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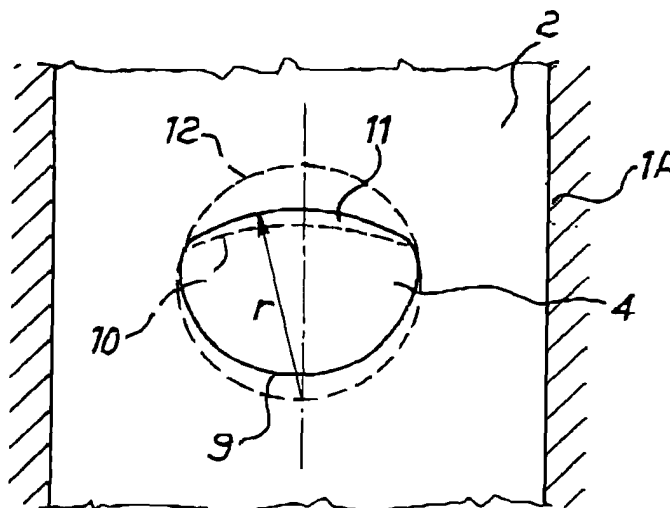
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(54) **A cylinder for engines having inlet and/or outlet ports**

(57) The invention relates to a cylinder with ports for engines or machines functionally associated with a piston provided with at least one piston ring, wherein it is

provided, on the inner surface thereof, at the level of at least one of the ports thereof, a guide ramp for the piston ring. The invention also relates to a process to design and produce the cylinder.

Fig. 4



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Description

[0001] The present Invention relates to a cylinder having intake and/or exhaust ports for engines or machines, such as two-stroke engines, two-stroke diesel engines, rotating piston machines, compressors or the like, and a process for the design and production thereof.

[0002] The demands of the engine market, especially two-stroke engines have for some time been directed towards reducing manufacturing, maintenance and running costs of said engines. Moreover, in recent years there has been a growing demand for silent engines that are also capable of satisfying increasingly strict anti-pollution and safety regulations. Therefore, the manufacturers of two-stroke engines or the like currently have to meet this dual requirement. Consequently, engines of the latest generations must be the result of an excellent compromise between performances on the one hand and production and maintenance costs on the other.

[0003] This aspect also includes the problem of reducing interference of the piston rings (mounted on the piston) with the cylinder walls and in particular with the intake and exhaust ports.

[0004] Operation of an engine or a machine of the type mentioned requires the seal between the piston and the cylinder to be guaranteed by piston rings housed in specific seats produced on the side surface of the piston. Each piston ring has both the job of facilitating sliding of the piston inside the cylinder and of creating a barrier against the unwanted flow of fluids in the interstice between piston and cylinder, to guarantee that operating pressures are maintained.

[0005] Normally, ports open onto the inner surface of the cylinders of said engines or machines, usually at least two ports, one for intake and the other for exhaust. The exhaust port in two-stroke engines is usually larger than the intake port as it has the job of conveying the exhaust gases out of the cylinder, said exhaust gases having high specific volumes at high temperatures.

[0006] During operation of an engine or a machine of said type, the piston, during vertical movement thereof inside the cylinder, alternately intercepts the intake port and the exhaust port. Consequently, the portion of each piston ring that covers a port, for a brief instant is positioned facing the inlet and outlet ducts defined by said ports. Due to their tangential pressure, the piston rings tend to penetrate the ports which open onto the cylinder barrel and, therefore, are subject to interference with the edges of said ports. The extent of penetration of the piston ring in a port is hereinafter referred to as "entrance" of the piston ring. The greater the entrance of the piston ring in a port is, the greater the Interference of the ring with the edge of said port will be in the instant in which the piston closes or opens the port completely.

[0007] Entrance of a piston ring depends on various factors, such as the type of material with which the piston ring is produced, the shape of the port and of the piston ring itself, the operating temperatures and pres-

ures of the engine, etc.. Typically, the entrance values of the piston rings in the ports vary from a few microns to a few tens of microns.

[0008] When entrance of the piston rings in the cylinder ports is high, the piston rings are subject to heavy wear, which can reach high levels. In the worst cases, interference of a piston ring with the edge of a port can cause breakage of the ring and, therefore, stoppage of the engine with consequent permanent mechanical damages to the piston and the cylinder.

[0009] Various measures have been proposed in order to reduce entrance of the piston rings in the ports of the cylinder.

[0010] For example, piston rings in which the outer surface, against which relative sliding of the cylinder takes place, is rounded, have been marketed for some time now. This type of piston ring is subject to less interference with the edges of the cylinder ports with respect to conventional piston rings. Nonetheless, they are costly and do not solve the problem completely.

[0011] Some manufacturers have designed cylinders in which the intake and exhaust ports have, generally in the central position, a guide plate for the piston rings. Although the use of the plate reduces entrance of the rings in the port of the cylinder, it also causes serious localized wear of the piston rings (scoring), as the portion of each piston ring that slides on the guide plate is destined to wear more rapidly than the other portions. Localized wear can cause a decrease in the seal of the piston ring and breakage thereof. Moreover, due to its small dimensions and position, the plate is subject to extremely high mechanical and thermal stresses and therefore requires precise and costly machining.

[0012] A further measure customarily used to lessen interference of the piston rings with the cylinder ports is to bevel the edges of the ports to facilitate transit of the piston rings, that is, to create a macro-bevel. As for the previous measures, this does not solve the problem completely and has various drawbacks. Generally, the macro-bevel is produced manually and in any case, even if machined automatically, causes an increase in times and production costs of the cylinder. Moreover, the presence of this type of bevel makes the surface finish of the cylinder barrel more difficult to obtain. From the viewpoint of engine operation, the presence of the macro-bevel on the edges of ports can in some cases cause incorrect opening/closing of the port or a decrease in the degree of seal against exhaust gases at the various rotation speeds of the engine.

