

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 837 982 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

13.01.1999 Bulletin 1999/02

(21) Application number: **96922776.8**

(22) Date of filing: **28.06.1996**

(51) Int Cl.⁶: **F02B 77/04**

(86) International application number:
PCT/DK96/00295

(87) International publication number:
WO 97/03280 (30.01.1997 Gazette 1997/06)

(54) **AN INTERNAL COMBUSTION ENGINE HAVING A COKE SCRAPING RING IN A CYLINDER**

BRENNKRAFTMASCHINE MIT EINEM KOKSSCHABRING IN EINEM ZYLINDER

**MOTEUR A COMBUSTION INTERNE DOTE D'UN ANNEAU DE GRATAGE DU DEPOT
CHARBONNEUX DANS UN CYLINDRE**

(84) Designated Contracting States:
DE ES FR GB IT NL SE

(30) Priority: **07.07.1995 DK 80495**

(43) Date of publication of application:
29.04.1998 Bulletin 1998/18

(73) Proprietor: **MAN B&W Diesel A/S**
2450 Copenhagen SV (DK)

(72) Inventor: **GRUNDTMANN, Ole**
DK-4300 Holbaek (DK)

(74) Representative: **Indahl, Peter Jensen et al**
c/o Internationalt Patent-Bureau
Hoeje Taastrup Boulevard 23
2630 Taastrup (DK)

(56) References cited:

CH-A- 672 353	DE-C- 800 448
FR-A- 2 322 269	US-A- 3 476 099
US-A- 3 489 130	US-A- 4 474 147
US-A- 4 770 133	

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 837 982 B1

Description

The present invention relates to an internal combustion engine having a coke scraping ring in a cylinder and having a piston longitudinally displaceable in the cylinder and provided with piston rings, which slide along the substantially cylindrical inner surface of the cylinder at the displacement of the piston and create a pressure-sealing separation between the volume below the piston and the working chamber, which is located above the uppermost piston ring of the piston and is defined by the uppermost piston ring, the piston, the inner surface of the cylinder and the cylinder cover, the coke scraping ring protruding from the inner surface of the cylinder and extending annularly in an axial position so that the uppermost piston ring is positioned near the lower edge of the coke scraping ring when the piston is in its top dead centre position.

Such an engine having a coke scraping ring is known from four-stroke engines with both a suction valve and an exhaust valve in the cylinder cover. The aim of the coke scraping ring is to scrape away coke deposits from the cylindrical uppermost piston section located above the uppermost piston ring.

The uppermost piston ring forms the lower limitation of the combustion chamber in the annular space located between the uppermost piston section above the piston ring and the inner surface of the cylinder. Therefore, part of the combustion products will penetrate into the annular space and be deposited on the outer surface of the uppermost piston section. Lubricating oil from the inner surface of the cylinder may also sprinkle on to this outer surface. The oil residues and the combustion products deposited are exposed to a strong heat influence from the combustion and, as the engine runs, will be transformed into a coherent coke layer on the outer piston surface. If a coke scraping ring is not used, the coke layer will grow in thickness until it touches the inner surface of the cylinder.

To avoid damage to the cylinder and the piston rings it is important that a suitable lubricating oil film is maintained between these mutually movable parts. When the coke layer on the periphery of the piston is built up to its maximum thickness and comes into contact with the inner surface of the cylinder, it will interfere with the thin oil film and absorb and/or scrape away some of the oil, which negatively affects the lubricating conditions. In the worst case, the lubrication will locally deteriorate so much that damage will occur to the piston rings or the liner.

The coke scraping ring in the known four-stroke engine restricts the thickness of the coke layer when the piston is moved near its top dead centre position and the uppermost piston section is reciprocated past the coke scraping ring, the upper and lower annular edges of which plane away the coke touching the edges. As the scraping ring protrudes from the inner surface of the cylinder, the coke layer is prevented from attaining the

thickness which results in contact between the coke layer and the inner surface of the cylinder.

Because the known engine with the coke scraping ring is a four-stroke engine and both the suction and the exhaust valves in the four-stroke engine are positioned in the cylinder cover, the other operating conditions of the engine are largely uninfluenced by the use or non-use of a coke scraping ring. In the four-stroke engine, the scavenging of the cylinder is effected by an independent piston stroke between each working stroke, and the air supply to the combustion is made from above down through the suction valve at the subsequent downward suction stroke. Therefore, the coke scraping ring has no influence on the scavenging and charging of the cylinder. A more important factor for the favourable results achieved with the coke scraping ring in the four-stroke engine is the movements of the piston itself in relation to the inner surface of the cylinder. The four-stroke cycle involves a different load on the piston at every second upward stroke, and also at the downward strokes the type of load changes every second time. The result is that the radial position of the piston near the top dead centre position varies all the time, so that the coke scraping ring scrapes off the coke to a greater depth than corresponding to its own internal diameter, whereby a clearance is automatically created between the coke-covered uppermost piston section and the coke scraping ring. In a two-stroke crosshead engine with uniflow scavenging the situation is not so simple, and experiments with the coke scraping ring known from the four-stroke engine have demonstrated bothersome operational problems in the form of increased specific fuel consumption and damage to the uppermost piston ring in particular, which is surprising since it was to be expected that the coke scraping ring would actually improve the lubrication conditions for the piston rings.

The object of the invention is to remedy the above disadvantages and render possible an advantageous use of a coke scraping ring in a two-stroke crosshead engine.

In view of this, the invention is characterized in that the engine is a two-stroke crosshead engine with uniflow scavenging having scavenging air ports positioned in a lower cylinder section, and that in its cylindrical inner surface the coke scraping ring is provided with several leakage grooves which extend obliquely relative to the longitudinal axis of the cylinder from the lower surface to the top surface of the coke scraping ring.

It is presumed that the disadvantages demonstrated in using the known coke scraping ring in a two-stroke engine can be explained by the aid of the following mechanisms. In a two-stroke crosshead engine the piston carries out a compression stroke during each upward movement and a working stroke during each downward movement. This means that the piston is loaded in largely the same manner, every time it passes up and down past the coke scraping ring, for which reason the piston performs a uniform, repeated pattern of

motion near the top dead centre position. The tendency towards a uniform pattern of motion is intensified by the crosshead, which guides the lower end of the piston rod in a purely translational movement along the longitudinal axis of the cylinder. Consequently the coke deposits on the piston periphery will build up to a shape fitting exactly into the coke scraping ring so that there is little clearance between the latter and the uppermost piston section. When the top of the piston passes the coke scraping ring in the compression stroke, an annular cavity between the outer surface of the piston with the coke layer and the inner surface of the cylinder is defined axially between the protruding coke scraping ring and the uppermost piston ring. The upward piston movement creates a rapid axial shortening of the annular cavity with a consequent strong compression of the air in it, which generates a heavily increased load on the uppermost piston ring.

The leakage grooves in the cylindrical inner surface of the coke scraping ring reduce or eliminate the pressure build-up in the annular cavity, as the air in it can escape through the leakage grooves to the part of the working chamber located above the piston top. This avoids exposure of the uppermost piston ring to increased load owing to the presence of the coke scraping ring. This factor is of particular importance in the large two-stroke crosshead engines of today, which are being developed towards very high effective compression ratios, such as 1:16 - 1:20, which in themselves result in very large loads on the piston rings.

