(19) DANMARK (10) DK 178937 B9

Patent- og Varemærkestyrelsen

(12) PATENTSKRIFT

Omtryk
publiceret 2017-07-03

(51) Int.Cl.: ***F 02 F 1/16 (2006.01)*** ***F 02 F 1/10 (2006.01)***

(21) Ansøgningsnummer: **PA 2015 70706**

(22) Indleveringsdato: **2015-11-02**

(24) Løbedag: **2015-11-02**

(41) Alm. tilgængelig: **2017-05-03**

(45) Patentets meddelelse bkg. den: **2017-06-19**

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(54) Benævnelse: **A CYLINDER LINER FOR A TWO-STROKE CROSSHEAD ENGINE**

(56) Fremdragne publikationer:
**GB 1219532 A**
**US 5150668 A**
**EP 1279823 A2**
**US 5979374 A**
**US 4244330 A**

(57) Sammendrag:
**A cylinder liner (1) for an internal combustion engine, particularly a two-stroke crosshead engine, the cylinder liner (1)has a first end adapted to engage a cylinder cover (22), scavenging ports (19) in the wall (29) of the cylinder liner (1) near a second end and a circumferential cooling recess (31) for a liquid coolant in the wall (29) of the cylinder liner (1) near the first end with a circumferentially extending opening in the outer surface of the wall (29) of cylinder liner (1). An axial support member (36) is at least partially inserted in the circumferential recess and the axial support member (36) bridges the circumferentially extending opening of the circumferential cooling recess (31).**

**Fortsættes ...**

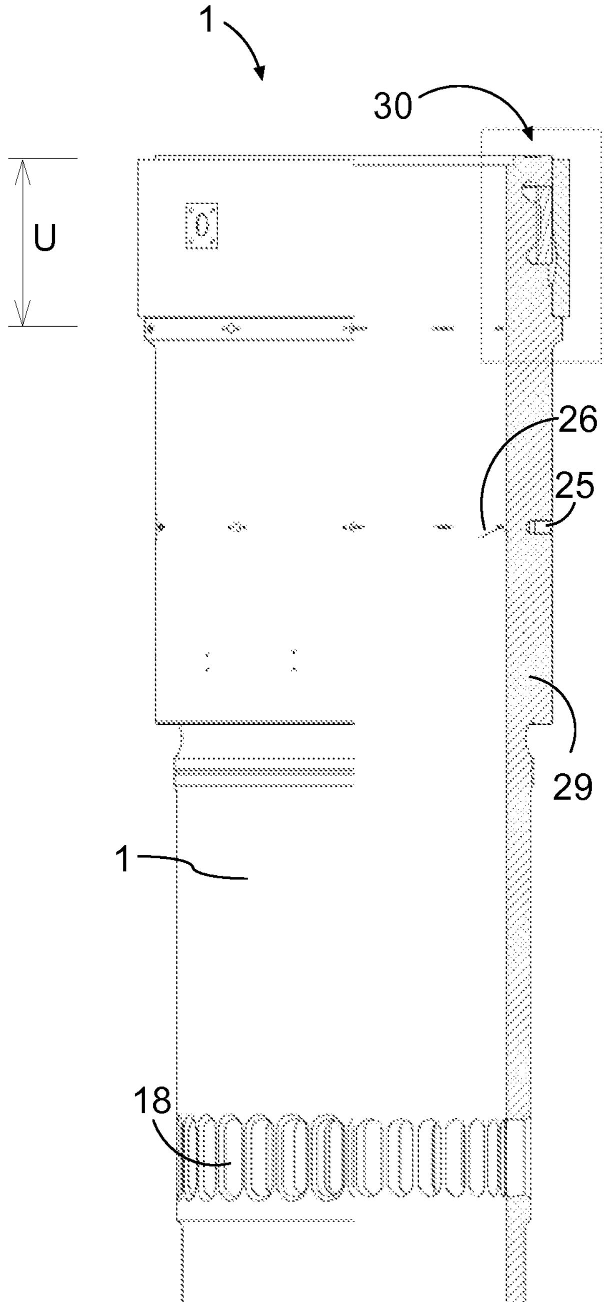



Fig. 6

# A CYLINDER LINER FOR A TWO-STROKE CROSSHEAD ENGINE

## TECHNICAL FIELD

This disclosure relates to a cylinder liner for an internal combustion engine, particularly a two-stroke crosshead engine, having a piston which is movable in the cylinder liner in its longitudinal (axial) direction between a bottom dead centre, at which scavenging air ports in the wall of the cylinder liner are exposed above the top surface of the piston, and a top dead centre, at which the piston is in its top position in the cylinder liner.

## BACKGROUND

In a large two-stroke crosshead compression ignited internal combustion engine, the upper portion of the cylinder liner, which normally projects upwards from the cylinder frame and is clamped against it by means of a cylinder cover, is thermally and mechanically very heavily loaded by the heat and pressure produced by the combustion process. The temperature level on the internal running surface for the piston of the cylinder liner is of decisive importance to the life span of the cylinder liner and thus also to the operating economy of the engine. If the temperature of the running surface is too high, heat cracks may develop in the cylinder liner, and if the temperature is too low, sulphuric acid from the combustion products may condense on the running surface, which results in increased wear owing to corrosive erosion of the material of the liner and leads to decomposition of the lubricating oil film of cylinder oil on the running surface and leads to increased consumption of (costly) cylinder oil.

The temperature of the running surface will normally vary with the engine load, and as the engine has to be able to run for a long period at both high and low loads, the liners are conventionally made so that the temperature of the running surface at the maximum load of the engine is close to the highest permissible temperature. The high temperature level renders it possible at partial loads to maintain a sufficiently high temperature to prevent acids from condensing on the running surface.

The cylinder lubrication oil and the material of the cylinder liner are affected by the high temperature at full engine load, and an increase of this temperature may lead to a decomposition of the lubricant and lasting damage to the cylinder liner material in the shape of heat cracks.

Known cylinder liners for large bore engines, e.g. engines with a bore of more than 50 cm in diameter, are provided with cooling means comprising cooling bores in the portion of the axial extent of the cylinder liner closest to the cylinder cover, i.e. the upper portion of the axial extent as the cylinder liners in large two-stroke crosshead engines are always placed in an upright position. This upper portion of the axial extent of the cylinder liner closest to the cylinder cover surrounds the portion of the combustion chamber where the compression ratio is highest and the combustion is initiated and therefore, the upper portion of the cylinder liner is exposed to the highest temperatures and pressures when compared to the rest of the axial extent of the cylinder liner. Thus, the upper portion of the cylinder liner has to deal with the highest pressures and temperatures whilst the remaining lower portion of the axial extent of the cylinder liner is only exposed to lower temperatures and pressures. Therefore, the wall thickness of the upper portion of the cylinder liner is particularly high and requires most cooling. The drop in temperature and pressure in the axial direction away from the cylinder cover is gradual, but for practical reasons the wall thickness of the cylinder liner is typically roughly divided into two or three levels with the thinnest wall thickness being provided at the axial end of the cylinder liner closest to the scavenge ports and the highest wall thickness being provided at the axial end of the cylinder liner that has the interface with the cylinder cover.

The upper portion of the axial extent of the cylinder liner just below the interface with the cylinder cover is provided with a plurality of relatively closely spaced cooling bores that are drilled into the relatively thick wall of the cylinder liner from an external recess so that the longitudinal axes of the straight cooling bores have an oblique or skew course in relation to the longitudinal axis of the liner. In each cooling bore, a pipe or guide plate is inserted for guiding the in-flowing liquid coolant from the recess to the upper dead end of the bore, from where the liquid coolant flows downwards and out into a chamber, from where the liquid coolant is passed up into the cylinder cover via pipes. The oblique cooling bores are evenly distributed over the circumferential extent of the upper portion of the cylinder liner. Nevertheless, the temperature of the liner material is not equally distributed over the circumferential extent of the upper portion of the cylinder liner since the cylinder liner material closest to the cooling bores will be less warm than the material in between two cooling bores. Thus, the temperature of the material in the upper portion of the cylinder liner will fluctuate when seen circumferentially. This uneven circumferential temperature distribution of the upper portion of the cylinder liner leads to stress in the cylinder liner material due to uneven temperature expansion of the cylinder liner material, which in turn leads to uneven wear of the cylinder liner and the piston rings since the running surface of the upper portion of the cylinder liner will not be perfectly circular. It will become somewhat more circular after the cylinder liner has been run in, but it will never be perfect in known cylinder liners due to new deformation at any new load.