[0013] Conventional measures also have the disadvantage, for the designer, of having to shape the cylinder ports to reduce phenomena of interference. This often causes the designer to use intake/exhaust ports with a shape which is not the most advantageous to obtain specific performances, but which guarantees durability of the piston rings.

[0014] The object of the present invention is to provide a cylinder for engines or machines of the type men-

tioned, functionally associable with a piston, which allows elimination of the problem of interference of the piston rings with the cylinder ports and increases the life of said piston rings.

[0015] A further object of the present invention is to provide a process to design and produce the cylinders of the aforesaid engines or machines which allows the production of a cylinder capable of functionally coupling with a piston without interference occurring between the cylinder ports and the piston rings or the ends (tail) of said piston, in order to increase the life of the rings and of the piston.

[0016] Another object of the present invention is to provide a cylinder with ports for engines or machines and a process for the design and production thereof which makes it possible to obtain engines with high performances, which are economical and able to easily satisfy anti-pollution regulations.

[0017] Yet another object of the present invention is to provide a cylinder for engines or machines and a process for the design and production thereof which makes it possible to obtain maximum performances and/or maximum reduction in consumption and/or maximum reduction in polluting emissions of the assembled engine, releasing the designer from the functional problem of interference between the cylinder ports and the piston rings.

[0018] One more object of the present invention is to provide a cylinder with ports for engines or machines and a process for the design and production thereof which makes it possible to assemble economical and silent engines or machines, which require minimum quantities of lubricants and are subject to low vibrations.

[0019] These and other objects are obtained by the present invention which relates to a cylinder with ports for engines or machines, functionally associated with a piston provided with at least one piston ring, characterized by having, on the inner surface thereof, at the level of at least one of the ports thereof, a guide ramp of said piston ring.

[0020] The ramp may be provided at the level of all the channels which open onto the inner surface of the cylinder, for example suction ports, exhaust ports, transfer ports, etc..

[0021] According to one aspect of the present invention, the guide ramp of the piston ring extends over the upper edge of the port and/or under the lower edge thereof. If the cylinder is also provided with a suction port regulated by said piston, the guide ramp may extend below said port to guide the lower end of the piston (tail).

[0022] According to another aspect of the present invention, the maximum depth of the ramp, with respect to the inner surface of the cylinder, is at the level of the edge of said port and said maximum depth is less than or equal to the maximum penetration of the piston ring in said port.

[0023] The aforesaid objects are also achieved by a

process according to the present invention, to design and produce a cylinder with ports for engines or machines, characterized in that, at the level of at least one of said intake and exhaust ports of the cylinder, at least one guide ramp of the piston ring is created through the steps of: determining, for at least one port of the cylinder and in the operating conditions of said engine, maximum penetration, with respect to the inner surface of the cylinder, of the piston ring in said port; choosing the inclination of said ramp with respect to a generatrix of the inner surface of said cylinder; bevelling the inner surface of said cylinder in order to produce said ramp, so that said ramp has the maximum depth thereof at the edge of said port, said maximum depth being greater than or equal to said maximum penetration, and so that said ramp extends vertically with said inclination.

[0024] Further characteristics of the invention will become more evident from the detailed description of a cylinder according to the invention and a process for the design and production thereof, made with reference to a two-stroke engine and with the aid of the accompanying drawings, provided as a nonlimiting example, wherein:

- Figure 1 shows two section views of a typical cylinder of a two-stroke engine;
- Figure 1A is a section view of a piston associable with the cylinder in Figure 1;
- Figure 2 is a diagram of penetration of a piston ring in a port as time varies;
- Figure 3 is a front view of a port of a cylinder similar to the cylinder in Figure 1;
- Figure 4 is a front view of the port in Figure 3 on which a guide ramp of the piston rings has been produced using the process of the invention;
- Figures 4A and 4B are representations of further possible shapes of ports in a cylinder of a two-stroke engine;
- Figure 5 is a section view of a detail of the upper edge of the port in Figure 4;
- Figure 6 is an enlarged section view of a detail of Figure 5;
- Figure 7 shows the influence of a macro-bevel on opening and closing of a port;
- Figure 7A shows the influence of the ramp according to the invention on opening and closing of a port;
- Figure 7B is a detail of the time-area diagram relative to the port in Figure 7;
- Figure 7C is a detail of the time-area diagram relative to the port in Figure 7A;
- Figure 8 is a perspective section view of a cylinder according to the invention;
- Figure 9 is a perspective section view of another cylinder according to the invention.

[0025] Figure 1 shows two section views of a typical

cylinder 1 of a two-stroke engine. The cylinder according to the invention and the process for the design and production thereof are obviously not limited, respectively in production and application, only to the cylinder shown, but can in general be used for all types of cylinders for two-stroke engines.

[0026] The intake ports, the exhaust ports and the transfer ports open onto the inner surface 2 of the cylinder 1. In general, the number of ports varies according to the type of engine for which the cylinder is intended. The specific cylinder 1 shown has one intake port 3 for the mixture formed of air, fuel and lubricant and one exhaust port 4 for the exhaust gases. The cylinder 1 is also provided with transfer ports 5.

[0027] The cylinder 1 is functionally associated with a piston 6 (Figure 1A), on which at least one piston ring 7 is housed near the crown 8 of the piston. Conventionally, the piston 6 slides inside the cylinder 1, with an alternate vertical movement, between the bottom dead centre and the top dead centre (not shown). Consequently, the piston intercepts, at different times, the intake port 3 and the exhaust port 4, determining the opening/closing thereof.

[0028] In conventional cylinders, when the piston 6 intercepts one of the ports 3 or 4, a portion of each piston ring 7, present on the piston 6, penetrates the port due to the tangential pressure thereof. When the piston ring 7 encounters the lower or upper edge of the port 3, 4, interference is produced between the ring 7 and the port 3 or 4, which reduces the functionality of the engine and the life of the ring. In fact, the speed with which the piston ring 7 encounters the edge of the port is considerable, and the ring is therefore subject to noteworthy abrasion.