An oblique course of the leakage grooves may ensure that the coke is also scraped off in the areas opposite the leakage grooves. The parts of the coke deposit opposite to the lower openings in the leakage grooves will not meet the lower edge of the coke scraping ring, but during the continued upward piston movement will pass the upper edges of the leakage grooves and be scraped off here to the desired dimension. The coke particles scraped off in the grooves are passed up into the space above the piston by the leakage air blowing through the grooves.

Furthermore, the leakage grooves counteract increased fuel consumption. If there were no leakage grooves, the effective piston area would be reduced during the first part of the combustion, when the piston top is located at a level with or above the coke scraping ring, as the latter would prevent the pressure increase in the working chamber from being transmitted down to the uppermost piston ring, where the effective piston area covers the whole cross-sectional area of the cylinder. The leakage grooves reduce or remove the pressure drop across the coke scraping ring both during the compression stroke and during the working stroke, and the specific fuel consumption is therefore substantially uninfluenced by the use or non-use of a coke scraping ring.

The coke scraping ring provides a further effect which is particularly advantageous in large two-stroke diesel engines having a high cylinder output, such as

from 1500 to 5500 kW, where the fuel is injected into the cylinder by means of two, three or four fuel injectors emitting direction-specific mists of atomized fuel. The combustion of the fuel generates relatively concentrated heat influences, but as the coke scraping ring covers the uppermost piston ring while the piston is near its top dead centre position, where the thermal load is greatest, and only passes the hot gas to the piston ring through the leakage grooves, the thermal load is distributed more evenly across the uppermost piston ring, thus also protecting the heat-sensitive lubricating oil film on the inner surface of the cylinder. Both factors contribute to better operating conditions for the piston ring pack and increase the effect of preventing the coke on the piston from touching the lubricating oil film.

As an alternative to the arrangement of the leakage grooves in the cylindrical inner surface of the coke scraping ring, it is also possible within the scope of the invention to design the internal combustion engine mentioned in the introduction with a coke scraping ring in a cylinder in a manner characterized in that the engine is a two-stroke crosshead engine with uniflow scavenging having scavenging air ports positioned in a lower cylinder section, and that in its cylindrical outer surface the uppermost piston section located above the uppermost piston ring is provided with several leakage grooves which extend from the top of the piston section down to the area at the annular groove with the uppermost piston ring. In this case, the cylindrical inner surface of the coke scraping ring can be formed as a coherent circularly cylindrical surface. During each engine cycle, the leakage grooves are passed by flows of both compressed air and combustion gas, which prevents coke deposits in the grooves.

In one embodiment, the substantially cylindrical inner surface of the cylinder is constituted by an upper cover section and a lower liner section, and the coke scraping ring is positioned at the top of the liner section. The coke scraping ring may be a ring shrunk into a recess in the inner surface of the liner or alternatively may be a protruding part in the material of the liner itself, viz., an integral coherent part of the liner. In the latter case, the piston with the piston rod has to be mounted before the liner is lowered into position in the engine at its assembly so that the piston is passed upwards from below through the liner. In the first case, the embodiment provides an advantageous possibility of post-mounting a coke scraping ring on already existing engines.

In an alternative embodiment, the substantially cylindrical inner surface of the cylinder is constituted by an upper cover section and a lower liner section, and the coke scraping ring is positioned at the bottom of the cover section. Also in this case, the coke scraping ring may be a separate ring inserted in a recess in the upper cover section or be formed integrally with the cover section, the lower portion of the cover section being fine-turned to a smaller internal diameter than the section located above. If the leakage grooves are to be positioned in the

coke scraping ring, they can subsequently be worked into said lowest part of the cover section. The alternative embodiment is especially applicable in cylinders exposed to especially high thermal loads, where the cylinder cover is manufactured from a more heat-resistant material than the liner. By placing the coke scraping ring in the cover section, the separating surface between the liner and the cover may be moved down to the area immediately above the position for the uppermost piston ring in the top dead centre position.

Preferably, the leakage grooves constitute from 0.25 to 50 per cent of the axially-directed area of the coke scraping ring protruding from the substantially cylindrical inner surface of the cylinder, preferably from 5 to 40 per cent thereof, and suitably from 20 to 30 per cent thereof. If the area of the leakage grooves becomes smaller than 0.25 per cent, the pressure drops across the coke scraping ring become too large, and at a leakage area of more than 50% no further positive effects are achieved. The limit of 5 per cent still results in a pressure drop, but nevertheless a noticeable improvement of the operating conditions, while the limit of 40 per cent is normally fully satisfactory to prevent pressure drops across the coke scraping ring. An area in the interval between 20 and 30 per cent constitutes a suitable compromise between the desire of achieving a small or no pressure drop and the desire of distributing the thermal load evenly.

For engines with uniflow scavenging, the scavenging air ports are preferably opened by the upper surface of the piston, which means that the coke scraping ring must not protrude too far from the inner surface of the cylinder, because the result of an excessive width of the annular space between the coke layer and the inner surface of the cylinder is that the passage by the uppermost piston ring of the upper side of the ports at the end of the working stroke will open the ports. Consequently, for cylinder bores in the interval from 250 to 1000 mm, the coke scraping ring preferably protrudes at least 0.2 mm, such as from 0.5 to 5 mm from the inner surface of the cylinder. The lower value of 0.2 mm, or 0.5 mm, ensures complete obstruction of the scavenging air ports until the upper piston surface has passed. In the largest engines, the coke scraping ring may suitably protrude at least 1 mm, such as from 2 to 3 mm, while 0.5-2 mm may be suitable for small engines. If the ring protrudes less than 0.25 mm, it is more difficult to achieve certainty that the coke deposit does not touch the lubricating film oil on the inner surface of the cylinder.

Preferably, the uppermost piston section located above the uppermost piston ring has a smaller diameter than the underlying piston section with the piston rings, and the internal diameter of the coke scraping ring is at least 0.5 mm, such as from 2 to 6 mm larger than the diameter of the uppermost piston section, suitably from 1 to 4 mm larger than it. With these diameter ratios, the coke layer may be built up to a thickness of from 0.5 to 3 mm, suitably from 0.75 to 2 mm, which provides a suit-

able clearance for the radial positioning of the piston in relation to the coke scraping ring, without any risk that the piston periphery touches the scraping ring.

Within the scope of the invention it is possible to let the coke scraping ring protrude further from the inner surface of the cylinder than stated above, concurrent with a corresponding reduction of the diameter of the uppermost piston section so that the annular space around this piston section and the inner surface of the cylinder has a large thickness. Such a design will entail an earlier opening of the scavenging air ports, viz., at the passage of the uppermost piston ring at the end of the working stroke, and the timing of the opening of the exhaust valve and the other engine parameters depending on the opening time of the scavenging air ports will then have to be changed in accordance with the earlier supply of scavenging air.

The number of leakage grooves in the coke scraping ring or the piston depends on the desired leakage area and on the desired evening out of the thermal load on the uppermost piston ring, a larger leakage area and a more even distribution of the thermal load speaking for the use of a larger number of leakage grooves. The coke scraping ring or the piston may suitably be provided with from 4 to 30 leakage grooves.

