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(54) **MONOLITHIC, GALLERYLESS PISTON AND METHOD OF CONSTRUCTION THEREOF**

MONOLITHISCHER, KANALFREIER KOLBEN UND VERFAHREN ZUR KONSTRUKTION DAVON
PISTON MONOLITHIQUE SANS GALERIE ET SON PROCÉDÉ DE CONSTRUCTION

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EP 3 400 381 B1

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Utility Patent Application Serial No. 14/988,885.

BACKGROUND OF THE INVENTION

1. Technical Field

[0002] This invention relates generally to internal combustion engines, and more particularly to pistons therefor.

2. Related Art

[0003] Engine manufacturers are encountering increasing demands to improve engine efficiencies and performance, including, but not limited to, improving fuel economy, reducing oil consumption, improving fuel systems, increasing compression loads and operating temperatures within the cylinder bores, reducing heat loss through the piston, improving lubrication of component parts, decreasing engine weight and making engines more compact, while at the same time decreasing the costs associated with manufacture.

[0004] While desirable to increase the compression load and operation temperature within the combustion chamber, it remains necessary to maintain the temperature of the piston within workable limits. Accordingly, although desirable to increase the compression load and operation temperature within the combustion chamber, achieving this goal comes with a tradeoff in that these desirable "increases" limit the degree to which the piston compression height, and thus, overall piston size and mass can be decreased. This is particularly troublesome with typical piston constructions having a closed or partially closed cooling gallery to reduce the operating temperature of the piston. The cost to manufacture pistons having upper and lower parts joined together along a bond joint to form the closed or partially closed cooling gallery is generally increased due to the joining process used to bond the upper and lower parts together. Further, the degree to which the engine weight can be reduced is impacted by the need to make the aforementioned "cooling gallery-containing" pistons from steel so they can withstand the increase in mechanical and thermal loads imposed on the piston. Gallery less pistons are known for example from WO2007135534 A1 and US2013233270 A1.

SUMMARY OF THE INVENTION

[0005] One aspect of the invention according to claim 1, provides a piston for an internal combustion engine designed to improve engine efficiency and performance. The piston is free of a cooling gallery along and under-

crown surface and thus has a reduced weight and related costs, relative to known piston constructions, but still provides for exceptional cooling to maintain the temperature of the piston within workable limits. The piston comprises a piston body extending along a central longitudinal axis. The piston body has an upper wall forming an upper combustion surface and an annular ring belt depending from the upper combustion surface. The upper combustion surface has first and second portions, the first portion extends annularly along an outer periphery of the upper wall, and the second portion forms a combustion bowl depending radially inwardly from the first portion. The piston body further includes a pair of skirt panels depending from the ring belt, and a pair of pin bosses spaced from one another by the skirt panels providing a pair of laterally spaced pin bores. The undercrown surface is formed on an underside of the upper wall and is located opposite the second portion of the upper combustion surface, radially inwardly of the ring belt. The undercrown surface has an exposed 2-dimensional surface area, as viewed looking along the central longitudinal axis, ranging from 25 to 60 percent of a cross-sectional area defined by a maximum outer diameter of the piston body.

[0006] Another aspect of the invention according to claim 13, provides a method of constructing a piston which is free of a cooling gallery along an undercrown surface. The method comprises forming a piston body extending along a central longitudinal axis by at least one of machining, forging, and casting. The piston body has an upper wall forming an upper combustion surface and an annular ring belt depending from the upper combustion surface. The upper combustion surface has first and second portions, the first portion extends annularly along an outer periphery of the upper wall, and the second portion forms a combustion bowl depending radially inwardly from the first portion. The piston body further includes a pair of skirt panels depending from the ring belt, and a pair of pin bosses spaced from one another by the skirt panels providing a pair of laterally spaced pin bores. The undercrown surface is formed on an underside of the upper wall and is located opposite the second portion of the upper combustion surface, radially inwardly of the ring belt. The undercrown surface has an exposed 2-dimensional surface area, as viewed looking along the central longitudinal axis, ranging from 25 to 60 percent of a cross-sectional area defined by a maximum outer diameter of the piston body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other aspects, features and advantages of the invention will become more readily appreciated when considered in connection with the following detailed description of presently preferred embodiments and best mode, appended claims and accompanying drawings, in which:

