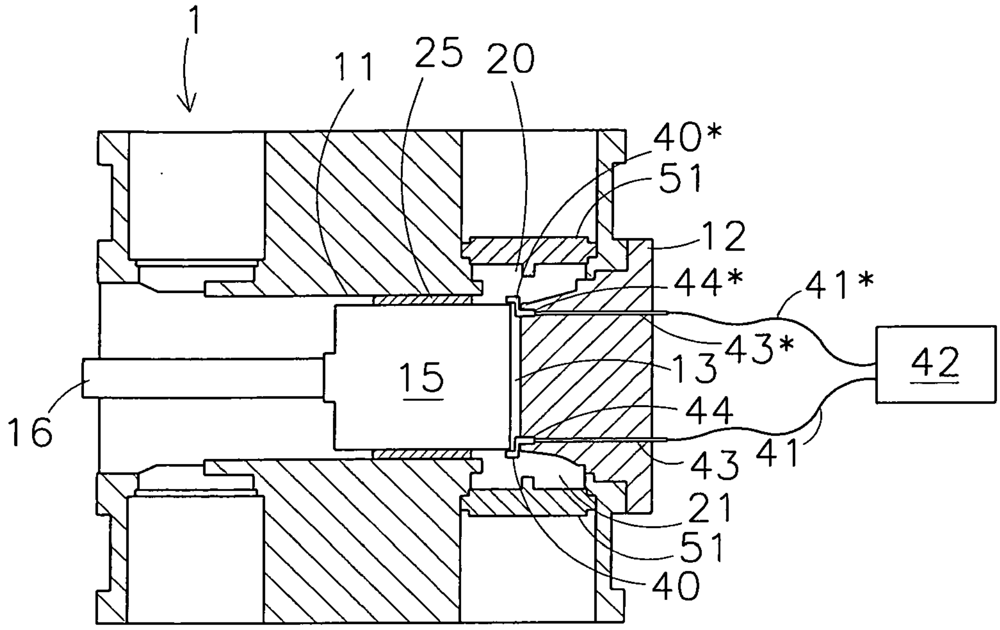
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Fig 3

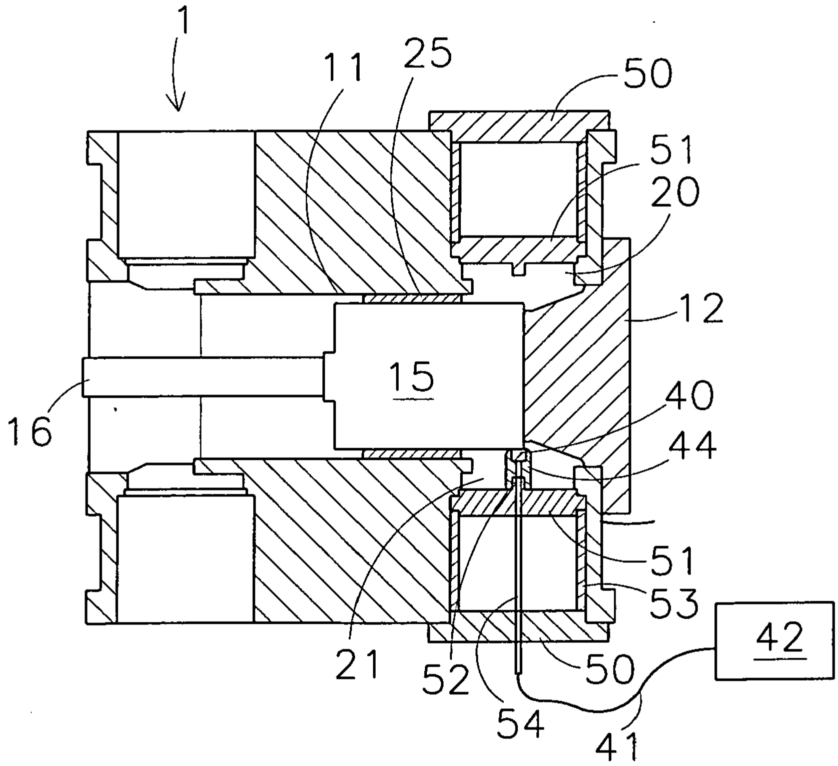
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Fig 4