As there are considerable advantages in evening out the thermal load on the uppermost piston ring, there are preferably more than 15 leakage grooves.

If the leakage grooves are formed in the periphery of the uppermost piston section, they may advantageously extend in parallel with the axis of the cylinder so that any broken-off pieces of coke are not immediately caught in a leakage groove with a consequent risk of clogging thereof. Otherwise, the number and size of the leakage grooves may be selected in the same manner as for the leakage grooves in the coke scraping ring, cf. the below description thereof.

Examples of embodiments of the invention will now be explained in greater detail below with reference to the highly schematic drawing, in which

Fig. 1 shows a simplified cross-sectional view through an engine with a coke scraping ring according to the invention,

Fig. 2 is a partially sectional view of an enlarged section of the area around the coke scraping ring in the cylinder in the engine of Fig. 1,

Fig. 3 is an unfolded side view of part of the coke scraping ring,

Fig. 4 is a top plane view of a section of the coke scraping ring,

Fig. 5 is a perspective view of an uppermost piston section with leakage grooves in the area above the uppermost piston ring, and

Fig. 6 is a corresponding view of another embodiment of the piston with leakage grooves.

The engine illustrated in Fig. 1 is a large two-stroke

diesel engine with uniflow scavenging and fuelled by oil, such as heavy fuel oil, the combustion of which forms residual products, which may be deposited as coke on the surfaces in the working chamber of the engine. Depending on cylinder dimensions and number, the engine may generate outputs of from 2,000 to, for example, 70,000 kW. Such an engine is conventionally used as a main engine of a ship or as a stationary power-generating engine. In both cases it is of importance that the engine can operate for very long periods without any need for checking and overhauling of the engine components. It is desirable that the engine can be in continuous operation for more than 2 years without any overhauls, and this requires the best possible operating conditions for the cylinder elements.

The stationary parts of the engine comprise a bed plate 1, in which the crankshaft 2 is journalled, and an engine frame box 3 mounted on the bed plate and supporting a cylinder section 4 on its upper surface. A cylinder liner 5 is clamped down against a top plate 6 in the cylinder section by means of cover studs 7 and a cylinder cover 8. The cylinder liner has an upper section having a large wall thickness which, via an annular intermediate member 9, rests on the upper surface of the top plate, and an elongated lower section projecting down into the cylinder section 4. At its lower end, the cylinder liner has a number of scavenging air ports 10, through which scavenging and charging air from a scavenging air receiver 11 flows into the cylinder, when the piston is near its bottom dead centre position. An exhaust valve housing 12 with a hydraulically actuatable exhaust valve is positioned centrally in the cylinder cover. When the exhaust valve is open, scavenging air from the scavenging air ports can flow up through the cylinder, and at the same time the combustion gases flow out through the exhaust valve and into an exhaust receiver 13, from where the gas flows into the exhaust pipe via a turbo-charger. The engine is high-pressure charged to a charging pressure of, for example, 3.5-4 bar.

A connecting rod 14 connects the crankshaft 2 with a crosshead 15, which by means of guide planes 16 in the engine frame box guides the lower end of a piston rod 17 in a translational reciprocal motion along the longitudinal axis of the cylinder. A piston 18 is mounted at the top of the piston rod. As most clearly shown in Fig. 2, the piston has several, such as four, piston rings 19, 19' which slide along the inner surface of the cylinder liner and create a pressure-sealing separation between the working chamber 20 and the volume which is located below the piston and communicates with the cavity in the cylinder section filled with scavenging air.

The combustion or working chamber 20 is defined by the inner surface of the cylinder cover 8, the inner surface of the cylinder liner 5, the top of the piston 18, the uppermost piston ring 19' and the periphery of an uppermost piston section 21 extending upwards from the uppermost piston ring. The uppermost piston section 21 has a smaller diameter than the underlying part

of the piston, so that between the outer surface of the uppermost piston section and the inner surface of the cylinder there is an annular space 22 in which coke will be deposited on the outer piston surface.

An annular coke scraping ring 23 in the cylinder protrudes from the inner surface of the cylinder and scrapes off the coke deposits on the outer surface of the uppermost piston section 21 so that these deposits can not exceed a maximum diameter corresponding to the internal diameter of the coke scraping ring. Preferably, the coke scraping ring has a position in the axial direction of the cylinder so that the upper piston ring 19' is less than one ring height below the coke scraping ring 23 when the piston is in its top dead centre position shown on the drawing, as this ensures that the coke layer is scraped off largely all the way down to the uppermost piston ring. A substantial coke-scraping effect will, however, still be obtained even though the coke scraping ring is positioned somewhat higher up, for example 2 to 3 ring heights further up.

Figs. 3 and 4 show that in its inner surface, the coke scraping ring is provided with several leakage grooves 24 creating gas flow communication between the part of the annular space 22 located below the coke scraping ring and the remaining upper section of the working chamber 20. The flow area of the leakage grooves is suitably adapted so that the pressure drop across the coke scraping ring becomes negligible. The leakage grooves may advantageously be evenly distributed along the inner periphery of the coke scraping ring, as this results in the most uniform thermal load on the uppermost piston ring 19'. The depth of the leakage grooves may correspond to the thickness of the projection of the coke scraping ring in relation to the inner surface of the cylinder. This is especially advantageous if the scraping ring only protrudes a small distance of at least 0.25 mm, such as 0.5 - 3 mm, from the inner surface. If the piston and the scraping ring are made in such a manner that the annular space 22 has large width and the scavenging air ports 10 are opened by the passage of the uppermost piston ring, the depth of the leakage grooves has to be smaller than the thickness of the inwardly protruding part of the coke scraping ring. Preferably the leakage grooves are not deeper than from 3 to 4 mm, as the gas flows through the individual groove at larger depths may become so large that the thermal loads on the uppermost piston ring will locally become too high. A very even thermal distribution may be obtained with grooves not deeper than 1.5 - 2 mm combined with a suitably large number of leakage grooves, such as 15 or more.

The width of the leakage grooves is selected on the basis of the number of leakage grooves, the groove depth and the desired total flow area, viz., the total axially-facing cross-sectional area of the groove ends. Groove widths of from 5 to 30 mm will be suitable in most cases, and a groove width of from 10 to 20 mm is preferred to achieve an even thermal load.

The leakage grooves 24 extend obliquely in relation to the longitudinal axis of the cylinder so that the upper groove end 25 is displaced in the circumferential direction in relation to the lower groove end 26. This provides the advantage that the coke layer is scraped off along the full periphery of the upper piston section 21. In the example shown, the longitudinal axes of the leakage grooves form an angle of 45° with the longitudinal axis of the cylinder. It is, of course, possible to use other angles, such as from 15° to 80° . The angle is adapted to the groove width so that the individual groove will not exhibit any overlap in the axial direction between the upper and lower groove ends 25 and 26. For manufacturing reasons the leakage grooves preferably extend in a straight line between the upper and lower groove ends, but other designs creating flow communication between the upper and lower groove ends 25 and 26 will naturally also function in practice, such as an L-shaped or otherwise non-linear course.