[0029] If the piston 6 is provided with two piston rings 7, the upper one is subject to a greater degree of penetration with respect to the lower one, as the pressure exerted by the exhaust gases is added to the tangential pressure thereof.

[0030] Figure 2 schematically shows, for discrete intervals of time, the phenomenon of penetration of a piston ring 7 in the exhaust port 4 of a conventional cylinder 1. It is assumed that the piston is moving from the bottom to the top. Initially, when the piston 6 moves upwards, the ring 7 slides on the inner surface 2 of the cylinder 1. At the moment in which the piston goes beyond the lower edge 9 of the port 4, the ring 7 penetrates the inner volume of the port 4. The depth of penetration of the ring increases as the width of the port 4 increases. Therefore, maximum penetration of the ring 7 occurs at the level of the portion of the port 4 having the maximum width. Typically, the ports are shaped as shown in Figure 3 and therefore the piston 6, during upward movement thereof, intercepts portions of the port 4 having different widths, said width increasing from the lower edge 9 to a maximum value and which becomes zero at the upper edge 10.

[0031] Figures 4-6 show a possible embodiment of a cylinder 1A according to the present invention. The cyl-

inder 1A is provided, on the inner surface 2 thereof, with a guide ramp 11 of the piston ring 7 above the upper edge 10 of the exhaust port 4. In general, the cylinder 1A can have more than one ramp, for example above the upper edge of all the ports or, anyway, on the upper and/or lower edge of at least one port, one transfer port, etc..

[0032] The term port is intended, in general, as any opening which opens in the cylinder, on the inner surface thereof. Therefore, the invention contemplates ports of different shapes, for example provided with one or more dividing plates, or ports with multiple openings in the cylinder, such as those shown in Figures 4A and 4B.

[0033] The maximum depth of the ramp 11, with respect to the inner surface 2 of the cylinder 1A, is at the level of the lower and/or upper edge of the port. This maximum depth depends principally on the maximum penetration (maximum entrance) of the piston ring 7 in the port and secondarily on the shape of said port. In general, the maximum depth of the ramp 11 is lower than or equal to the maximum entrance of the piston ring 7.

[0034] In the embodiment illustrated, the maximum depth of the ramp 11, measured with respect to the inner surface 2 of the cylinder 1A, is indicated with E (Figures 2 and 5) and corresponds to the maximum entrance of the piston ring 7 in the port 4 of the cylinder 1 (Figure 2).

[0035] In practice, the maximum entrance of the piston ring 7 in a port is measured experimentally on the conventional cylinder 1. Alternatively, the maximum entrance can be calculated by suitable mathematical formulas. On the basis of the value of maximum entrance thus obtained, the ramp 11 is produced on the surface of the cylinder 1, obtaining the cylinder 1A according to the invention.

[0036] In general, the ramp 11 has an inclination, with respect to the inner surface 2 of the cylinder 1A, ranging from 0.01 to 10 degrees, for example between 5° and 10°. The degree of inclination must guarantee, in all operating conditions of the engine, seal of the piston rings 7 against the inner surface 2 of the cylinder 1A. The height H of the ramp 11 therefore depends on the maximum depth E thereof and on the inclination. Preferably, the ramp is connected to the edge of the port 3 or 4 by means of curved surfaces.

[0037] Alternatively, the ramp 11 can have more than one inclination, for example, in the case in which it is obtained by a series of surfaces having different inclinations. The ramp 11 can even have a curved profile.

[0038] In general, the ramp 11 can be included in the ideal circumference circumscribed to the port on which said ramp is provided. In the embodiment shown in Figure 4, the ramp 11 extends over the port 4, within the ideal circumference 12. The port can also be included in ideal geometrical shapes that differ from the circumference 12 such as ellipses, parabolas or series of curves.

[0039] The ramp 11 can also be produced around

multiple adjacent ports or ports having a dividing wall.

[0040] The ramp 11 can be produced in many different known ways. Preferably, it is obtained by bevelling the inner surface 2 of the cylinder 1, said bevelling being produced by numerically controlled automatic machines.

[0041] The cylinder 1A can be, in the same way as conventional cylinders, subjected to processes to treat the inner surface, such as zinc coating, plasma coating, or more generically coatings that make the inner surface of the cylinder resistant to wear and facilitate sliding of the piston.

[0042] The cylinder 1A, thanks to the presence of the ramp 11 on at least one of the ports 3 or 4 thereof, allows the problem of interference between the piston rings 7 and the port 3 or 4 to be solved. In fact, the ramp 11 is configured as a guide surface of the piston rings 7 when they slide on the inner surface 2 of the cylinder at the level of the port. In practice, the ramp 11 prevents the piston ring 7 of the piston 6 from knocking against the edge of the port. The ramp 11 makes it possible to greatly reduce the vibrations to which the engine is subject during operation and, therefore, reduces the noise thereof. Moreover, the ramp 11 makes it possible to obtain an increase in the life of the piston rings. This has a positive effect on engine maintenance costs, which are greatly reduced.

[0043] The ramp 11 also has the advantage of offering the designer of the cylinder ample freedom of choice with regard to the shape of the ports. In fact, the designer is not obliged to choose a specific shape for a port in order to take into account wear of the piston rings, as instead occurs with conventional cylinders.

[0044] Another advantage of the cylinder 1A according to the present invention lies in the fact that the ramp 11 allows high precision to be obtained with regard to the opening and closing phases of the ports and a considerable reduction, with respect to conventional cylinders, in the amount of lubricant to be used in the engine together with the fuel. In fact, the ramp 11 according to the invention allows the assembly of engines in which opening of the ports 4 by the piston is surprisingly rapid and precise with respect to conventional engines. Moreover, opening of the port 4 does not cause the losses of pressure which instead characterize conventional engines provided with macro-bevels on the cylinder, as the ramp 11 guides the piston rings and guarantees in any case the seal thereof.