The portion of the cylinder liner just below the upper portion is provided with one or more cooling jackets that completely surround the outer surface of the cylinder liner and provide for a circumferentially extending space for the liquid coolant. Typically, the cooling jacket or jackets extend downwards from the upper portion of the cylinder liner with the cooling bores for a significant length towards the cylinder frame, and sometimes completely to the cylinder frame.

A cylinder liner of the type described above is known from WO 97/42406.

GB 1219532 discloses internal combustion engine cylinder that has an upper flange provided with an annular groove which serves as a water-cooling duct and is closed externally by a two part ring whose height is slightly greater than the corresponding part of the groove. A steel ring is shrunk over the flange and water is supplied and discharged through bores.

SUMMARY

It is an object of the invention to overcome or at least reduce the drawbacks mentioned above.

This object is achieved according to a first aspect, by providing a cylinder liner for an internal combustion engine, particularly a two-stroke crosshead engine, the cylinder liner comprising a first end adapted to engage a cylinder cover, scavenging ports in the wall of the cylinder liner near a second end, a circumferential cooling recess for a liquid coolant in a wall of the cylinder liner near the first end, the circumferential cooling recess having a circumferentially extending opening in the outer surface of the wall of the cylinder liner, an axial support member that is at least partially inserted in the circumferential recess, the at axial support member bridging the circumferentially extending opening, and the axial support member being provided with coolant passage openings.

By using a circumferentially extending cooling recess the circumferential distribution of the liquid coolant is substantially completely even and problems with uneven temperature distribution and resulting stresses and uneven wear are substantially eliminated. Providing a axial support member inside the circumferential opening of the circumferentially extending cooling recess allows the cooling recess to be deep and large and allows for a robust construction that can handle the enormous compressive forces that are applied to the top of the cylinder liner.

In a first possible implementation form of the first aspect the axial support member is configured to provide axial support to the circumferential cooling recess

In a second possible implementation form of the first aspect the axial support member fills the axial space between opposing axially facing surfaces of the opening.

In a third possible implementation form of the first aspect the axial space between the opposing axially facing surfaces of the opening in an unloaded state of the cylinder liner is slightly larger than the axial distance h between opposing axial surfaces of the axial support member, so that there is a slight axial clearance between the opening and the axial support member.

In a fourth possible implementation form of the first aspect the axial support member is a split ring that is formed by two or more sections.

In a fifth possible implementation form of the first aspect the circumferential cooling recess comprises an upper lobe and optionally a lower lobe.

In a sixth possible implementation form of the first aspect the circumferential cooling recess comprises a cylindrical surface that connects the upper lobe with the lower lobe.

In a seventh possible implementation form of the first aspect the axial support member comprises an inwardly facing annular recess and wherein a space for coolant is defined between the inwardly facing annular recess and the cylindrical surface.

In an eighth possible implementation form of the first aspect the circumferential cooling recess is sufficiently deep to receive the axial support member without the axial support member protruding from the circumferential cooling recess.

In a ninth possible implementation form of the first aspect the cylinder liner further comprises a plurality of cylinder lubrication supply holes in the wall of the cylinder liner that are distributed, preferably at substantial equal level, around the circumference of the cylinder liner.

The object above is also achieved in accordance with a second aspect by providing a two-stroke crosshead engine comprising at least one cylinder liner according to the first aspect and any of its implementations.

These and other aspects of the invention will be apparent from the detailed description and the embodiments described below.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the following detailed portion of the present disclosure, the invention will be explained in more detail with reference to the example embodiments shown in the drawings, in which:

Fig. 1 is a front view of a large two-stroke diesel engine according to an example embodiment,
Fig. 2 is a side view of the large two-stroke engine of Fig. 1,
Fig. 3 is a diagrammatic representation the large two-stroke engine according to Fig. 1,
Fig. 4 is a sectional view of the cylinder frame and a cylinder liner according to an example embodiment with a cylinder cover and an exhaust valve fitted thereto,
Fig. 5 is a side view of a cylinder liner according to an example embodiment,

Fig. 6 is a partial sectional view of the cylinder liner of Fig. 5,

Fig. 7 is a sectional view of a detail of the upper portion of the cylinder liner of Fig. 5 showing a circumferential cooling recess,

Fig. 8 is the detail of Fig. 7 with an axial support member inserted in the circumferential cooling recess,

Fig. 9 is a detail of Fig. 8 with a circumferential support member surrounding the upper portion of the cylinder liner,

Fig. 10 shows a detail of the axial support member,

Fig. 11 shows the detail of Fig. 9 with piping for supply of a coolant to the circumferential cooling recess,

Fig. 12 shows the details of Fig. 9 with piping for the discharge of coolant from the cooling recess,

Fig. 13 shows the circumferential support member in sectional view,

Fig. 14 shows an elevated exploded view of the cylinder liner of Fig. 5 without the circumferential support member,

Fig. 15 shows an elevated view of the cylinder liner of Fig. 5 without the circumferential support member,

Fig. 16 illustrates the axial support member,

Fig. 17 is a sectional view of the top of the cylinder liner of Fig. 5, and

Fig. 18 is a graph illustrating the temperature of the running surface of the cylinder liner of Fig. 6 and of a prior art cylinder liner.

## DETAILED DESCRIPTION

In the following detailed description, an internal combustion engine will be described with reference to a large two-stroke low-speed turbocharged compression-ignited internal combustion crosshead engine in the example embodiments. Figs. 1, 2 and 3 show a large low-speed turbocharged two-stroke diesel engine with a crankshaft 8 and crossheads 9. Fig. 3 shows a diagrammatic representation of a large low-speed turbocharged two-stroke diesel engine with its intake and exhaust systems. In this example embodiment the engine has four cylinders in line. Large low-speed turbocharged two-stroke diesel engines have typically between four and fourteen cylinders in line, carried by an engine frame 11. The engine may e.g. be used as the main engine in a marine vessel or as a stationary engine for operating a generator in a power station. The total output of the engine may, for example, range from 1,000 to 110,000 kW.

The engine is in this example embodiment a compression ignited engine of the two-stroke uniflow type with scavenge ports 18 at the lower region of the cylinder liners 1 and a central exhaust valve 4 at the top of the cylinder liners 1. The scavenge air is passed from the scavenge air receiver 2 to the scavenge ports 18 of the individual cylinders 1. A piston 10 in the cylinder liner 1 compresses the scavenge air, fuel is injected from fuel injection valves in the cylinder cover 22, combustion follows and exhaust gas is generated.

When an exhaust valve 4 is opened, the exhaust gas flows through an exhaust duct associated with the cylinder 1 into the exhaust gas receiver 3 and onwards through a first exhaust conduit 19 to a turbine 6 of the turbocharger 5, from which the exhaust gas flows away through a second exhaust conduit via an economizer 20 to an outlet 21 and into the atmosphere. Through a shaft, the turbine 6 drives a compressor 7 supplied with fresh air via an air inlet 12. The compressor 7 delivers pressurized scavenge air to a scavenge air conduit 13 leading to the scavenge air receiver 2. The scavenge air in conduit 13 passes an intercooler 14 for cooling the scavenge air - that leaves the compressor at approximately 200 °C - to a temperature between approximately 36 and 80 °C.

The cooled scavenge air passes via an auxiliary blower 16 driven by an electric motor 17 that pressurizes the scavenge air flow when the compressor 7 of the turbocharger 5 does not deliver sufficient pressure for the scavenge air receiver 2, i.e. in low- or partial load conditions of the engine. At higher engine loads the turbocharger compressor 7 delivers sufficient compressed scavenge air and then the auxiliary blower 16 is bypassed via a non-return valve 15.

Figs. 4, 5 and 6 show a cylinder liner generally designated 1 for a large two-stroke crosshead engine. Depending on the engine size, the cylinder liner 1 may be manufactured in different sizes with cylinder bores typically ranging from 250 mm to 1000 mm, and corresponding typical lengths ranging from 1000 mm to 4500 mm. The cylinder liner 1 is normally manufactured in cast iron, and it may be integral or divided into two or more parts assembled end to end. In case of the divided liner it is also possible to manufacture the upper part in steel. Large two-stroke crosshead engines are developed towards very high effective compression ratios, such as 1:16 to 1:20, which entail heavy loads on the elements that need to withstand the pressure in the combustion chamber, such as e.g. the cylinder liner 1, the piston 10 and the piston rings (not shown).