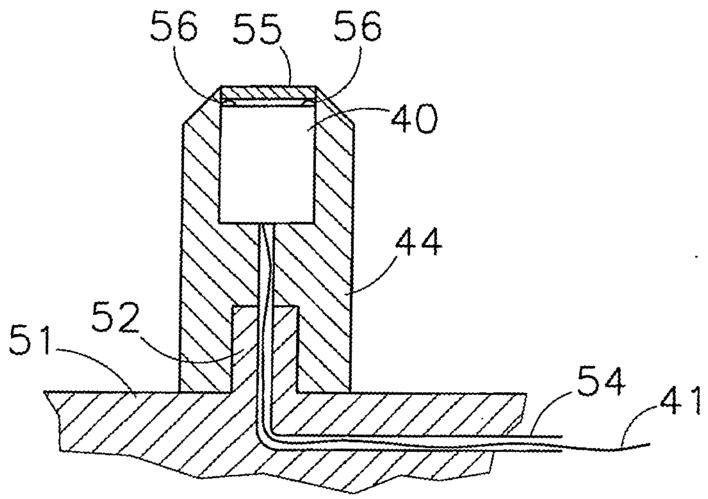

Fig 5

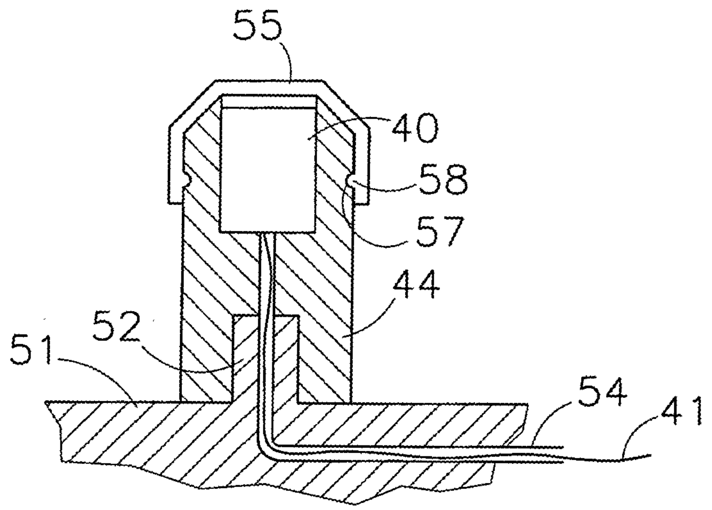

Fig 6

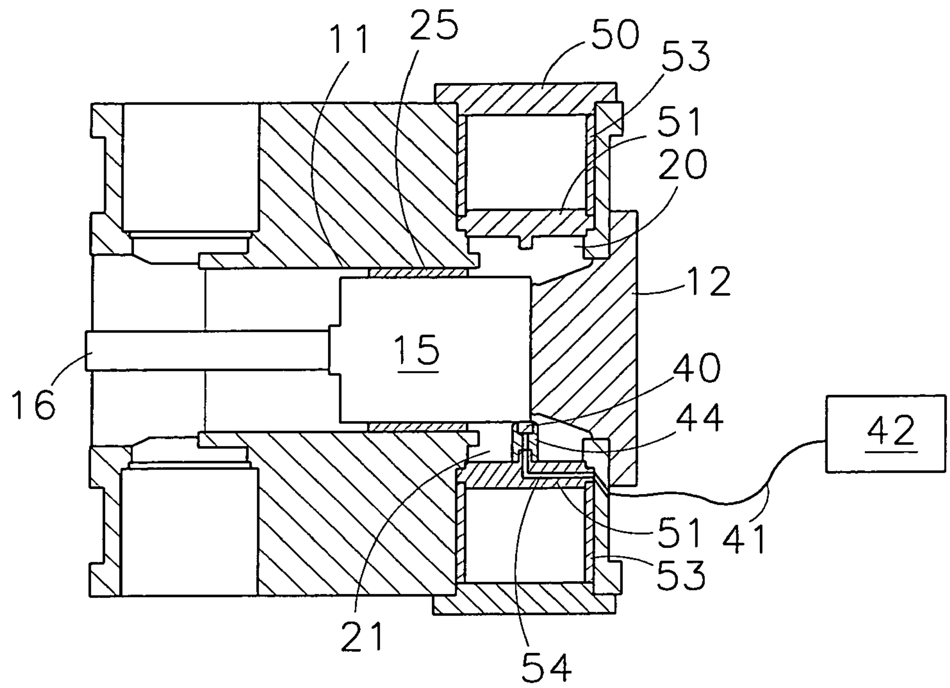
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Fig 7