[0045] Consequently, regulation of the engine provided with the cylinder according to the present invention is simplified with respect to engines provided with conventional cylinders. The cylinder according to the invention thus allows the assembly of two-stroke engines capable of operating in accordance with the strictest anti-pollution regulations, thanks also to the small amounts of lubricant required for the operation thereof.

[0046] Moreover, by using the ramp 11 according to the invention, the designer can size the exhaust, suc-

tion, transfer ports, etc., to find the best functional compromise between performances, consumptions and emissions of the assembled engine, without having to worry about problems relative to the aforesaid interference of the piston rings, as instead has been the case with conventional cylinders. Therefore, the designer has fewer constructional constraints, and can use many different shapes for the ports, transfer ports, etc..

[0047] The presence of the ramp 11 can also allow cylinders with macro-bevels of smaller dimensions to be produced with respect to those conventionally produced, or even cylinders without macro-bevels, with evident positive reflections on the operation of the finished engine. Figure 7 shows a conventional cylinder provided with macro-bevels and highlights how a macro-bevel delays closing of the port 4, allowing gases to enter the port.

[0048] Figure 7A shows the positive effect of the ramp 11 according to the invention on the precision of both closing and opening of the port 4. In fact, in this case, when the piston ring 7 intercepts the edge 10 of the port 4, closing of the port 4 is immediate and precise.

[0049] Figures 7B and 7C respectively show the influence of a macro-bevel and of a ramp 11 according to the invention on the time-area diagram of a cylinder, said diagram indicating the area of a port intercepted by the piston rings as the crank angle of the assembled engine varies. It can be seen that, due to the presence of the macro-bevels (Figure 7B), the initial and the final slopes of the time-area curve are small, and therefore the opening instant of the port is brought forward, that is, it takes place several crank degrees prior to the intended crank degrees, while the closing instant is delayed. Consequently, during the opening phase of the port, there is an early loss of pressure particularly penalizing for the performances of the engine. With the ramp 11 according to the invention (Figure 7C), it is possible to produce cylinders having a time-area diagram with greater slopes, which thus tends to the ideal "rectangular" shape, with surprisingly rapid and precise opening and closing of the ports and, therefore with improved performances compared to those of conventional cylinders.

[0050] Figures 8 and 9 each show, perspective, a cylinder according to the invention. In the cases illustrated, the port provided with the ramp 11 is the exhaust port 4. The ramp 11 in Figure 8 has a greater extension than the ramp 11 in Figure 9.

[0051] According to the present invention, it is possible to allocate a weight to the extension of the ramp 11 based on the ratio between the radius of curvature of the port and the radius of curvature of the ramp. In particular, this ratio is preferably referred to the radius of curvature of the circumference 12 circumscribed to the port and the radius of curvature of the ramp, at the outermost edge thereof. In this way, it is possible to also take into account any elliptical, polyelliptical, parabolic or polyparabolic shaping of the port. With reference again to Figure 4, if, for example, the circumference cir-

cumscribed around the port 4 has a radius of curvature r equal to 28 mm and the ramp 11 has a radius of curvature equal to 34.1 mm, the aforesaid ratio is equal to approximately 0.82, that is, the "weight" of the ramp 11 with respect to the port 4 is approximately 82%.

[0052] The beneficial effects described above can be exploited on all types of machine shaped to have ports with opening and closing controlled by the sliding of a piston or another member with or without piston rings, such as volumetric machines (compressors), two-stroke diesel engines, rotating piston machines, etc..

Claims

1. A cylinder with intake and/or exhaust ports for engines or machines, functionally associated with a piston provided with at least one piston ring, **characterized by** having on the inner surface thereof, at the level of at least one of the ports thereof, at least one guide ramp of said piston ring.
2. A cylinder as claimed in claim 1, **characterized in that** said ramp extends over the upper edge of said port.
3. A cylinder as claimed in claim 1, **characterized in that** said ramp extends under the lower edge of said port.
4. A cylinder as claimed in claims 2 and 3, **characterized in that** said ramp also extends at the sides of said port.
5. A cylinder as claimed in any of the previous claims, **characterized in that** said ramp has the maximum depth thereof, with respect to the inner surface of the cylinder, at the level of the edge of said port.
6. A cylinder as claimed in any of the previous claims, **characterized in that** said maximum depth is greater than or equal to the maximum penetration of said piston ring in said port.
7. A cylinder as claimed in any of the previous claims, **characterized in that** said ramp is inclined, with respect to a generatrix of the inner surface of the cylinder, according to a constant angle ranging from 0.01 to 10 degrees.
8. A cylinder as claimed in any of the previous claims, **characterized in that** said ramp has several portions each inclined, with respect to a generatrix of the inner surface of the cylinder, according to an angle ranging from 0.01 and 10 degrees.
9. A cylinder as claimed in claim 8, **characterized in that** the portion of said ramp nearest to the edge of

said port is inclined, with respect to a generatrix of the inner surface of the cylinder, according to an angle between 5 and 10 degrees.