In Fig. 4 the cylinder liner 1 is shown mounted in a cylinder frame 23 with the cylinder cover 22 placed on the top of the cylinder liner 1 with the gas tight interface therebetween. In Fig. 4, the piston 10 is not shown in order to provide an unhindered view of the cylinder liner

1 with its cylinder lubrication holes 25 and cylinder lubrication line 24 that allow supply of cylinder lubrication oil when the piston 10 passes the lubrication line 24, whereafter the piston rings distribute the cylinder lubrication oil over the running surface of the cylinder liner.

Piping 26 serves to supply liquid coolant, e.g. water to the cooling and reinforcing arrangement 30 at the upper portion of the cylinder liner 1. Piping 28 serves to transport the liquid coolant from the cooling and reinforcing arrangement 30 to the cylinder cover 22. Piping 27 serves to discharge the liquid coolant from the cylinder cover 22 to the cooling system. The liquid coolant supplied to the cooling and reinforcement arrangement 30 is provided by an as such well-known cooling system (not shown) that provides liquid coolant with a controlled supply temperature, and the coolant that is discharged from the cylinder cover 22 is returned to the cooling system for reconditioning. The wall 29 of the cylinder liner 1 has a varying thickness over the axial extent of the cylinder liner 1. In the shown embodiment, the thinnest portion of the wall 29 is at the bottom of the cylinder liner 1, i.e. the portion below the scavenge ports 18. The thickest portion of the wall 29 of the cylinder liner 1 is in the upper portion of the axial extent of the cylinder liner 1. A sharp transition in the thickness of the cylinder liner 1 around the middle of the axial extent of the cylinder liner 1 serves as a shoulder that allows the cylinder to rest on the cylinder frame 23. The cylinder cover 22 is pressed with great force applied by tensioning bolts onto the upper surface of the cylinder liner 1.

Figs. 5 and 6 show the cylinder liner 1 in greater detail, with its axial axis X and the cooling and supporting arrangement 30 enclosed in a dotted rectangle in Fig. 6.

Fig. 7 shows the cooling and supporting arrangement 30 in greater detail. The cooling and supporting arrangement 30 is provided at the portion U of the cylinder liner 1 that is closest to the axial end of the cylinder liner 1 that forms the interface with the cylinder cover 22. This portion U is also the portion of the cylinder liner that is exposed to the highest pressures and temperatures from the combustion process. Therefore, the thickness of the wall 29 of the cylinder liner in this portion of the cylinder liner 1 is relatively high.

However, forced cooling is required and the forced cooling has to be arranged relatively close to the running surface of this portion of the cylinder liner 1 in order to keep the temperature of the running surface of this portion of the cylinder liner 1 at acceptable levels (depending on the type of material of the cylinder liner 1 the maximum running face temperatures have to be below e.g. approximately 300°C or in certain cases below approximately 280°C. Hereto, a circumferential recess 31 is provided in the upper portion U of the cylinder liner 1 in order to provide space for receiving liquid coolant. The recess 31 opens towards the outer surface of the cylinder liner 1 and is in an embodiment provided with an upper lobe 32 and a lower lobe 33. The opening of the recess has an axial extent H between a downwardly facing support surface 34 and upwardly facing support surface 35.

The recess 31 can be created by a milling process or as part of the casting process in case the liner is a cast product. In the latter case the recess will be machined to a precisely defined shape after casting.

The curved surface of the upper lobe 32 and the lower lobe 33 is in accordance with a calculated shape that minimizes stress in the material of the cylinder liner 1.

The arrow F in Fig. 7 represents the force that the cylinder cover 22 applies on the top surface of the cylinder liner 1. The magnitude of this force F is so significant that the cylinder liner 1 would deform without axial support in the gap between the downwardly facing support surface 34 and the upwardly facing support surface 35. This axial support is illustrated in Fig. 8. An axial support member 36 is inserted into the annual recess 31 so as to substantially fill the gap with the span H between the downwardly facing surface 34 and the upwardly facing surface 35. As shown in Fig. 8, the axial support member 36 supports the structure of the cylinder liner wall and transmits a significant portion of the force F and thereby prevents the formation of the upper portion of the cylinder liner 1 as illustrated by the vertical arrows. Fig. 10 shows a detail of the axial support member 36. The axial support member can be in the form of a ring, such as a split ring with two or more parts (a split ring with two parts is shown in the drawings but it is clear to the skilled person that the axial support member could be formed by a plurality of more than two members, and this plurality of members does not need to form a continuous ring and may just as well be a plurality of columns or the like that are suitable to provide axial support to the annular recess 31). The axial support member 36 has an axial extent h between an upwardly facing surface 39 and a downwardly facing surface 40. The axial extent h of the axial support member 36 is preferably slightly less than the axial extent H of the gap in the opening of the circumferential recess 31 so that there is a clearance between the axial support member and the gap when there is no force F applied by the cylinder cover 22. This clearance will allow the cylinder liner 1 to deform slightly until the downwardly facing support surface 34 and the upwardly facing support surface 35 abut with the respective upwardly facing surface 39 and downwardly facing surface 40 of the axial support member 36. This slight deformation of the material of the upper portion of the cylinder liner 1 causes a pre-tensioning of the material of the liner around the upper lobe 32 and around the lower lobe 33, which counters the risk of crack formation in the respective lobes 31,32.

It is also possible to use a zero clearance or a negative clearance for controlling the tension in other ways.

Figs. 14, 15 and 16 show a circumferential support member 36 and its assembly in greater detail. In this example embodiment the axial support member 36 comprises two halves 48, 49 that together form a ring. The two halves 48, 49 are loosely inserted into the circumferential recess 31 and they are not connected to one another. Fig. 14 shows the two halves 48, 49 during assembly, and Fig. 15 shows the 2 halves 48, 49 after assembly.

Each halve 48, 49 is provided with slots that form coolant in the openings 43 and slots that form coolant outlet openings 42. The slots that form the coolant outlet openings 42 are T shaped with rounded ends in order to avoid cracks due to stress in the material.

As shown in Fig. 9, a circumferential support member 37 is placed around the upper portion of the cylinder liner 1. A downwardly facing surface of the circumferential support member 37 rests on an upwardly facing shoulder 38 in the upper portion U of the cylinder liner 1. The circumferential support member 37 provides radial support for the upper portion U of the cylinder liner 1, which is illustrated by the horizontal arrows in Fig. 9. In an example embodiment the circumferential support member 37 is an integral annular body of high-strength steel. In order to improve the capacity of the circumferential support member 37 to provide radial support it is shrink-fitted around the upper portion of the cylinder liner 1 to thereby create pre-tensioning in the cylinder liner material and in the material of the circumferential support member 37.

In another embodiment a loose mounting of the circumferential support member 37 (Strong back) is used. Heat expansion from the cylinder liner will create contact to the circumferential support member (Strong back).

In an embodiment the circumferential support member 37 has a substantial wall thickness and can be considered to be a strong back.

The radial forces are transmitted between the cylinder liner 1 and the circumferential support member 37 at the upper portion of the circumferential support member 37 as shown by the upper pair of horizontal arrows in Fig. 9 and at the lower portion of the circumferential support member 37 as illustrated by the lower pair of horizontal arrows in Fig. 9. The middle section of the circumferential support member 37 does not handle any radial forces of significance and there is no radial force of significant size between the axial support member 36 and the circumferential support member 37.

The circumferential support member 37 is provided with an annual recess 47 to provide space for passage of liquid coolant. Gaskets (not shown) for sealing the transition between the cylinder liner 1 and the circumferential support member 37 are provided to ensure a liquid tight seal. Fig. 13 shows the circumferential support member 37 in greater detail in a sectional view.

As shown in Fig. 11, a flow inlet opening 46 is provided in the circumferential support member 37 The flow inlet opening 46 is substantially placed in an area with low stress level (such as e.g. the middle of the height) of the circumferential support member, i.e. in the portion of the circumferential support member 37 that does not handle any radial forces of significance. The flow inlet opening 46 connects to the inwardly facing circumferential recess 47 in the circumferential support member 37. There could be more than one flow inlet opening 46, but this is not deemed necessary or advantageous. The flow inlet opening 46 is connected to a liquid coolant supply conduit 26 that supplies liquid coolant from the cooling system. The liquid coolant can flow into the circumferential recess 31 via the flow inlet openings 43 in the axial support member 36. Via the flow inlet openings 43 the liquid coolant can enter the lower lobe 33 directly and the liquid coolant can flow towards the upper lobe 32 via the inwardly directed circumferential recess 41 in the axial support member 36. The arrows in Fig. 11 roughly indicate the direction of the flow of the liquid coolant.