Figs. 5 and 6 show examples of embodiments in which the leakage grooves are positioned on the outer surface of the piston in the uppermost piston section. For the sake of simplicity, the same reference numerals are used as above for elements of the same type. It should also be noted that the piston rings have been omitted from the figure.

In Fig. 5, to the left of the piston, a longitudinal section has been indicated through the innermost part of the liner 5 and the cylinder cover 8 in the area around a coke scraping ring 23', formed directly in the material of the cylinder cover, viz., as an integral and coherent part of the cover. To the right of the piston a corresponding longitudinal section through an alternative design is indicated, in which the coke scraping ring 23' is manufactured directly in the material of the cylinder liner, viz., as an integral and coherent part of the liner. On comparison of the right and left sides of the figure it is immediately seen that in one and the same engine it is possible to achieve the advantage in positioning the coke scraping ring 23' in the cylinder cover that the separating surface 27 between the cover and the liner is moved downwards in the longitudinal direction of the cylinder. As the inner surface of the cover does not constitute a running surface for the piston rings, lubricating considerations and sliding properties can be disregarded in the choice of materials for the cover. Therefore, the cover can be manufactured from a material, such as steel, which is more corrosion and heat resistant than the liner material, which is typically cast iron. The thermal influence is largest in the upper area of the cylinder, and consequently the cylinder can achieve a longer life by the cover extending further downwards.

In the embodiment shown, the coke scraping ring 23', which is either positioned on or in the liner 5 or on or in the cover 8, has a circularly cylindrical inner surface 28, which is annular and without leakage grooves. Of course, it is possible to position some of the leakage grooves on the coke scraping ring and some on the pis-

ton, but for manufacturing reasons the said design is preferred, which may be manufactured, for example, by suitable turning of the inner surface of the liner or the cover.

The leakage grooves 24' are positioned in the uppermost section 21 of the piston and extend from a chamfer at the upper rim of the piston down to the uppermost annular groove 29 for the uppermost piston ring 19'. The uppermost section 21 of the piston is of large height, and thus the piston rings are positioned further down in the cylinder when the piston is in its top dead centre point, which enables the cylinder cover to extend advantageously further down the cylinder.

The leakage grooves in Fig. 5 form an angle of about $\gamma = 30^\circ$ with the longitudinal direction of the cylinder. In practice, the angle can be selected between 0° and 60° or larger, but preferably the groove along at least part of its length forms an angle of minimum 15° to prevent the upper and lower groove ends in lying one vertically above the other.

Fig. 6 shows an alternative embodiment of the piston, in which the leakage grooves 24" have an upper section 24a extending in parallel with the longitudinal axis of the cylinder, and a lower section 24b extending obliquely in relation thereto. The lower oblique section 24b displaces the lower groove end in the circumferential direction in relation to the upper groove end so that the coke is scraped off along the full circumference. The upper sections 24a of the leakage grooves do not contribute to scraping off coke and therefore do not risk becoming clogged by scraped-off coke particles. It is also possible to arrange the oblique sections of the leakage grooves at the upper ends of the grooves, which provides the advantage that the gas velocities through the grooves are higher while the scraping is taking place, because the velocity of motion of the piston is higher while the upper groove sections pass the coke scraping ring.

The design shown of the oblique groove sections at the lower ends of the grooves is especially advantageous when the relatively large height of the uppermost section 21 of the piston is created by means of a separate piston top fixed to an underlying piston section with annular grooves for the piston rings. In this case, the two sections of the leakage grooves can be manufactured in a simple manner as straight grooves in respective piston sections.

Otherwise, as to area and number the leakage grooves can be formed correspondingly to the leakage grooves arranged in the coke scraping ring.

Claims

1. An internal combustion engine having a coke scraping ring in a cylinder and having a piston (18) longitudinally displaceable in the cylinder and provided with piston rings (19, 19') which slide along the sub-

stantially cylindrical inner surface of the cylinder at the displacement of the piston and create a pressure-sealing separation between the volume below the piston and the working chamber (20), which is located above the uppermost piston ring of the piston and is defined by the uppermost piston ring (19'), the piston (18), the inner surface of the cylinder and the cylinder cover (8), the coke scraping ring (23) protruding from the inner surface of the cylinder and extending annularly in an axial position so that the uppermost piston ring is positioned near the lower edge of the coke scraping ring when the piston is in its top dead centre position, **characterized** in that the engine is a two-stroke crosshead engine with uniflow scavenging having scavenging air ports (10) positioned in a lower cylinder section, and that in its cylindrical inner surface the coke scraping ring (23) is provided with several leakage grooves (24) which extend obliquely relative to the longitudinal axis of the cylinder from the lower surface to the top surface of the coke scraping ring.

2. An internal combustion engine having a coke scraping ring in a cylinder and having a piston (18) longitudinally displaceable in the cylinder and provided with piston rings (19, 19') which slide along the substantially cylindrical inner surface of the cylinder at the displacement of the piston and create a pressure-sealing separation between the volume below the piston and the working chamber (20), which is located above the uppermost piston ring of the piston and is defined by the uppermost piston ring (19'), the piston (18), the inner surface of the cylinder and the cylinder cover (8), the coke scraping ring (23) protruding from the inner surface of the cylinder and extending annularly in an axial position so that the uppermost piston ring is positioned near the lower edge of the coke scraping ring when the piston is in its top dead centre position, **characterized** in that the engine is a two-stroke crosshead engine with uniflow scavenging having scavenging air ports (10) positioned in a lower cylinder section, and that in its cylindrical outer surface the uppermost piston section (21) located above the uppermost piston ring is provided with several leakage grooves (24') which extend from the top of the piston section down to the area at the annular groove with the uppermost piston ring (19').
3. An internal combustion engine according to claim 1 or 2, **characterized** in that the substantially cylindrical inner surface of the cylinder is constituted by an upper cover section and a lower liner section, and that the coke scraping ring (23, 23') is positioned at the top of the liner section (5).
4. An internal combustion engine according to claim 1 or 2, **characterized** in that the substantially cylin-

drical inner surface of the cylinder is constituted by an upper cover section and a lower liner section, and that the coke scraping ring (23, 23') is positioned at the bottom of the cover section.

5. An internal combustion engine according to claim 3 or 4, **characterized** in that the coke scraping ring (23, 23') is an integral coherent part of the cylinder liner or of the upper cover section, being manufactured as a protruding portion in the material of the cylinder liner or the cover section.
6. An internal combustion engine according to any one of the preceding claims, **characterized** in that the leakage grooves (24, 24') constitute from 0.25 to 50 per cent of the axially-directed area of the coke scraping ring (23, 23') protruding from the substantially cylindrical inner surface of the cylinder, preferably from 5 to 40 per cent thereof, and suitably from 20 to 30 per cent thereof.
7. An internal combustion engine according to any one of the preceding claims, **characterized** in that the cylinder bore is in the interval from 250 to 1000 mm, and that the coke scraping ring (23, 23') protrudes at least 0.2 mm, preferably from 0.5 to 5 mm from the inner surface of the cylinder.
8. An internal combustion engine according to any one of the preceding claims, **characterized** in that the uppermost piston section (21) located above the uppermost piston ring (19') has a smaller diameter than the underlying piston section with the piston rings, and that the internal diameter of the coke scraping ring (23, 23') is at least 0.5 mm, such as from 2 to 6 mm larger than the diameter of the uppermost piston section, suitably at least 1 mm, such as from 3 to 4 mm larger than it.
9. An internal combustion engine according to any one of the preceding claims, **characterized** in that the coke scraping ring (23, 23') or the uppermost piston section (21) is provided with from 4 to 30 leakage grooves, preferably more than 15 leakage grooves.
10. An internal combustion engine according to any one of the preceding claims, **characterized** in that the longitudinal axes of the leakage grooves (24, 24') form an angle of from 0° to 60° with the axial direction of the cylinder, preferably minimum 15° and suitably 45°.