10. A cylinder as claimed in any of the previous claims, **characterized in that** said ramp is connected to the inner surface of said port by means of curved surfaces or includes said port.
11. A cylinder as claimed in any of the previous claims, **characterized in that** said ramp is included in the ideal circumference circumscribed to said port or in other closed geometrical shapes.
12. A process to design and produce cylinders with intake and/or exhaust ports of engines or machines, **characterized in that**, at the level of at least one of the intake and exhaust ports of the cylinder, at least one guide ramp of the piston ring is created through the steps of:
 - determining, for at least one port of the cylinder and in the operating conditions of said engine, maximum penetration, with respect to the inner surface of the cylinder, of the piston ring in said port;
 - choosing the inclination or inclinations of said ramp with respect to a generatrix of the inner surface of said cylinder;
 - machining the inner surface of said cylinder in order to produce said ramp, so that said ramp has the maximum depth thereof at the edge of said port, said maximum depth being greater than or equal to said maximum penetration, and so that said ramp extends vertically with said inclination.
13. A process to design and produce cylinders as claimed in claim 12, **characterized in that** said bevelling step of the cylinder is produced with automatic machine tools.
14. A process to design and produce cylinders as claimed in claim 12, **characterized in that** said maximum penetration is measured through laboratory tests.
15. A process to design and produce cylinders as claimed in claim 12, **characterized in that** said maximum penetration is determined through the use of mathematical correlations.
16. A process to design and produce cylinders as claimed in claim 12, **characterized in that** said inclination is constant and ranges from 0.01 to 10 degrees.
17. A process to design and produce cylinders as

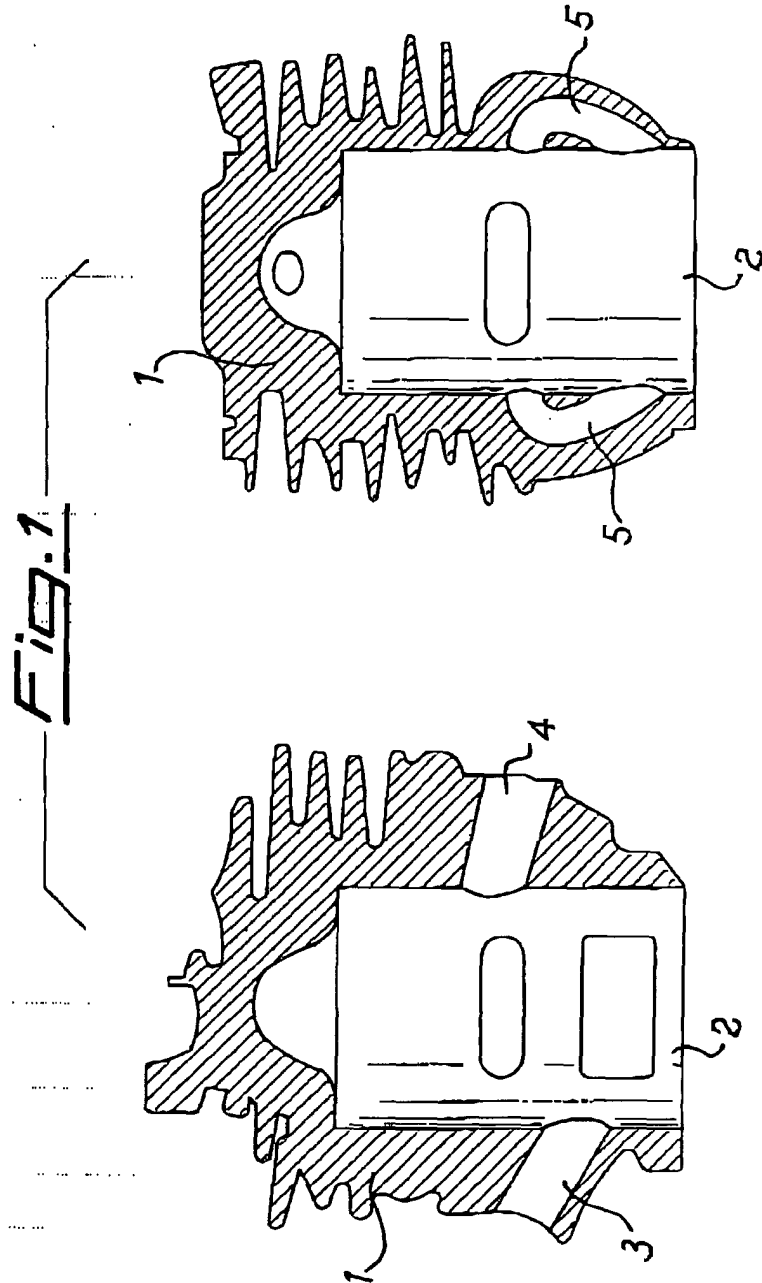
claimed in claim 12, **characterized in that** said inclination is variable and ranges from 0.01 to 10 degrees.

18. A process to design and produce cylinders as claimed in any of the previous claims, **characterized in that** said ramp extends over the upper edge of said port. 5
19. A process to design and produce cylinders as claimed in any of the previous claims, **characterized in that** said ramp extends under the lower edge of said port. 10
20. A process to design and produce cylinders as claimed in any of claims 18 and 19, **characterized in that** said ramp also extends at the sides of said port. 15
21. A process to design and produce cylinders as claimed in any of the previous claims, **characterized in that** the outer edge of said ramp is included in the ideal circumference circumscribed around said port or in other closed geometrical shapes. 20
22. A process to design and produce cylinders as claimed in any of the previous claims, **characterized in that** it includes the further step of connecting, by means of bevelling, said ramp to the inner surface of said port through curved connecting surfaces. 25 30
23. A process to design and produce cylinders as claimed in any of the previous claims, **characterized in that** it includes a step to provide a zinc-coating and/or plasma coating and/or wear-resistant coating on said ramp and/or on the inner surface of said cylinder, or to provide a coating of another material on said ramp and/or on said inner surface. 35 40