As shown in Fig. 12, an inclined flow outlet pipe 44 extends from the upper lobe 32 to a connection block 50 on the outer side of the circumferential support member 37. The inclined flow outlet pipe 44 extends through an outlet opening 42 in the axial support member 36 and further through an inclined bore 45 that is arranged substantially in the middle of the height of the circumferential support member 37. The inclined arrangement of the flow outlet pipe 44 ensures that the inlet of the flow outlet pipe 44 is located at the highest portion of the circumferential recess 31, i.e. in the upper lobe 32, and the inclined direction of the flow outlet pipe 44 allows the inclined bore 45 to be placed in the middle of the height of the circumferential support member 37, i.e. in the portion of the circumferential support member 37 that is not handling any radial forces of significance. The outlet of the inclined flow outlet pipe 44 is connected to the connection block 50, e.g. via a welded flange at the end of the flow outlet pipe 44.

The connection block 50 is secured to the outer circumferential surface of the circumferential support member 37. The connection block 50 is provided with an angled bore, and an upwardly extending cooling water transfer conduit 28 connects to the upper side of the connection block 50. The cooling water transfer conduit 28 serves to guide the liquid coolant towards the cylinder cover 22 for cooling of the latter. The arrows in Fig. 12 roughly indicate the direction of the flow of the liquid coolant.

Fig. 17 is a sectional view of the upper portion U of the cylinder liner 1 that illustrates both the inlet and outlet arrangements of the cooling and supporting arrangement 30.

The construction of the cooling supporting arrangement 30 provides for a circumferentially substantially even temperature distribution of the cylinder wall material in the upper portion U of the cylinder liner 1, in contrast to the strongly fluctuating temperatures of the cylinder liner material in the upper portion of the cylinder liner in the prior art design.

Fig. 18 is a graph illustrating the temperature of the running surface of the cylinder liner 1 set out against the distance to the mate surface (top surface) of the cylinder cover 22. The uninterrupted line shows the temperature curve for the present design, i.e. the cylinder cover according to the embodiments described in this document. The interrupted curve shows the temperature curve for a prior art cylinder liner, such as for example known from W097/42406. In the upper portion U of the cylinder liner 1 the temperature curves for the present design and the prior art design are practically overlapping, i.e. identical. This was expected since the upper portion U of the cylinder liner 1 is force cooled in both the present design and the prior art design. The difference being that the present design provides for a circumferentially completely even cooling using the circumferential cooling recess whilst the plurality of inclined bores of the prior art design could not provide a circumferentially even cooling and resulted in temperature fluctuations along the circumferential extent of the upper portion of the cylinder liner 1. However, this cannot be seen in Fig. 18 since it plots the temperature in relation to the axial direction and not in the circumferential direction. The two curves differ significantly in the portion of the axial extent of the cylinder liner 1 just below the upper portion U (in the graph the upper portion extends from 0 to approximately 0.3

m and the portion there below with the significantly different temperatures extends from approximately 0.3 m to 1.3 m, but it is to be noted that these numbers are valid only for a particular shaped and sized cylinder liner 1 and can be very different in other designs).

The lack of forced cooling in the portion of the axial extent just below the upper portion of the cylinder liner 1 of the present design results in significantly higher temperatures of the running surface, the difference in temperature being up to 50°C. The increased temperature of the running surface in the area just below the upper portion U of the cylinder liner 1 results in less condensation of acidic combustion products and thus less corrosion of the cylinder liner 1 and reduced consumption of cylinder oil (the cylinder oil has a basic component to compensate for the acidity in the combustion products). Further down the running surface, i.e. more than approximately 1.3 m from the cylinder cover, the temperature of the running surface of the present design and the prior art design is identical and again there is no need for increased temperatures because high concentrations of acidic combustion products do not reach this part of the running surface of the cylinder liner due to the expansion of the combustion chamber. At engine loads below 100% of the maximum continuous rating the advantage of the absence of forced cooling of the cylinder liner, except for the upper portion U of the cylinder liner, is equally significant. The resulting higher temperatures of the running surface in the axial cylinder liner 1 just below the upper portion U of the cylinder liner also apply at lower engine loads.

The invention has been described in conjunction with various embodiments herein. However, other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word “comprising” does not exclude other elements or steps, and the indefinite article “a” or “an” does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage. The reference signs used in the claims shall not be construed as limiting the scope.

PATENTKRAV

1. Cylinderforing (1) til en totaktsmotor med krydshoved, hvilken cylinderforing (1) omfatter:

en første ende, der er tilpasset til at gå i indgreb med et cylinderdæksel (22),

skylleåbninger (18) i cylinderforingens (1) væg (29) i nærheden af en anden ende,

en periferisk køleindskæring (31) til et flydende kølemiddel i cylinderforingens (1) væg i nærheden af den første ende, hvilken periferisk køleindskæring (31) har en åbning, der strækker sig i periferien, i den ydre overflade af cylinderforingens (1) væg,

et aksialt støtteorgan (36), der er mindst delvist indsat i den periferiske indskæring, hvilket aksialt støtteorgan (36) danner bro over åbningen, der strækker sig i periferien, og hvilket aksialt støtteorgan er forsynet med passageudgangsåbninger (42) til kølemiddel og passageindgangsåbninger (43) til kølemiddel.

2. Cylinderforing (1) ifølge krav 1, hvor det aksiale støtteorgan (36) er konfigureret til at tilvejebringe aksial støtte til den periferiske køleindskæring.

3. Cylinderforing (1) ifølge krav 1 eller 2, hvor det aksiale støtteorgan (36) udfylder det aksiale rum mellem modstående aksialt vendende overflader (34, 35) af åbningen.

4. Cylinderforing (1) ifølge krav 3, hvor det aksiale rum (H) mellem de modstående aksialt vendende overflader (34, 35) af åbningen i en ubelastet tilstand af cylinderforingen er lidt større end den aksiale afstand h mellem de modstående aksiale overflader af det aksiale støtteorgan (36), således at der er et mindre aksialt frirum mellem åbningen og det aksiale støtteorgan (36).

5. Cylinderforing (1) ifølge et hvilket som helst af kravene 1 til 4, hvor det aksiale støtteorgan (36) er en splitring, der er dannet af to eller flere sektioner (49, 48).

6. Cylinderforing (1) ifølge et hvilket som helst af kravene 1 til 5, hvor den periferiske køleindskæring (31) omfatter et øvre fremspring (32) og eventuelt også et nedre fremspring (33).

7. Cylinderforing (1) ifølge krav 6, hvor den periferiske køleindskæring (31) omfatter en cylindrisk overflade (51), der forbinder det øvre fremspring (32) med det nedre fremspring (33).

8. Cylinderforing (1) ifølge krav 7, hvor det aksiale støtteorgan (36) omfatter en indadvendende ringformet indskæring (41) og hvor et rum til kølemiddel er defineret mellem den indadvendende ringformede indskæring (41) og den cylindriske overflade (51).

9. Cylinderforing (1) ifølge et hvilket som helst af kravene 1 til 8, hvor den periferiske køleindskæring (21) er tilstrækkelig dyb til at modtage det aksiale støtteorgan (36) uden at det aksiale støtteorgan (36) rager frem fra den periferiske køleindskæring (31).

10. Cylinderforing (1) ifølge et hvilket som helst af kravene 1 til 9, hvilken cylinderforing endvidere omfatter en flerhed af huller (25) til tilføring af cylindersmøremiddel i cylinderforingens (1) væg, hvilke huller fortrinsvist er fordelt i et i alt væsentligt ens niveau omkring cylinderforingens (1) periferi.

11. Totaktsmotor med krydshoved, der mindst omfatter én cylinderforing (1) ifølge et hvilket som helst af kravene 1 til 10.