Patentansprüche

1. Brennkraftmaschine mit einem Koksschabring in einem Zylinder und mit einem Kolben (18), der in dem Zylinder in Längsrichtung verschiebbar und mit Kol-

benringen (19, 19') versehen ist, die bei der Verschiebung des Kolbens entlang der im wesentlichen zylindrischen Innenfläche des Zylinders gleiten und eine druckdichtende Trennung zwischen dem Volumen unter dem Kolben und der Arbeitskammer (20) herstellen, die über dem obersten Kolbenring des Kolbens gelegen ist und durch den obersten Kolbenring (19'), den Kolben (18), die Innenfläche des Zylinders und den Zylinderdeckel (8) definiert ist, wobei der Koksschabring (23) von der Innenfläche des Zylinders vorsteht und sich ringförmig in eine axiale Lage erstreckt, so daß der oberste Kolbenring nahe dem unteren Ende des Koksschabbrings positioniert ist, wenn sich der Kolben in seinem oberen Totpunkt befindet, dadurch gekennzeichnet, daß die Maschine eine Zweitakt-Kreuzkopf-Maschine mit Gleichstromspülung ist, die in einem unteren Zylinderabschnitt positionierte Spülluftschlitze (10) aufweist, und daß der Koksschabring (23) in seiner zylindrischen Innenfläche mit mehreren Lecknuten (24) versehen ist, die sich schräg bezüglich der Längsachse des Zylinders von der unteren Fläche zu der oberen Fläche des Koksschabbrings erstrecken.

2. Brennkraftmaschine mit einem Koksschabring in einem Zylinder und mit einem Kolben (18), der in dem Zylinder in Längsrichtung verschiebbar und mit Kolbenringen (19, 19') versehen ist, die bei der Verschiebung des Kolbens entlang der im wesentlichen zylindrischen Innenfläche des Zylinders gleiten und eine druckdichtende Trennung zwischen dem Volumen unter dem Kolben und der Arbeitskammer (20) herstellen, die über dem obersten Kolbenring des Kolbens gelegen ist und durch den obersten Kolbenring (19'), den Kolben (18), die Innenfläche des Zylinders und den Zylinderdeckel (8) definiert ist, wobei der Koksschabring (23) von der Innenfläche des Zylinders vorsteht und sich ringförmig in eine axiale Lage erstreckt, so daß der oberste Kolbenring nahe dem unteren Ende des Koksschabbrings positioniert ist, wenn sich der Kolben in seinem oberen Totpunkt befindet, dadurch gekennzeichnet, daß die Maschine eine Zweitakt-Kreuzkopf-Maschine mit Gleichstromspülung ist, die in einem unteren Zylinderabschnitt positionierte Spülluftschlitze (10) aufweist, und daß der über dem obersten Kolbenring gelegene oberste Kolbenabschnitt (21) in seiner zylindrischen Außenfläche mit mehreren Lecknuten (24') versehen ist, die sich vom Kopf des Kolbenabschnitts hinunter zu dem Bereich an der ringförmigen Nut mit dem obersten Kolbenring (19) erstrecken.

3. Brennkraftmaschine nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die im wesentlichen zylindrische Innenfläche des Zylinders durch einen oberen Deckelbereich und einen unteren Buchsen-

bereich gebildet ist und daß der Koksschabring (23, 23') an dem Kopf des Buchsenbereichs (5) positioniert ist.

4. Brennkraftmaschine nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die im wesentlichen zylindrische Innenfläche des Zylinders durch einen oberen Deckelbereich und einen unteren Buchsenbereich gebildet ist und daß der Koksschabring (23, 23') am Unterteil des Deckelbereichs positioniert ist.
5. Brennkraftmaschine nach Anspruch 3 oder 4, dadurch gekennzeichnet, daß der Koksschabring (23, 23') ein integral zusammenhängender Teil der Zylinderbuchse oder des oberen Deckelbereichs ist und als ein vorstehender Bereich in dem Material der Zylinderbuchse oder des Deckelbereichs gefertigt ist.
6. Brennkraftmaschine nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß die Lecknuten (24, 24') 0.25 bis 50 Prozent, vorzugsweise 5 bis 40 Prozent und geeigneterweise 20 bis 30 Prozent der axialgerichteten Fläche des aus der im wesentlichen zylindrischen Innenfläche des Zylinders hervorstehenden Koksschabbrings (23, 23') ausmachen.
7. Brennkraftmaschine nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß die Zylinderbohrung im Bereich von 250 bis 1000 mm ist und daß der Koksschabring (23, 23') zumindest 0.2 mm, vorzugsweise 0.5 bis 5 mm von der Innenfläche des Zylinders vorsteht.
8. Brennkraftmaschine nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß der oberhalb des obersten Kolbenrings (19') angeordnete oberste Kolbenabschnitt (21) einen kleineren Durchmesser als der darunterliegende Kolbenbereich mit den Kolbenringen aufweist und daß der Innendurchmesser des Koksschabbrings (23, 23') wenigstens 0.5 mm, insbesondere 2 bis 6 mm, größer als der Durchmesser des obersten Kolbenbereichs und geeigneterweise wenigstens 1 mm, insbesondere 3 bis 4 mm, größer als dieser ist.
9. Brennkraftmaschine nach einem der vorstehenden Ansprüche, daß der Koksschabring (23, 23') oder der oberste Kolbenbereich (21) mit 4 bis 30 Lecknuten, vorzugsweise mit mehr als 15 Lecknuten versehen ist.
10. Brennkraftmaschine nach einem der vorstehenden Ansprüche, dadurch gekennzeichnet, daß die Längsachsen der Lecknuten (24, 24') einen Winkel von 0° bis 60° mit der Axialrichtung des Zylinders,

vorzugsweise mindestens 15° und geeigneterweise 45° bilden.