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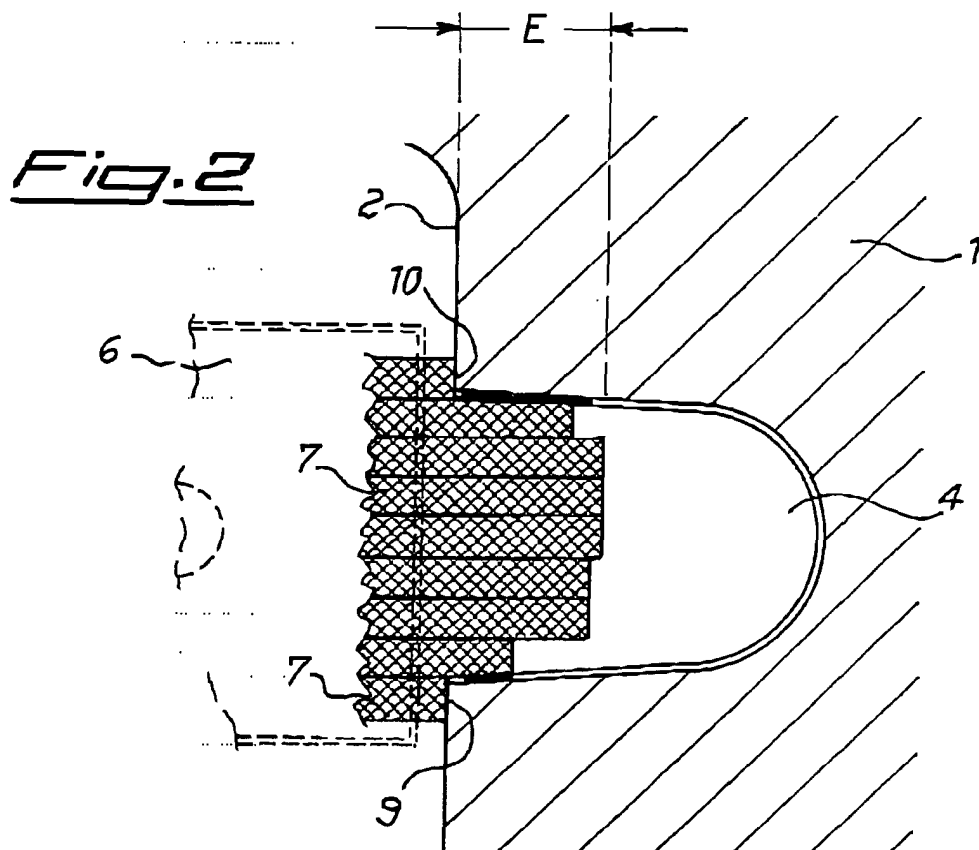
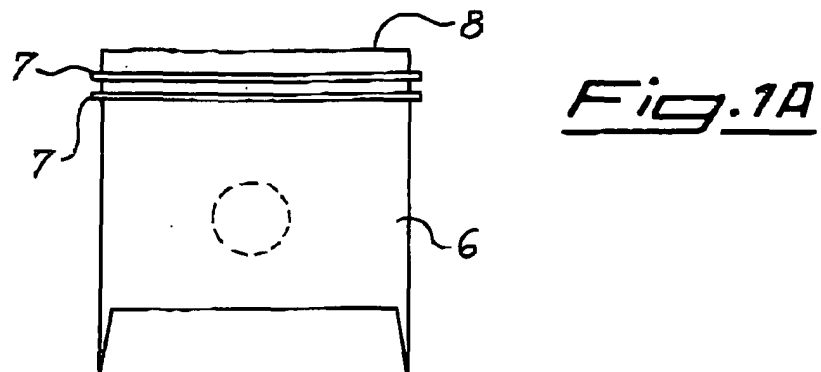