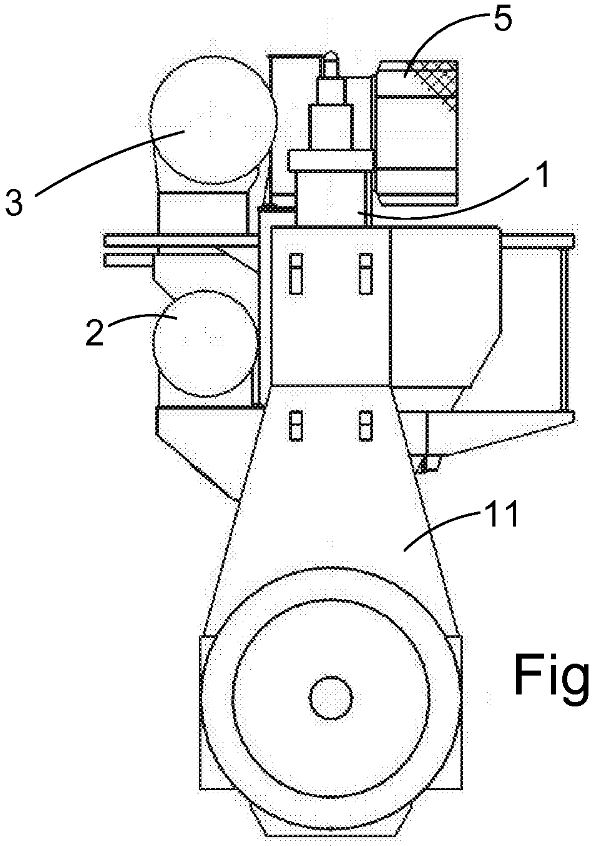



Fig. 1

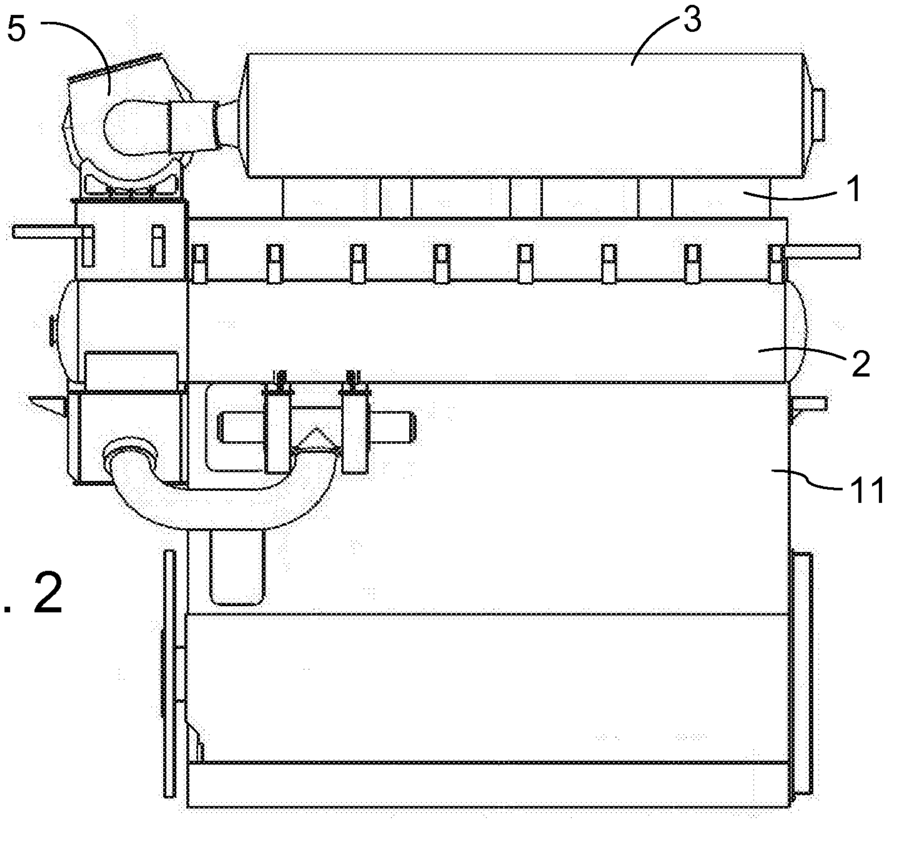



Fig. 2

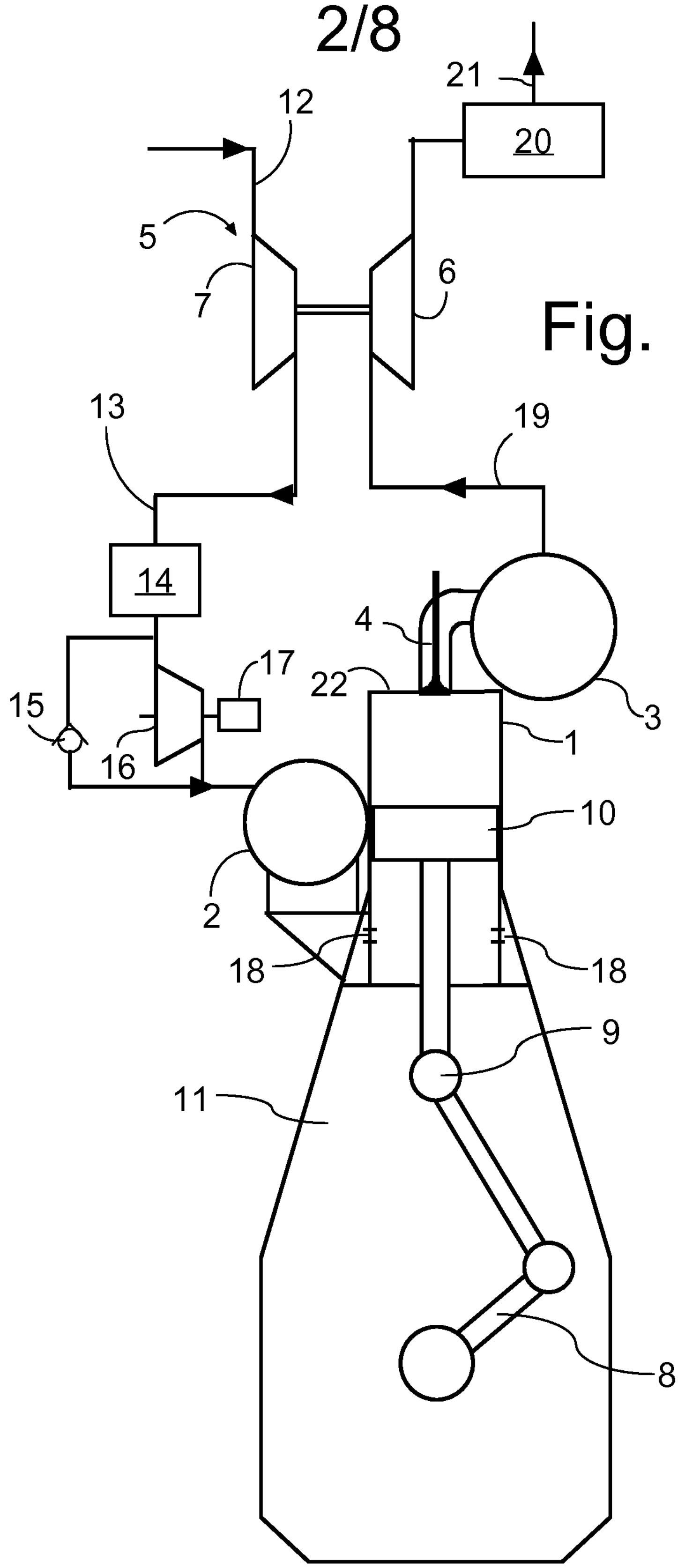



Fig. 3

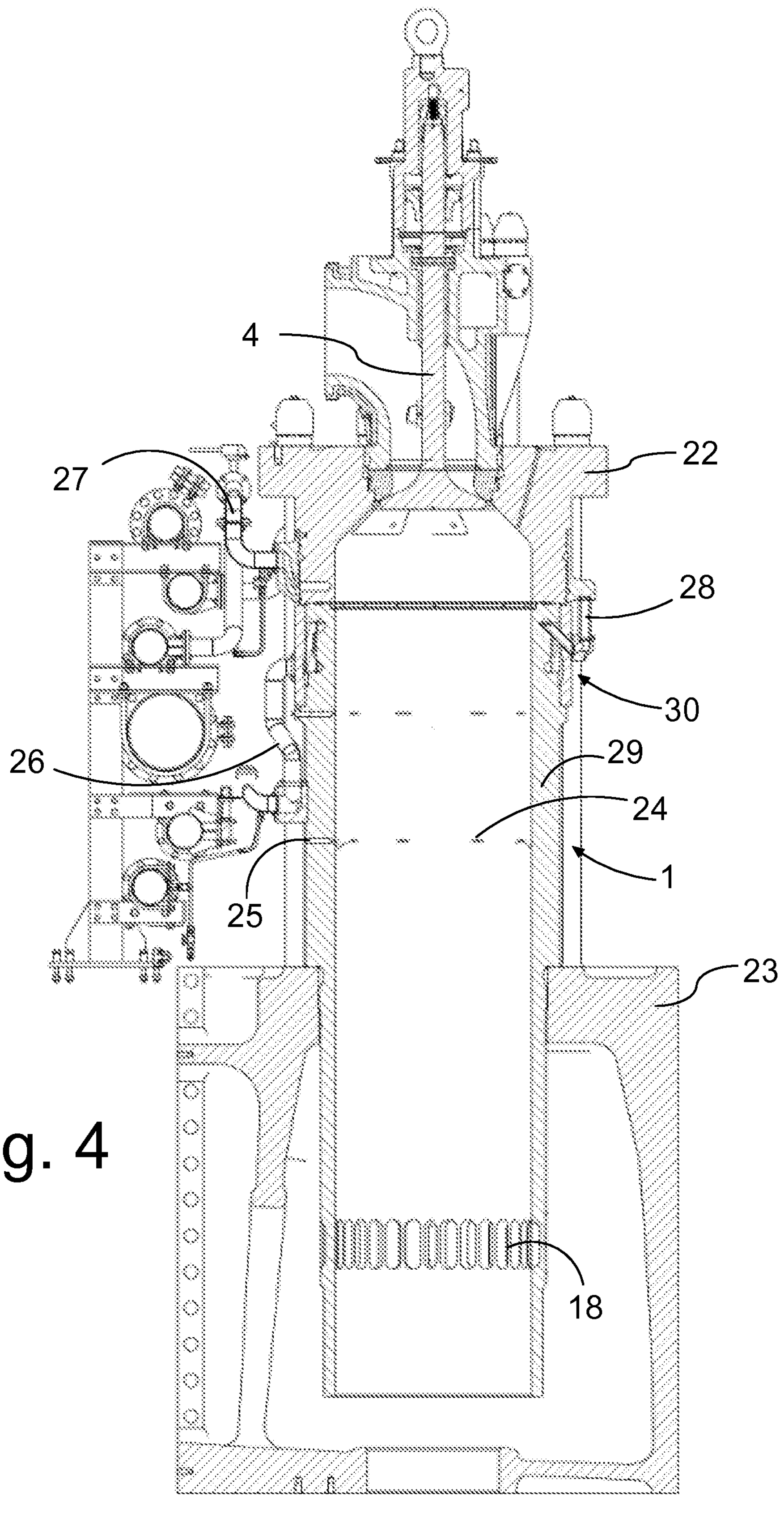



Fig. 4

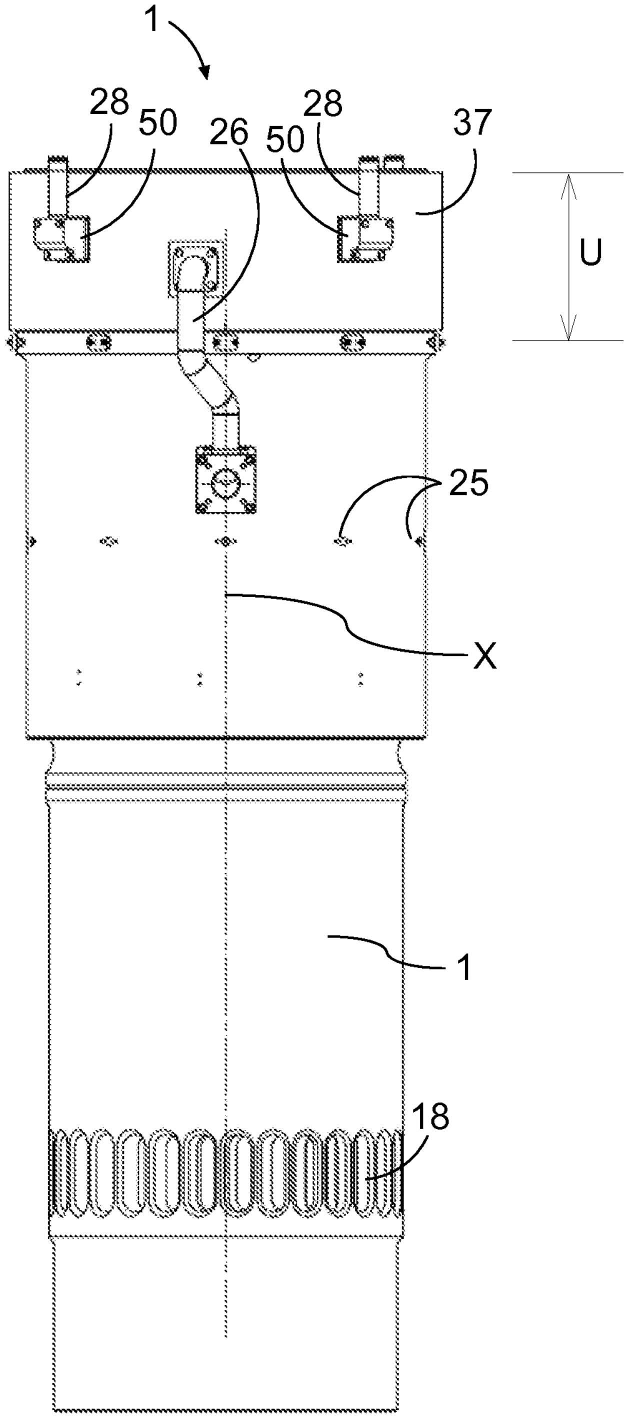



Fig. 5

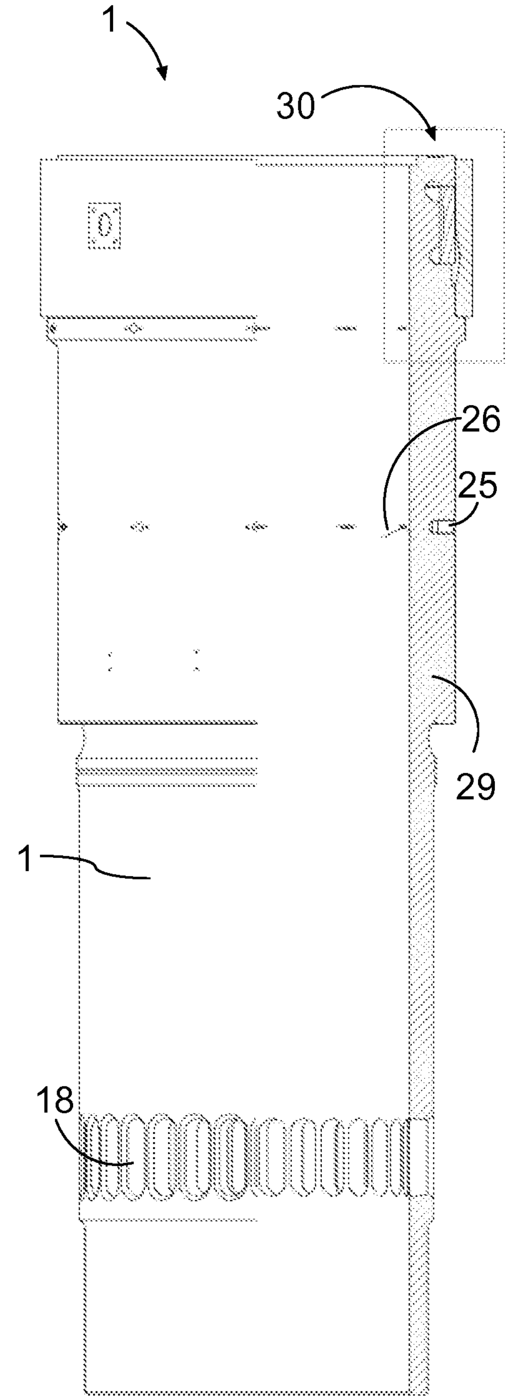



Fig. 6