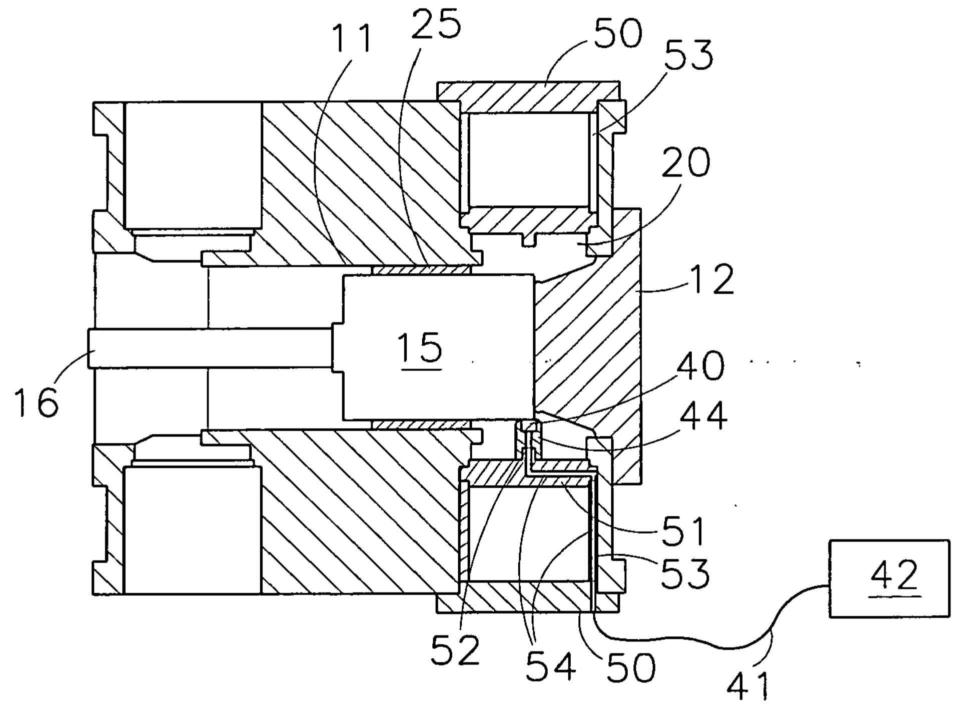
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Fig 8

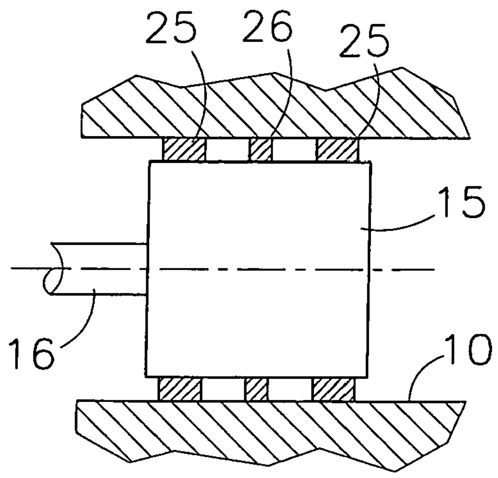

Fig 9A

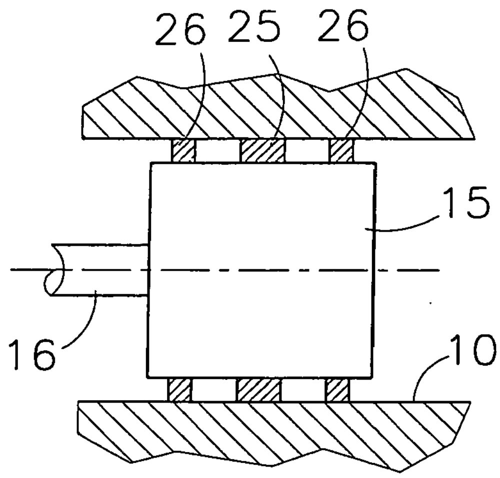

Fig 9B

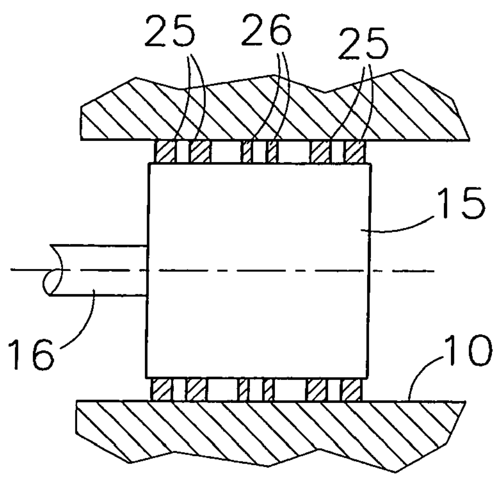

Fig 9C

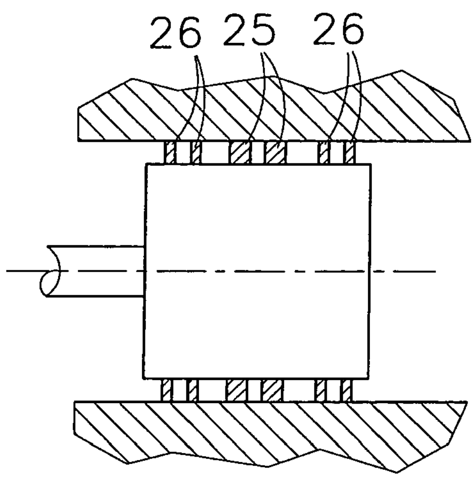

Fig 9D

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Application Number
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Place of search	Date of completion of the search	Examiner
Munich	19 September 2007	Pinna, Stefano

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