Fig. 3

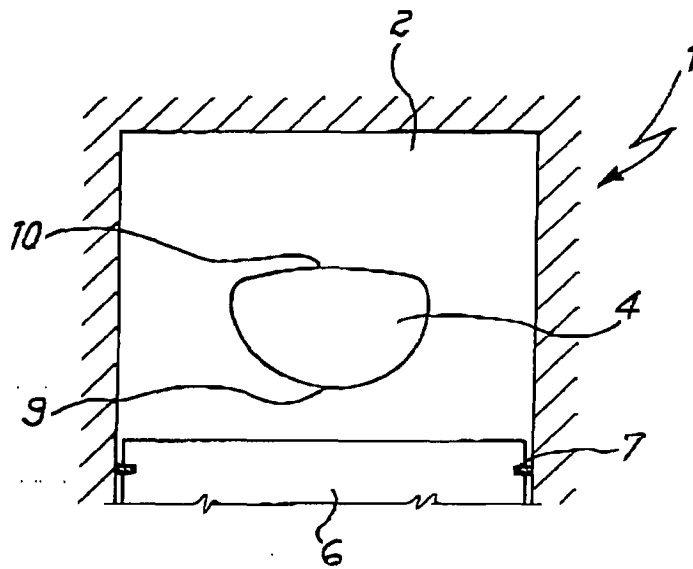


Fig. 4A

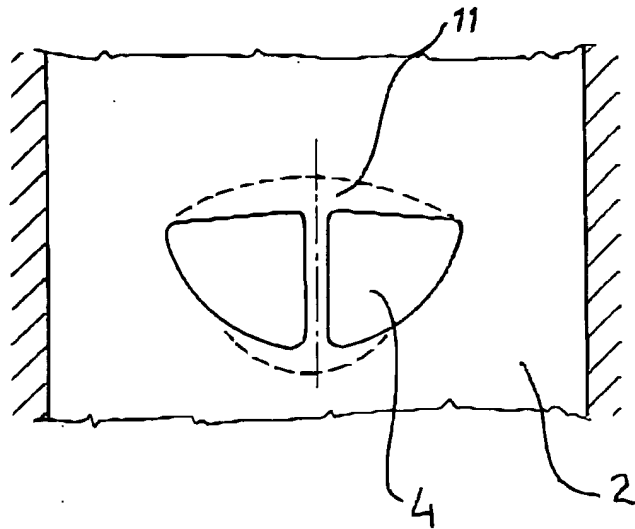


Fig. 4B

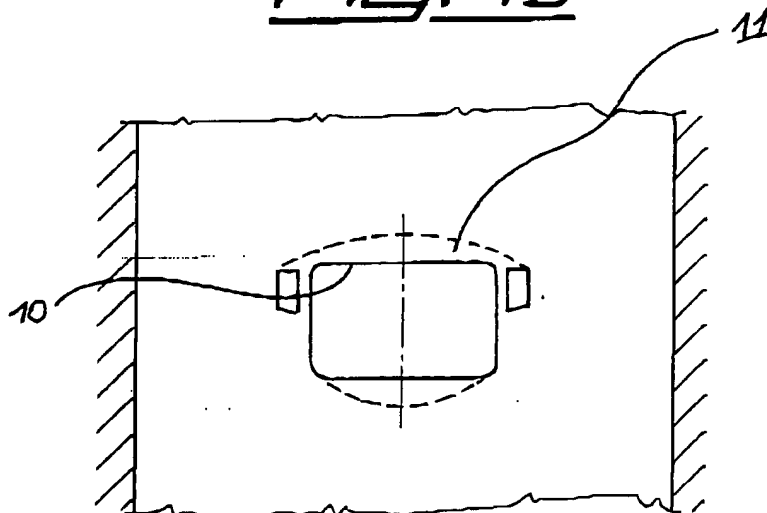


Fig. 4

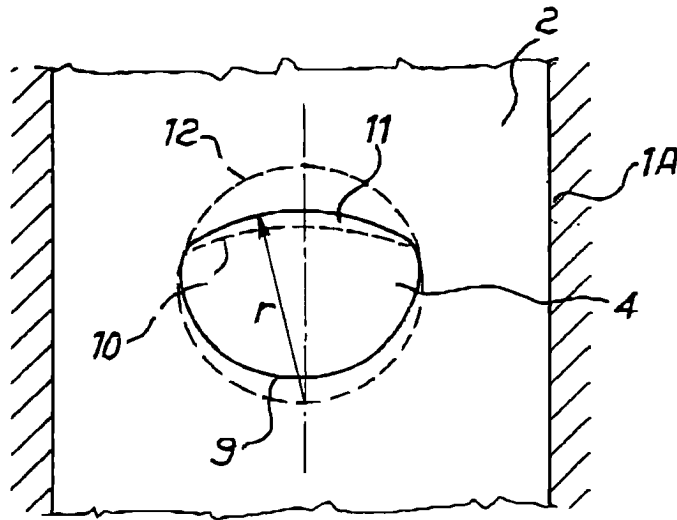


Fig. 5

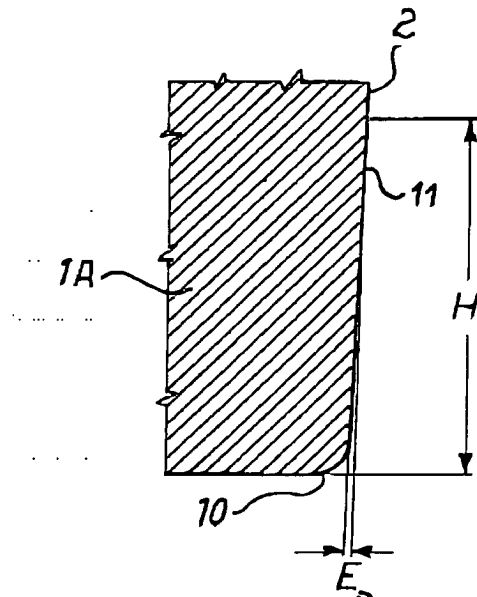


Fig. 6

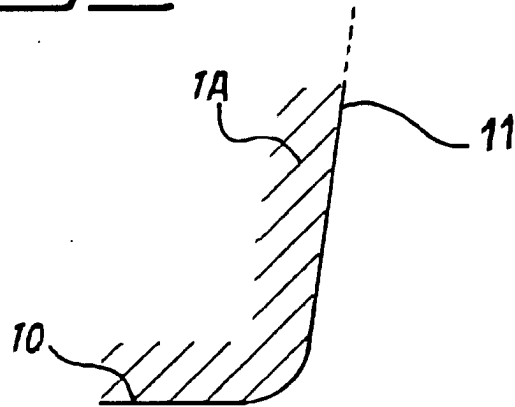


Fig. 7

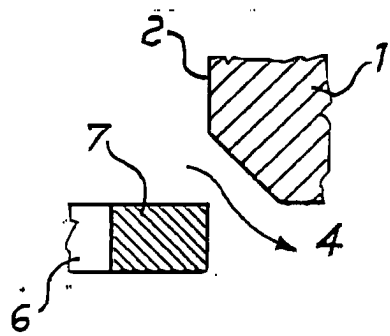
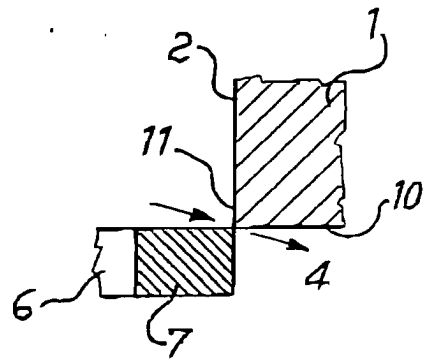