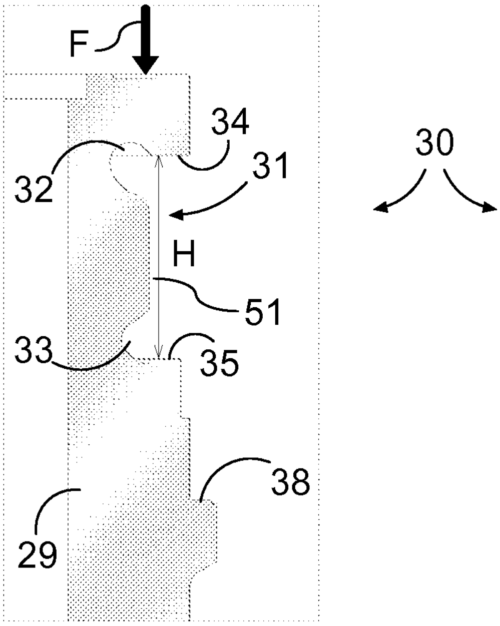



Fig. 7

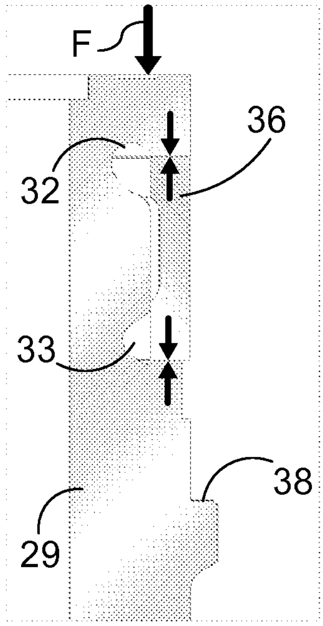



Fig. 8

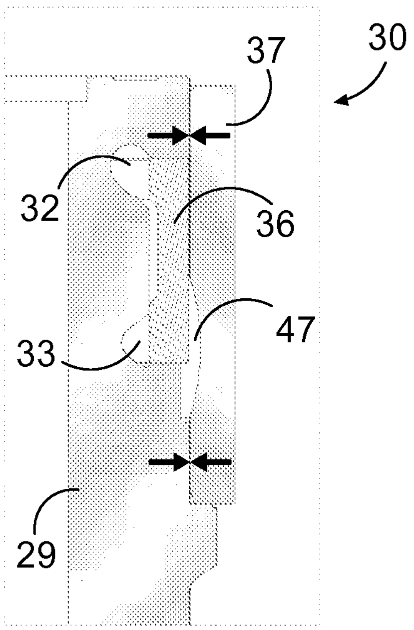



Fig. 9

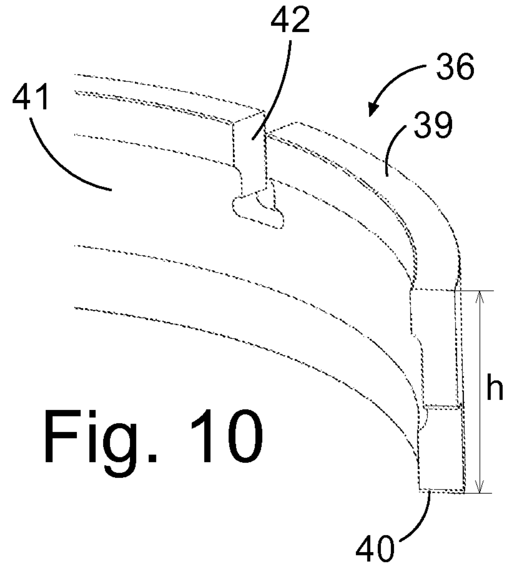



Fig. 10

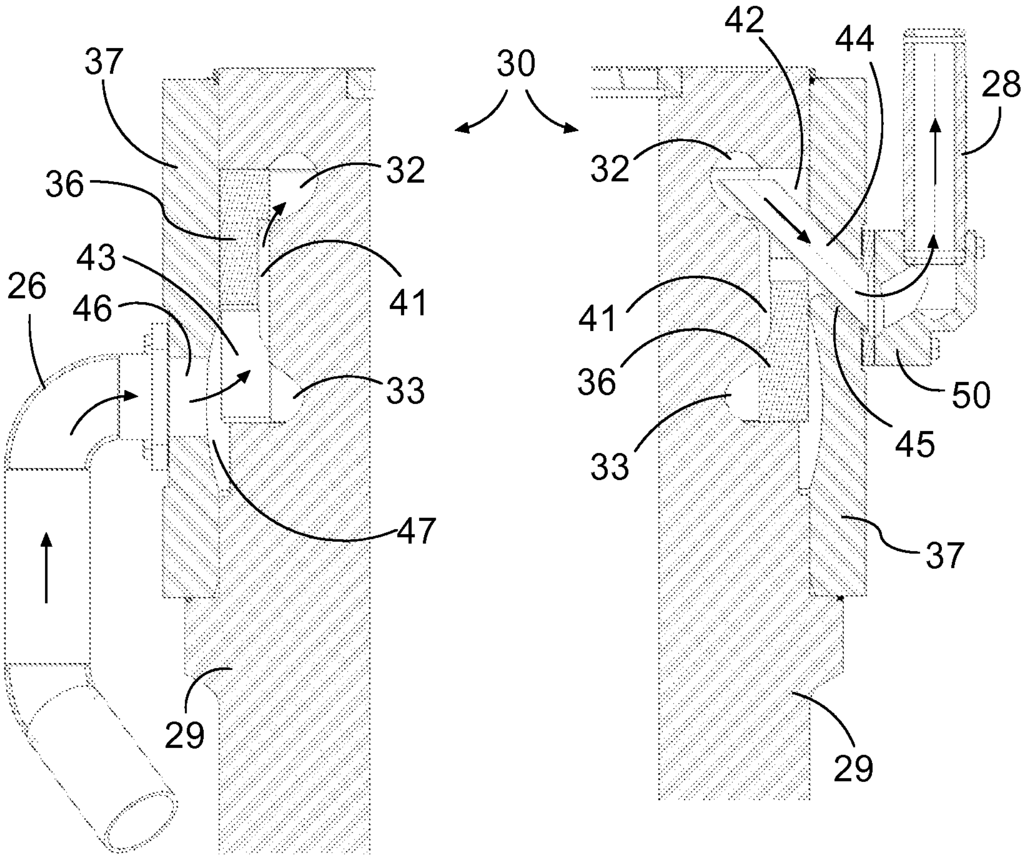



Fig. 11

Fig. 12

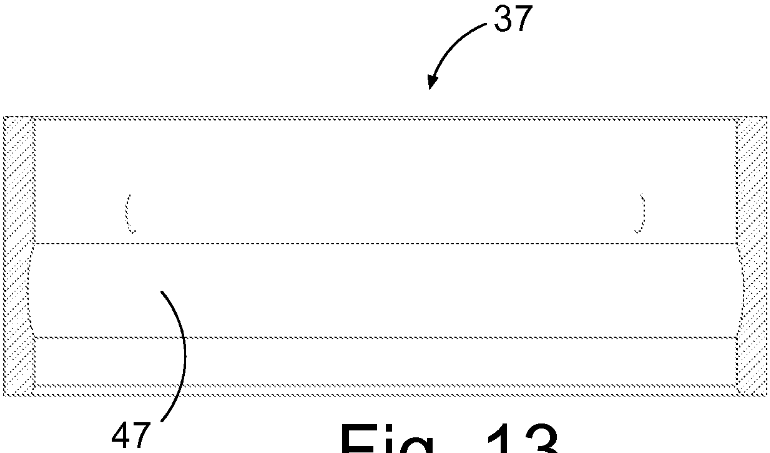



Fig. 13