Figure 1 is a bottom perspective view of a piston

constructed in accordance with an example embodiment of the invention, wherein the piston includes a concave portion along the undercrown surface; Figure 2 is a cross-sectional view taken generally transversely to a pin bore axis of a piston in accordance with an embodiment which is not part of the invention;

Figure 3 is a bottom perspective view of a piston constructed in accordance with another example embodiment of the invention;

Figure 4 is a side view of a piston constructed in accordance with yet another example embodiment of the invention;

Figure 5 is a bottom view of the piston of Figure 4;

Figure 6 is a bottom view of the piston of Figure 4 according to another example embodiment;

Figure 7 illustrates the 2-dimensional undercrown surface area of the piston shown in Figure 6;

Figure 8 illustrates the 3-dimensional undercrown surface area of the piston shown in Figure 6;

Figure 9 illustrates the 2-dimensional surface area of the combustion bowl of the piston shown in Figure 6;

Figure 10 illustrates oil being sprayed onto the undercrown surface of the piston shown in Figure 6 at a top dead center position;

Figure 11 illustrates oil being sprayed onto the undercrown surface of the piston shown in Figure 6 at a bottom dead center position;

Figure 12 is a bottom perspective view of a piston constructed in accordance with yet another example embodiment of the invention, wherein the piston includes a concave portion axially offset from a central axis of the piston; and

Figure 13 is a side cross-sectional view of a piston constructed in accordance with yet another example embodiment which is not part of the invention which includes a convex portion.

DETAILED DESCRIPTION

[0008] Referring in more detail to the drawings, Figures 1-13 illustrate views of a piston 10 constructed in accordance with example embodiments of the invention for reciprocating movement in a cylinder bore or chamber (not shown) of an internal combustion engine, such as a modern, compact, high performance vehicle engine, for example. The piston 10 is constructed having a monolithic body formed from a single piece of material, such as via machining, forging or casting, with possible finish machining performed thereafter, if desired, to complete construction. Accordingly, the piston 10 does not have a plurality of parts joined together, such as upper and lower parts joined to one another, which is commonplace with pistons having enclosed or partially enclosed cooling galleries bounded or partially bounded by a cooling gallery floor. To the contrary, the piston 10 is "galleryless" in that it does not have a cooling gallery floor or other features

bounding or partially bounding a cooling gallery. The piston body, being made of steel, is strong and durable to meet the high performance demands, i.e. increased temperature and compression loads, of modern day high performance internal combustion engines. The steel (i.e., the steel alloy) used to construct the body can be SAE 4140 grade or different, depending on the requirements of the piston 10 in the particular engine application. Due to the piston 10 being galleryless, and the novel configuration of the body, among other things discussed below, minimizes the weight and compression height (CH) of the piston 10, thereby allowing an engine in which the pistons 10 are deployed to achieve a reduced weight and to be made more compact. Further yet, even though being galleryless, the novel construction discussed below and shown in the Figures allows the piston 10 to be sufficiently cooled during use to withstand the most severe operating temperatures.

[0009] The piston body has an upper head or top section providing an upper wall 14, which provides an upper combustion surface 16 that is directly exposed to combustion gasses within the cylinder bore of the internal combustion engine. The upper combustion surface 16 includes an annular first portion 18 formed as a substantially planar surface extending along an outer periphery of the upper wall 14 and a second portion 20 forming a combustion bowl. The second portion 20 of the upper combustion surface 16, which forms the combustion bowl, typically has a non-planar, concave, or undulating surface that depends from the planar first portion 18.

[0010] The piston 10 also includes an undercrown surface 24 formed on an underside of the upper wall 14, directly opposite the second portion 20 of the upper combustion surface 16 and radially inwardly of the ring belt 32. The undercrown surface 24 is preferably located at a minimum distance from the combustion bowl and is substantially the surface on the direct opposite side from the combustion bowl. The undercrown surface 24 is defined here to be the surface that is visible, excluding the pin bores 40, when observing the piston 10 straight on from the bottom.