Fig. 7A



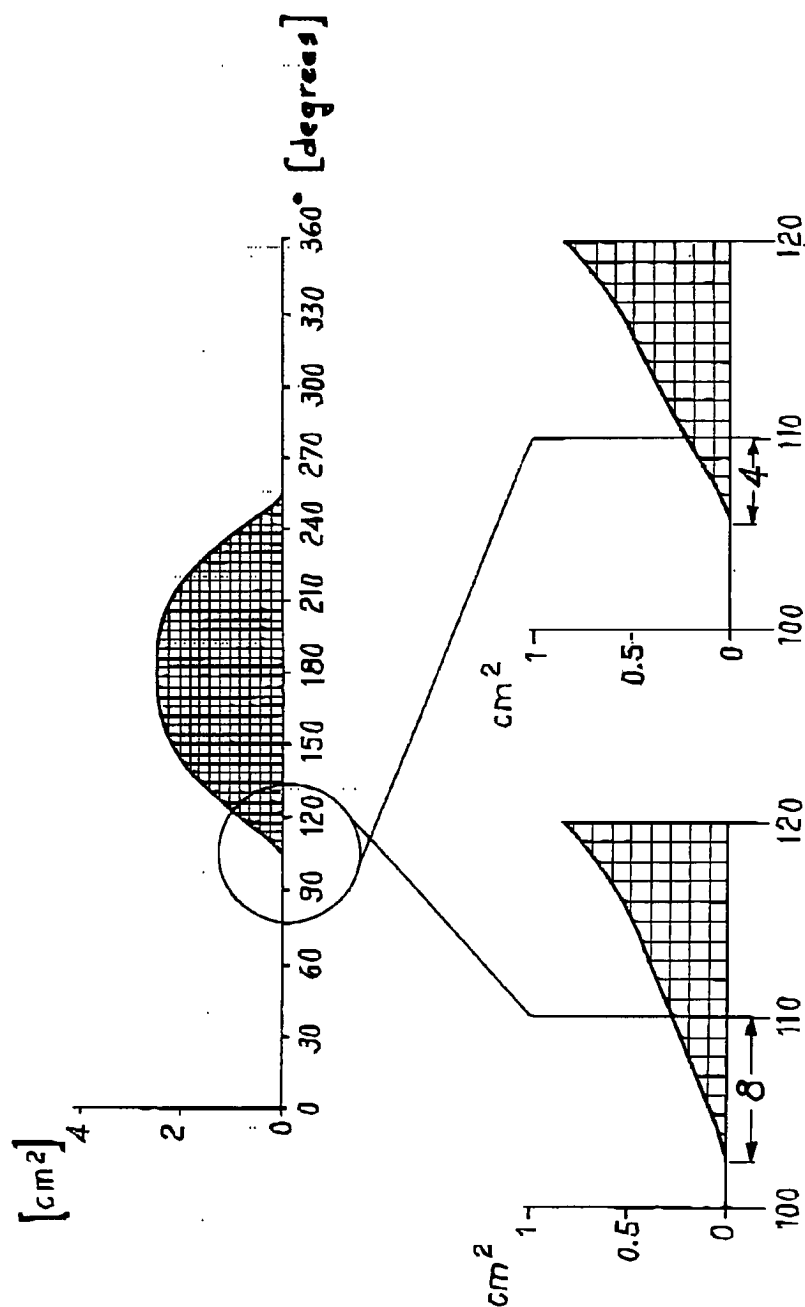


Fig. 7C

Fig. 7B

Fig. 8

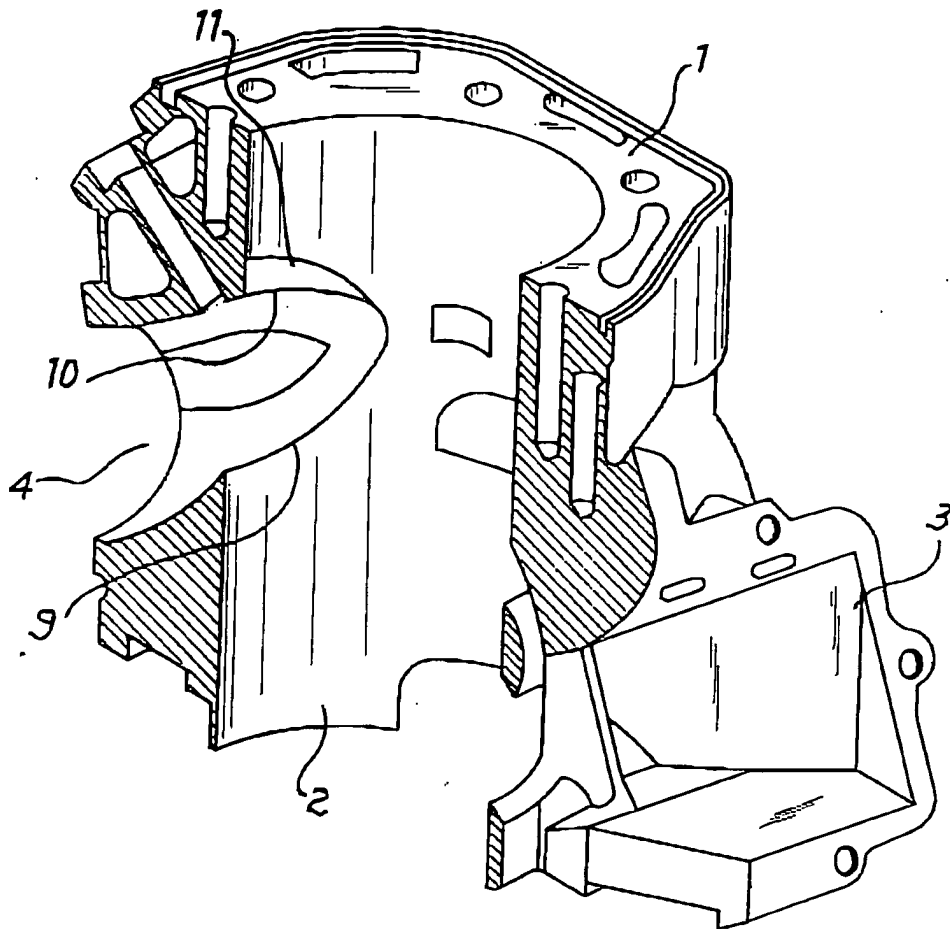


Fig. 9