Revendications

1. Moteur à combustion interne ayant un segment racleur de dépôt charbonneux dans un cylindre et ayant un piston (18) apte à se déplacer longitudinalement dans le cylindre et pourvu de segments (19, 19') de piston qui coulissent sur la surface intérieure sensiblement cylindrique du cylindre lors du déplacement du piston et créent une séparation étanche à la pression entre le volume situé sous le piston et la chambre de travail (20'), qui se trouve au-dessus du segment supérieur du piston et est définie par le segment supérieur (19') de piston, le piston (18), la surface intérieure du cylindre et le couvercle (8) du cylindre, le segment racleur (23) de dépôt charbonneux dépassant de la surface intérieure du cylindre et s'étendant de manière annulaire dans une position axiale de façon que le segment supérieur du piston soit placé près du bord inférieur du segment racleur de dépôt charbonneux lorsque le piston est dans sa position de point mort haut, **caractérisé** en ce que le moteur est un moteur à crosse à deux temps à balayage équilibrant ayant des orifices (10) d'air de balayage situés dans une partie inférieure du cylindre, et en ce que, dans sa surface intérieure cylindrique, le segment racleur (23) de dépôt charbonneux comporte plusieurs rainures d'écoulement (24) qui s'étendent de manière oblique par rapport à l'axe longitudinal du cylindre, depuis la surface inférieure jusqu'à la surface supérieure du segment racleur de dépôt charbonneux.
2. Moteur à combustion interne ayant un segment racleur de dépôt charbonneux dans un cylindre et ayant un piston (18) apte à se déplacer longitudinalement dans le cylindre et pourvu de segments (19, 19') de piston qui coulissent sur la surface intérieure sensiblement cylindrique du cylindre lors du déplacement du piston et créent une séparation étanche à la pression entre le volume situé sous le piston et la chambre de travail (20'), qui se trouve au-dessus du segment supérieur du piston et est définie par le segment supérieur (19') de piston, le piston (18), la surface intérieure du cylindre et le couvercle (8) du cylindre, le segment racleur (23) de dépôt charbonneux dépassant de la surface intérieure du cylindre et s'étendant de manière annulaire dans une position axiale de façon que le segment supérieur du piston soit placé près du bord inférieur du segment racleur de dépôt charbonneux lorsque le piston est dans sa position de point mort haut, **caractérisé** en ce que le moteur est un moteur à crosse à deux temps à balayage équilibrant ayant des orifices (10) d'air de balayage situés dans une

partie inférieure du cylindre, et en ce que, dans sa surface extérieure cylindrique, la partie supérieure (21) du piston est pourvue de plusieurs rainures d'écoulement (24') qui, depuis le haut de la partie formant piston, s'étendent vers le bas jusqu'à la zone située au niveau de la gorge annulaire avec le segment supérieur (19') du piston.

3. Moteur à combustion interne selon la revendication 1 ou 2, **caractérisé** en ce que la surface intérieure sensiblement cylindrique du cylindre est constituée par une partie supérieure formant couvercle et par une partie inférieure formant chemise, et en ce que le segment racleur (23, 23') de dépôt charbonneux est placé dans le haut de la partie formant chemise.
4. Moteur à combustion interne selon la revendication 1 ou 2, **caractérisé** en ce que la surface intérieure sensiblement cylindrique du cylindre est constituée par une partie supérieure formant couvercle et par une partie inférieure formant chemise, et en ce que le segment racleur (23, 23') de dépôt charbonneux est placé dans le bas de la partie formant couvercle.
5. Moteur à combustion interne selon la revendication 3 ou 4, **caractérisé** en ce que le segment racleur (23, 23') de dépôt charbonneux fait partie intégrante de la chemise du cylindre ou de la partie supérieure formant couvercle, étant réalisé sous la forme d'une portion saillante dans la matière de la partie formant chemise ou couvercle du cylindre.
6. Moteur à combustion interne selon l'une quelconque des revendications précédentes, **caractérisé** en ce que les rainures d'écoulement (24, 24') constituent de 0,25 à 50 pour 100 de la zone à orientation axiale du segment racleur (23, 23') de dépôt charbonneux dépassant de la surface intérieure sensiblement cylindrique du cylindre, de préférence de 4 à 40 pour 100 de celle-ci, et avantageusement de 20 à 30 pour 100 de celle-ci.
7. Moteur à combustion interne selon l'une quelconque des revendications précédentes, **caractérisé** en ce que l'alésage du cylindre mesure de 250 à 1000 mm, et en ce que le segment racleur (23, 23') de dépôt charbonneux dépasse d'au moins 0,2 mm, de préférence de 0,5 à 5 mm de la surface intérieure du cylindre.
8. Moteur à combustion interne selon l'une quelconque des revendications précédentes, **caractérisé** en ce que la partie supérieure (21) du piston, située au-dessus du segment supérieur (19') du piston a un diamètre plus petit que celui de la partie du piston située au-dessous avec les segments du piston, et en ce que le diamètre intérieur du segment racleur (23, 23') de dépôt charbonneux est au moins

de 0,5 mm, par exemple de 2 à 6 mm plus grand que le diamètre de la partie supérieure du piston, avantageusement d'au moins 1 mm, par exemple de 3 à 4 mm plus grand que celui-ci.

5

9. Moteur à combustion interne selon l'une quelconque des revendications précédentes, **caractérisé** en ce que le segment racleur (23, 23') de dépôt charbonneux ou la partie supérieure (21) de piston est pourvue de 4 à 30 rainures d'écoulement, de préférence de plus de 15 rainures d'écoulement.

10

10. Moteur à combustion interne selon l'une quelconque des revendications précédentes, **caractérisé** en ce que les axes longitudinaux des rainures d'écoulement (24, 24') forment un angle de 0° à 60° avec la direction axiale du cylindre, de préférence d'au moins 15° et avantageusement de 45°.