[0011] The undercrown surface 24 can also be defined in view of a thickness t of the upper wall 14. The thickness t of the upper wall 14 extends from the upper combustion surface 16 to the underside of the upper wall 14. The portion of the underside of the upper wall 14 which is considered to be the undercrown surface 24 is typically a portion that is located a certain distance away from the second portion 20 of the upper combustion surface 16, and that distance is no more than two times the minimum thickness t of the upper wall 14 along the second portion 20. The undercrown surface 24 can also be defined as a portion of the underside of the upper wall 14 which is located at a distance not greater than 10 mm away from the upper combustion surface 16. Accordingly, the undercrown surface 24 is generally form fitting to the combustion bowl of the upper combustion surface 16. The undercrown surface 24 is also openly exposed, as

viewed from an underside of the piston 10, and it is not bounded by an enclosed or partially enclosed cooling gallery, or any other features tending to retain oil or a cooling fluid near the undercrown surface 24.

[0012] The annular first portion 18 of the upper wall 14 forms an outer periphery of the upper wall 14 and surrounds the second portion forming the combustion bowl, which depends therefrom. Thus, the second portion 20, including the combustion bowl, is recessed below the uppermost first portion 18 of the upper combustion surface 16. The combustion bowl of the second portion 20 also extends continuously through a central axis 30 and across the entire diameter of the piston 10, between opposite sides of the annular first portion 18. The combustion bowl typically comprises a concave surface extending continuously between the opposite sides of the annular first portion 18. Alternatively, the combustion bowl wall can be contoured, for example to provide an upper apex, also referred to as center peak (not shown), which may lie coaxially along the central axis 30 of the piston 10, or may be axially offset relative to the piston central axis 30. The top section of the piston 10 further includes a ring belt 32 that depends from the upper combustion surface 16 to provide one or more ring grooves 34 for receipt of one or more corresponding piston rings (not shown). In the example embodiments, at least one valve pocket 29 having a curved profile is formed in the annular first portion 18 of the upper wall 14. The combustion bowl does not include the valve pockets 29.

[0013] The piston body further includes a bottom section including a pair of pin bosses 38 depending generally from the upper wall 14. The pin bosses 38 each have a pin bore 40, preferably bushingless given the steel construction, wherein the pin bores 40 are laterally spaced from one another coaxially along a pin bore axis 42 that extends generally transversely to the central longitudinal axis 30. The pin bosses 38 have generally flat, radially outermost surfaces, referred to as outer faces 43, that are spaced from one another along the pin bore axis 40 a distance PB, shown as being generally parallel with one another. The PB dimension is minimized, thereby maximizing an exposed area of a recessed, generally cup-shaped region, referred to hereafter as undercrown pockets 50.

[0014] The undercrown pockets 50 are located radially outwardly of the pin bosses 38 and at least a portion of each pocket 50 forms a portion of the undercrown surface 24. In the example embodiment, the portions of the undercrown pockets 50 forming the portion of the undercrown surface 24 are located opposite the second portion 20 of the upper combustion surface 16 and radially inwardly of the ring belt 32, at a distance of no more than two times a minimum thickness of the upper wall 14, and according to the invention at a distance of not greater than 10 mm from the upper combustion surface 16.

[0015] The undercrown pockets 50 also extend radially outwardly beyond the undercrown surface 24 along an underside surface of the annular first portion 18 of the

upper combustion surface 16 and depend from the upper wall 14 along an inner surface of the ring belt 32. These portions of the undercrown pockets 50 are either located outwardly of the second portion 20 of the upper combustion surface 16, at a distance of greater than two times a minimum thickness of the upper wall 14, and/or at a distance of greater than 10 mm from the upper combustion surface 16, and thus they do not form a portion of the undercrown surface 24.

[0016] With the 2-dimensional and 3-dimensional surface area of the pockets 50 being maximized, at least in part due to the minimized distance PB, the cooling caused by oil splashing or being sprayed upwardly from the crankcase against the exposed surface of the undercrown pockets 50 is enhanced, thereby lending to further cooling of the upper combustion surface 16, the undercrown surface 24, as well as a portion of the ring belt 34.

[0017] The pin bores 40 each have a concave uppermost load bearing surface, referred to hereafter as uppermost surface 44, disposed near the ring belt 32. As such, the compression height CH is minimized (the compressing height is the dimension extending from the pin bore axis 42 to the upper combustion surface 16). The pin bosses 38 are joined via outer panels, also referred to as struts 46, to diametrically opposite skirt panels, also referred to as skirt panels 48.