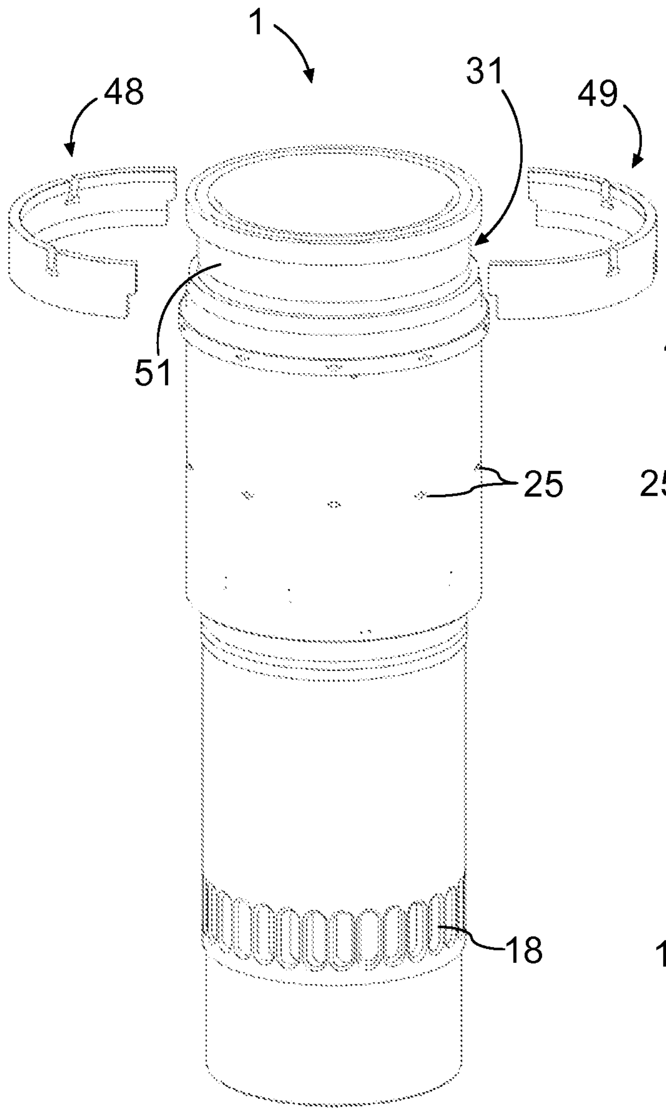



Fig. 14

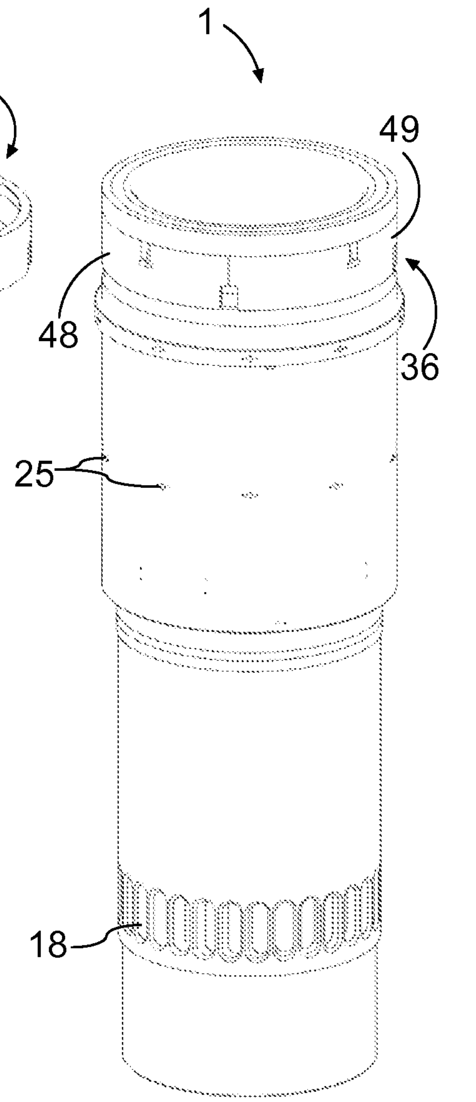



Fig. 15

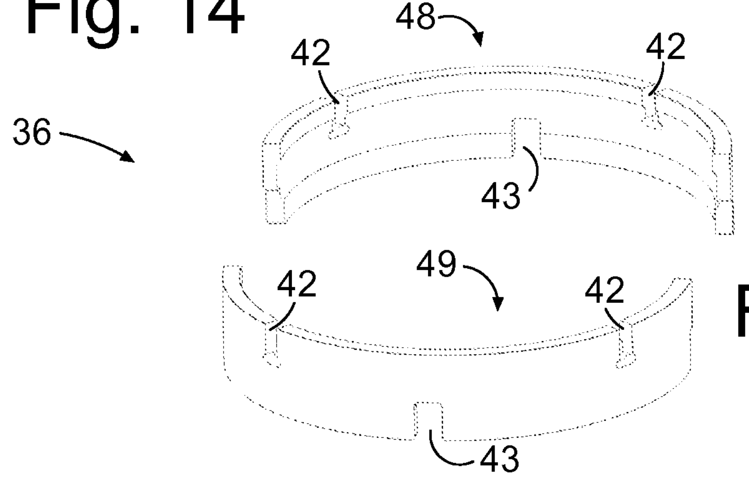
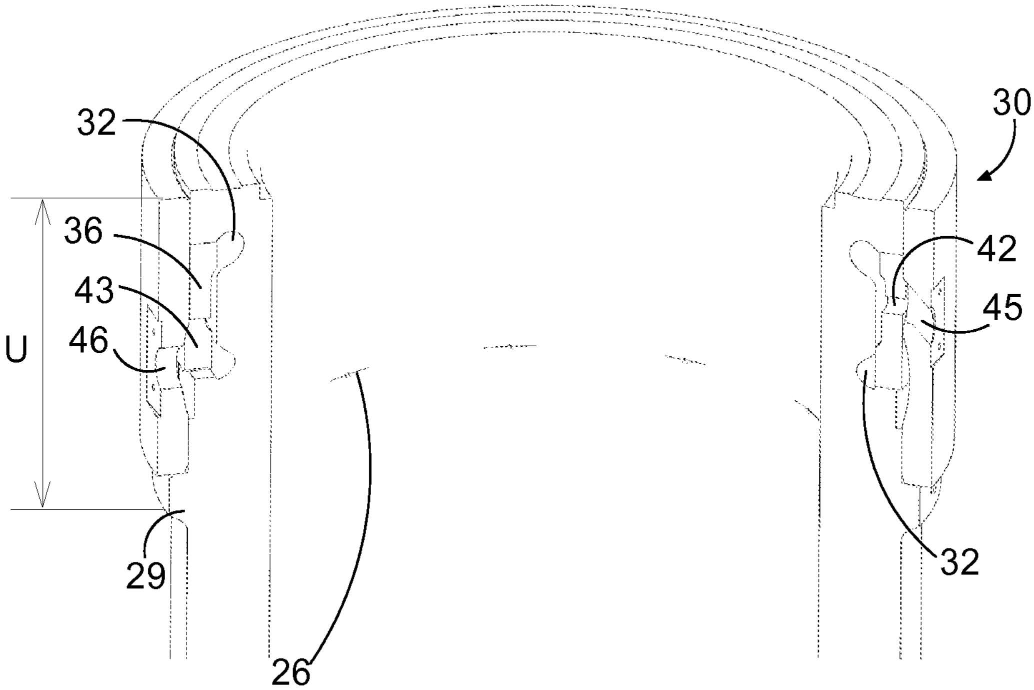



Fig. 16


32
30
36
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43
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46
29
32
26

Fig. 17