15

20

25

30

35

40

45

50

55

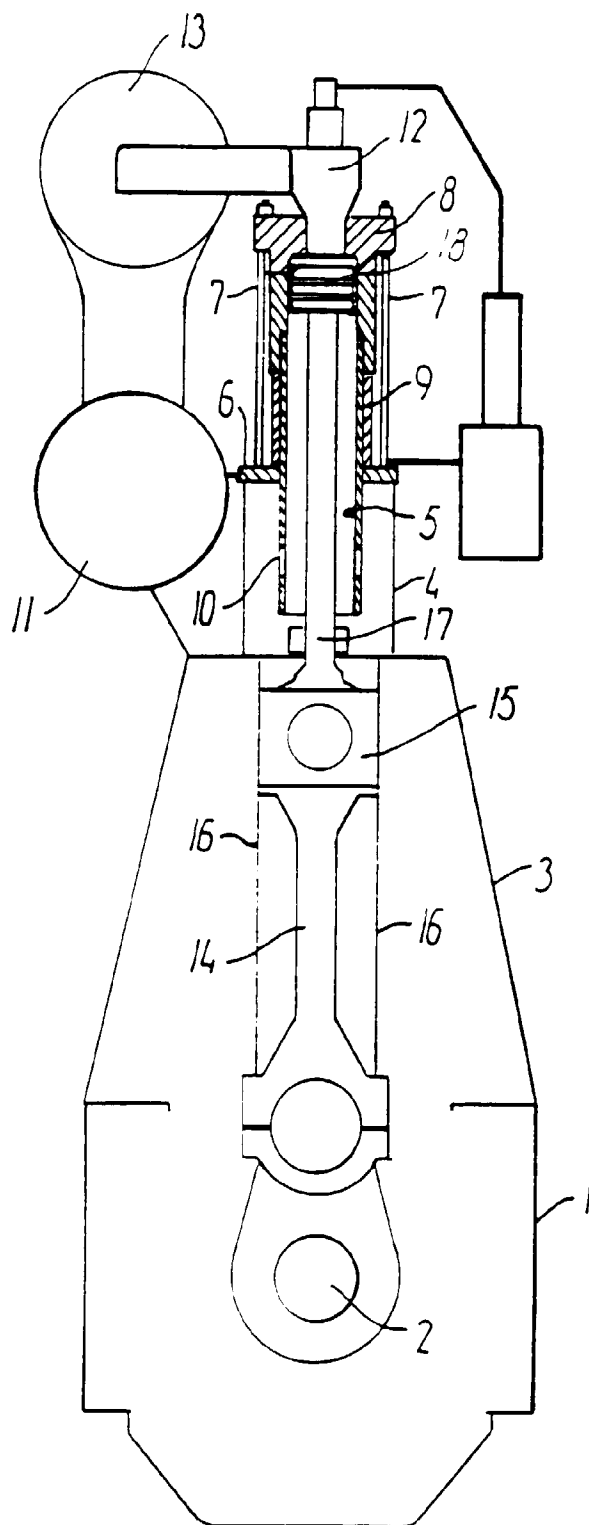


FIG. 1

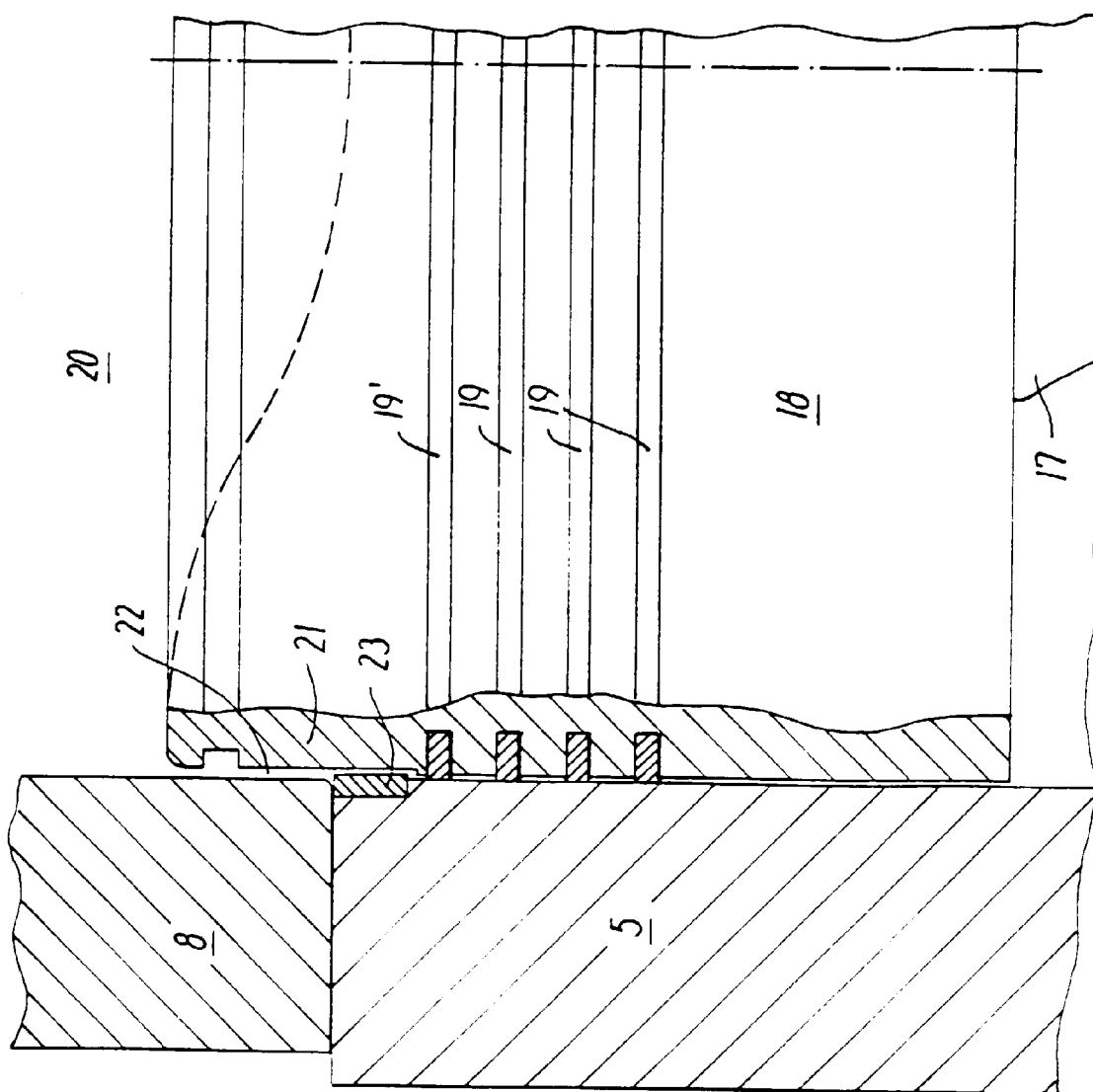


FIG. 2

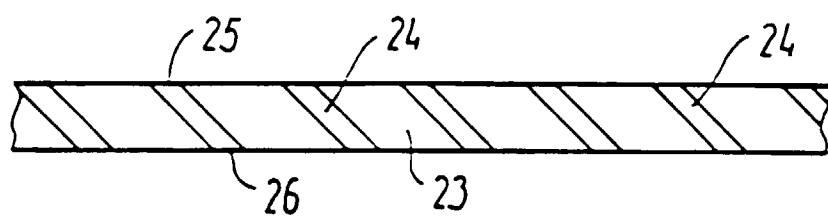