[0018] The pin bosses 38, skirt panels 48 and struts 46 bound an open region extending from a lowermost or bottom surface 51 of the struts 46 and skirt panels 48 to the undercrown surface 24. In the embodiments of Figures 1, 2, and 4-13, no ribs are located along the undercrown surface 24, along the pin bosses 38, along the skirt panels 48, or along the struts 46 in the open region. In addition, no closed or partially closed cooling gallery is formed in the open region. However, the piston 10 can include a stepped region 54 along the uppermost edge of each skirt panel 48 adjacent the undercrown surface 24, as identified in Figures 1 and 2. In the example embodiments of Figures 1 and 2, the stepped regions 54 are not considered part of the undercrown surface 24. In another embodiment, for example the embodiment shown in Figure 3, the piston 10 does include a pair of ribs 58 along the undercrown surface 24 to enhance cooling. These ribs 58 extend continuously along the undercrown surface 24 between the opposite skirt panels 38.

[0019] The open region along the underside of the piston 10 provides direct access to oil splashing or being sprayed from within the crankcase directly onto the undercrown surface 24, thereby allowing the entire undercrown surface 24 to be splashed directly by oil from within the crankcase, while also allowing the oil to freely splash about the wrist pin (not shown), and further, significantly reduce the weight of the piston 10. Accordingly, although not having a typical closed or partially closed cooling gallery, the generally open configuration of the galleryless piston 10 allows optimal cooling of the undercrown surface 24 and lubrication to the wrist pin joint within the pin bores 40, while at the same time reducing oil residence

time on the surfaces near the combustion bowl, which is the time in which a volume of oil remains on the surface. The reduced residence time can reduce unwanted build-up of coked oil, such as can occur in pistons having a closed or substantially closed cooling gallery. As such, the piston 10 remains "clean" over extended use, thereby allowing it to remain substantially free of build-up.

[0020] Owing to the optimal cooling of the undercrown surface 24 is the percentage of the undercrown surface 24 directly underlying the upper combustion surface 16 that is directly exposed to the splashing and sprayed oil from the crankcase. The undercrown surface 24 of the piston 10 has greater a total surface area (3-dimensional area following the contour of the surface) and a greater projected surface area (2-dimensional area, planar, as seen in plan view) than comparative pistons having a closed or partially closed cooling gallery.

[0021] The total exposed surface area, defined as the 3-dimensional area A_{u3D} following the contour of the undercrown surface 24, is an expansive area for contact by cooling oil while the piston 10 is in use. In the example embodiments, the 3-dimensional area A_{u3D} of the undercrown surface 24 is greater than 30 percent of, and typically ranges from 40 to 90 percent of a cross-sectional area A_{OD} defined by the maximum outer diameter OD of the piston 10.

[0022] The undercrown surface 24 has a projected surface area, defined as the 2-dimensional surface area A_{u2D} seen looking generally along the central longitudinal axis 30 from the bottom of the piston 10 of greater than 25 percent, and typically ranging from 30 to 60 percent of the cross-sectional area defined by the maximum outer diameter OD of the piston 10. More preferably, the 2-dimensional surface area A_{u2D} ranges from 30 to 55 percent of the cross-sectional area defined by the maximum outer diameter OD of the piston 10. As indicated above, a portion of the 2-dimensional surface area A_{u2D} of the undercrown surface 24 is located within the pockets 50. The 2-dimensional surface area A_{u2D} of the undercrown surface 24 can also be measured relative to the 2-dimensional surface area A_{c2D} of the combustion bowl along the upper combustion surface 16. In the example embodiments, the 2-dimensional surface area A_{u2D} of the undercrown surface 24 ranges from 50 to 125 percent of the 2-dimensional surface area A_{c2D} of the combustion bowl. In addition, the valve pockets 29 are not included in the 2-dimensional surface area A_{c2D} of the combustion bowl.

[0023] The 3-dimensional surface area A_{u3D} of the undercrown surface 24 can also be measured relative to the 3-dimensional surface area A_{c3D} of the combustion bowl along the upper combustion surface 16. In the example embodiments, the 3-dimensional surface area A_{u3D} of the undercrown surface 24 ranges from 50 to 120 percent of the 3-dimensional surface area A_{c3D} of the combustion bowl. As indicated above, a portion of the 3-dimensional surface area A_{u3D} of the undercrown surface 24 is located within the pockets 50.