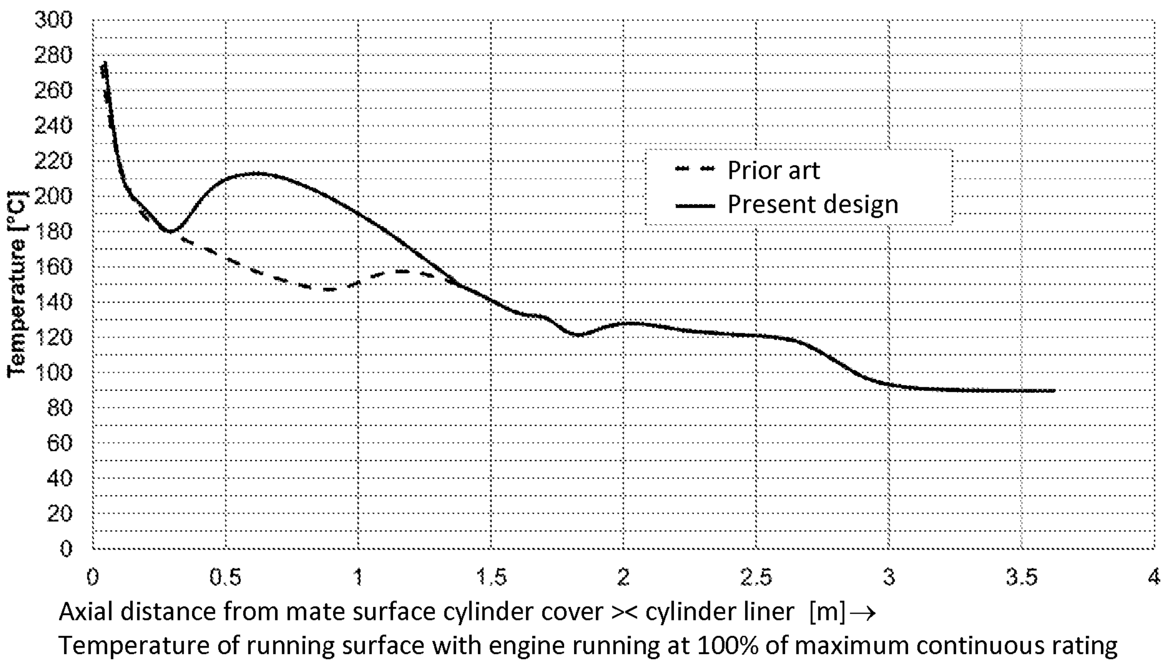
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Temperature [°C]
Prior art
Present design
0
0.5
1
1.5
2
2.5
3
3.5
4
Axial distance from mate surface cylinder cover >< cylinder liner [m]→
Temperature of running surface with engine running at 100% of maximum continuous rating

Fig. 18