FIG.3

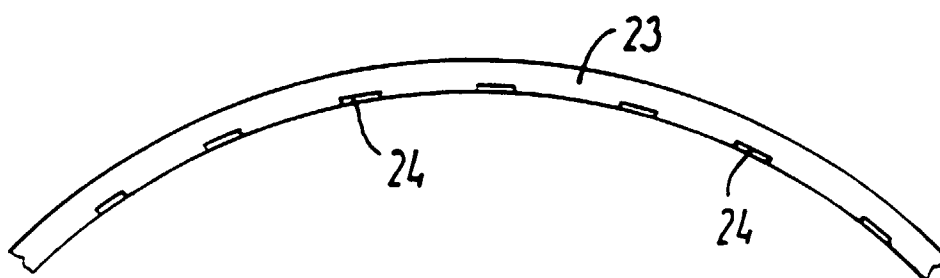


FIG.4

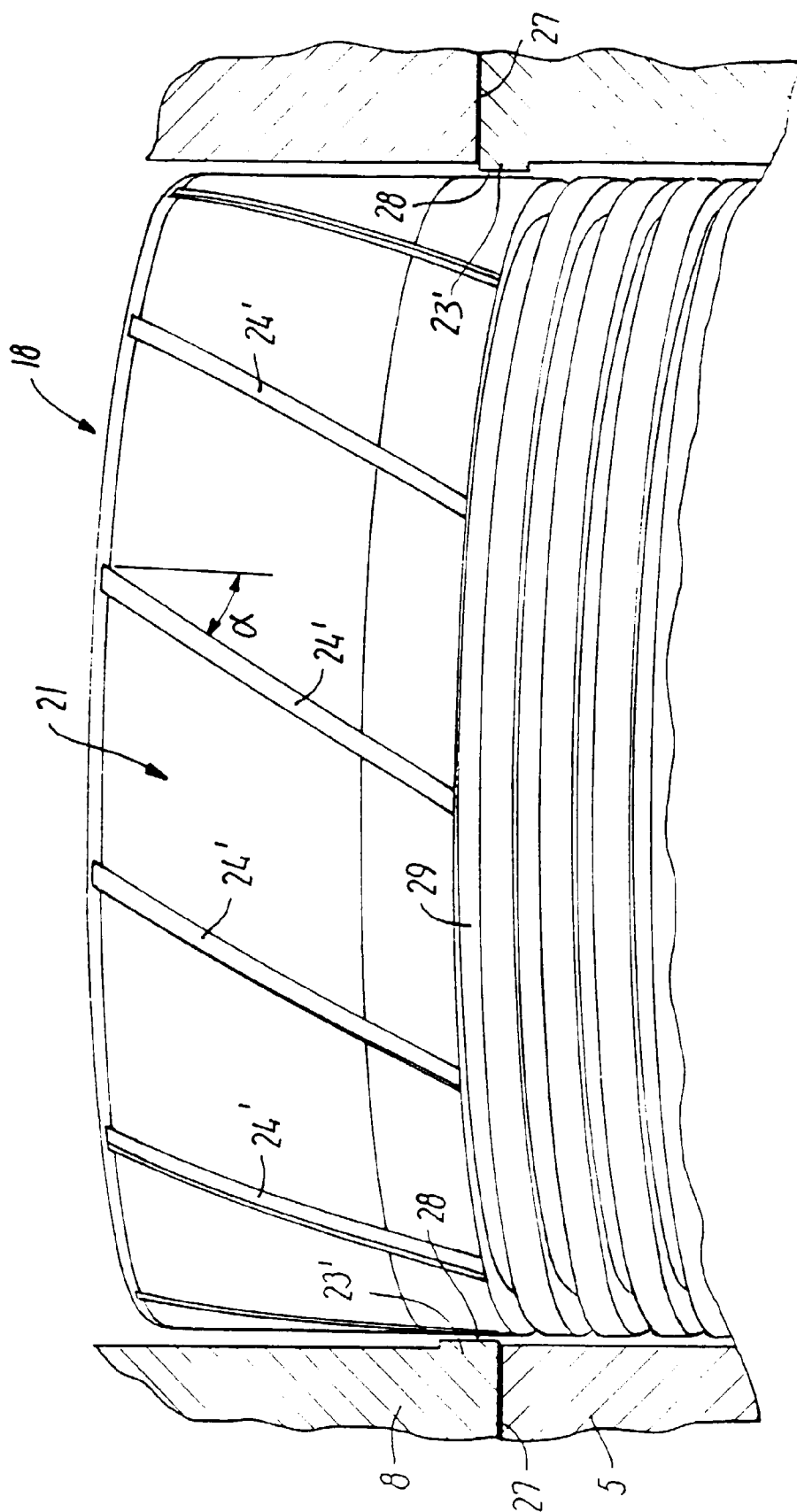


FIG. 5

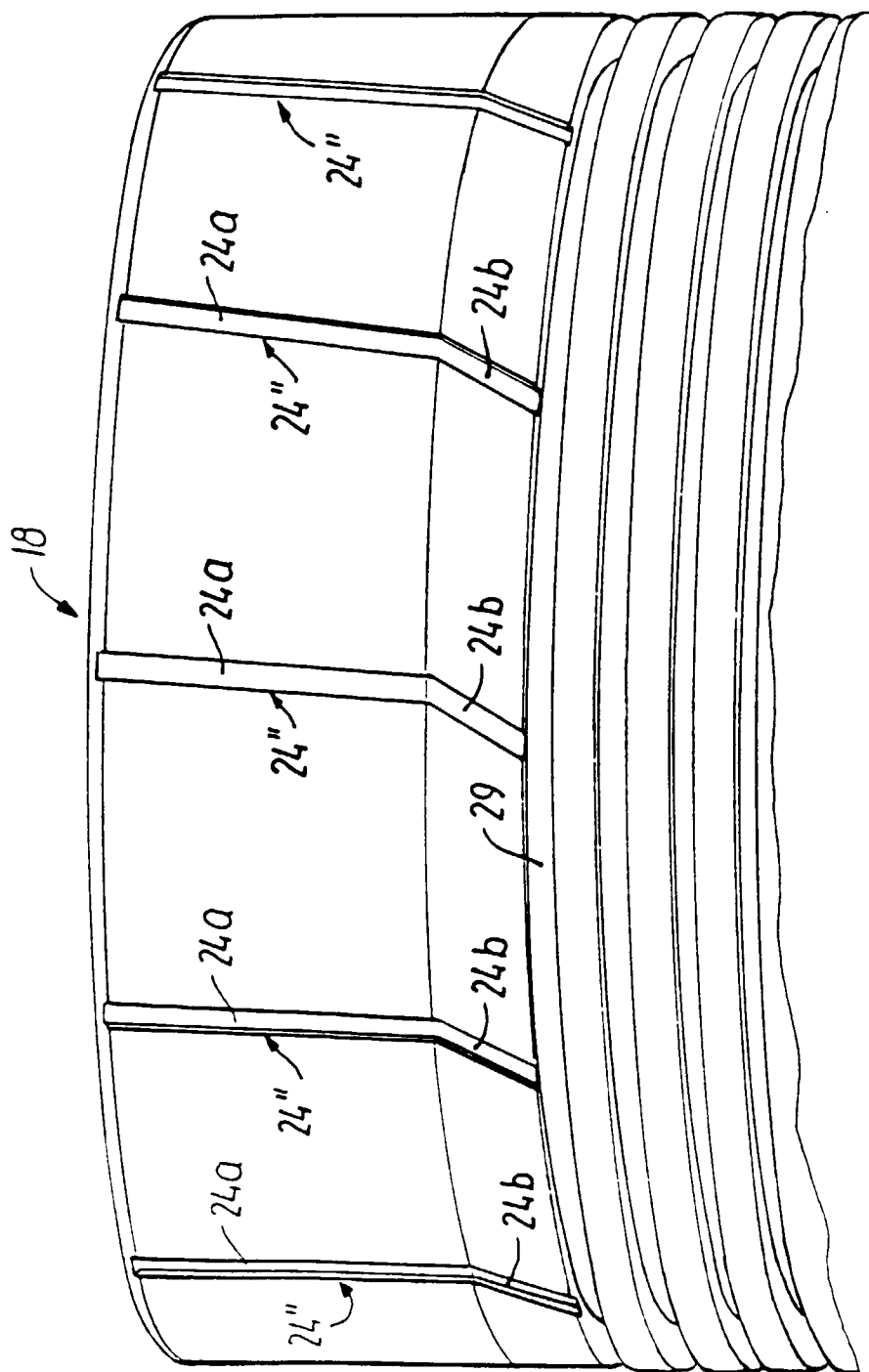


FIG. 6