[0024] As an example, Figure 7 identifies the outer diameter OD and the 2-dimensional surface area A_{u2D} of the undercrown surface 24 of the piston 10 of Figure 6; Figure 8 illustrates the 3-dimensional undercrown surface area A_{u3D} of the piston 10 shown in Figure 6; and Figure 9 illustrates the 2-dimensional surface area A_{c2D} of the combustion bowl of the piston 10 shown in Figure 6.

[0025] Further yet, the exposed area of the undercrown surface 24 typically has a diameter D_u , as shown in Figure 7, ranging from 75 to 90 percent of the maximum outer diameter OD of the piston 10. The exposed area of the undercrown surface 24 can have a diameter D_u ranging from 85 to 140 percent of the diameter D_c of the combustion bowl, which is in contrast to a maximum of 100 percent for a piston having a closed or substantially closed cooling gallery.

[0026] However, the percentages of relative surface areas and relative diameters can vary from the ranges disclosed above while still providing for enhanced cooling. The percentages of relative surface areas and relative diameters of the exposed undercrown surface 24 of the piston 10 are far in excess of conventional pistons, and in some cases, are upwards to three times greater or more. As such, the upper combustion surface 16 can be cooled directly via oil splashing upwardly from the crankcase, which can be coupled with the assistance from oil jets, if desired.

[0027] As mentioned above, at least a portion of the undercrown pockets 50 of the piston 10 define at least a portion of the undercrown surface 24, as well as a portion of an underside of the first portion 18 and a portion of an inner surface of the annular ring belt 32. According to the invention, the undercrown pockets 50 together have a total 2-dimensional surface area A_{p2D} ranging from 18 to 35 percent of the cross-sectional area A_{OD} defined by the maximum outer diameter of the piston 10. The undercrown pockets 50 also have a total 3-dimensional area A_{p3D} ranging from 50 to 85 percent of the cross-sectional area A_{OD} defined by the maximum outer diameter of the piston 10. An example of the 3-dimensional area A_{p3D} of the undercrown pockets 50 is also shown in Figure 8.

[0028] However, it is noted that the 3-dimensional surface areas of the undercrown pockets 50 can vary from the ranges disclosed above while still being able to contribute significantly to the cooling of the regions of the upper combustion surface 16 located directly above the pockets 50.

[0029] Another significant aspect of the example pistons 10 shown in Figures 1-11 is that at least a center portion 52 of the undercrown surface 24 of the piston 10 disposed between the opposite skirt panels 38 and the opposite pin bosses 38 is concave in form, when viewing from the bottom of the piston 10. As such, oil is channeled during reciprocation of the piston 10 from one side of the piston 10 to the opposite side of the piston 10, thereby acting to further enhance cooling of the piston 10. This concave portion 52 has a length extending longitudinally

between the skirt panels 38 and a width extending between the pin bosses 38. The length of the concave portion 52 is typically greater than the width. In the example embodiments, the radius of curvature of the concave portion 52 ranges from 30 to 500 mm. Also, in the example embodiments shown in Figures 2 and 5-9, the concave portion 52 is axially offset from the pockets 50 or other surrounding area of the undercrown surface 24. For example, the concave portion 52 can be disposed closer to the pin bosses 38 than the surrounding area.

[0030] Figure 12 illustrates a piston 10' with an enhanced undercrown surface 24' according to another example embodiment. In this embodiment, the piston 10' includes a concave portion 52' which is axially offset from the central longitudinal axis 30' of the piston 10'. This offset concave portion 52' can be used in place of, or in addition to, the concave portion 52.

[0031] Figure 13 illustrates yet another example piston 10" with an enhanced undercrown surface area 24". In this embodiment, the undercrown surface 24" includes a convex portion 56" disposed along the central longitudinal axis 30" of the piston 10" to channel oil during reciprocation of the piston 10". In the example embodiment, the convex portion 56" extends continuously along the entire undercrown surface 24" between the opposite skirt panels 38". However, the convex portion 56" could be located along only a portion of the undercrown surface 24", either at the central longitudinal axis or axially offset from the central longitudinal axis 30". The radius of curvature of the convex portion 56" typically ranges from 80 to 300 mm.

[0032] Many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that the invention may be practiced otherwise than as specifically described, and that the scope of the invention is defined by any ultimately allowed claims.

Claims

1. A piston (10) for an internal combustion engine, comprising:

a piston body extending along a central longitudinal axis (30);
 said piston body having an upper wall (14) forming an upper combustion surface (16) and an annular ring belt (32) depending from said upper combustion surface (16);
 said upper combustion surface (16) having first and second portions (18, 20), said first portion (18) extending annularly along an outer periphery of said upper wall (14) and said second portion (20) forming a combustion bowl depending radially inwardly from said first portion (18);
 said upper wall (14) having an undercrown surface (24) formed on an underside thereof, said

undercrown surface (24) located opposite said second portion (20) of said upper combustion surface (16) and radially inwardly of said ring belt (32);

said piston body including a pair of skirt panels (48) depending from said ring belt (32);

said piston body including a pair of pin bosses (38) spaced from one another by said skirt panels (48) and providing a pair of laterally spaced pin bores (40);

said piston body being free of a cooling gallery along said undercrown surface (24); and

said undercrown surface (24) having an exposed 2-dimensional surface area (Au2D), as viewed looking along said central longitudinal axis (30), ranging from 25 to 60 percent of a cross-sectional area (AOD) defined by a maximum outer diameter (OD) of said piston body, wherein said piston body includes undercrown pockets (50) located radially outwardly of said pin bosses (38), at least a portion of said undercrown pockets (50) form at least a portion of said undercrown surface (24), and said undercrown pockets (50) have a total 2-dimensional surface area (Ap2D) ranging from 18 to 35 percent of said cross-sectional area (AOD) defined by said maximum outer diameter (OD) of said piston body,

wherein said undercrown surface (24) is located along said underside of said upper wall (14) at a distance away from said upper combustion surface (16), and said distance is not greater than 10 mm,

characterized in that

said undercrown surface (24) has a diameter (Du) ranging from 100 to 140 percent of a diameter (Dc) of said combustion bowl.

2. The piston (10) of claim 1, wherein said 2-dimensional surface area (Au2D) of said undercrown surface (24) ranges from 30 to 55 percent of said cross-sectional area (AOD) defined by said maximum outer diameter (OD) of said piston body.

3. The piston (10) of claim 1, wherein a 3-dimensional surface area (Au3D) of said undercrown surface (24) ranges from 50 to 120 percent of a 3-dimensional surface area (Ac3D) of said combustion bowl.

4. The piston (10) of claim 1, wherein said undercrown surface (24) has a 3-dimensional surface area (Au3D) ranging from 30 to 90 percent of said cross-sectional area (AOD) defined by said maximum outer diameter (OD) of said piston body.

5. The piston (10) of claim 1, wherein said undercrown pockets (50) have a total 3-dimensional surface area (Ap3D) ranging from 50 to 85 percent of said cross-

sectional area (AOD) defined by said maximum outer diameter (OD) of said piston body.

6. The piston (10) of claim 1, wherein said portions of said undercrown pockets (50) forming said portion of said undercrown surface (24) are located opposite said second portion (20) of said upper combustion surface (16) and radially inwardly of said ring belt (32) and at a distance of not greater than 10 mm from said upper combustion surface (16). 5 10
7. The piston (10) of claim 1, wherein said undercrown surface (24) includes a concave portion (52) located along said central longitudinal axis (30), wherein a length of said concave portion (52) is greater than a width of said concave portion (52). 15
8. The piston (10) of claim 1, wherein said undercrown surface (24) includes a concave portion (52) axially offset from said central longitudinal axis (30). 20
9. The piston (10) of claim 8, wherein said concave portion (52) has a radius of curvature ranging from 30 to 500 mm. 25
10. The piston (10) of claim 1, wherein said undercrown surface (24) includes a convex portion (56) located along said central longitudinal axis (30), and said convex portion (56) has a radius of curvature ranging from 80 to 300 mm. 30
11. The piston (10) of claim 1, wherein said upper wall (14) has a thickness (t) extending from said combustion surface (16) to said underside of said upper wall (14), said undercrown surface (24) is located along said underside at a distance away from said combustion surface (16), and said distance is no more than two times a minimum thickness (t) of said upper wall (14). 35 40
12. The piston (10) of claim 1, wherein said undercrown surface (24) is located along said underside of said upper wall (14) at a distance away from said upper combustion surface (16), and said distance is not greater than 10 mm. 45
13. A method of constructing a piston (10), comprising the step of:

forming a piston body extending along a central longitudinal axis (30) by at least one of machining, forging, and casting; 50
the piston body having an upper wall (14) forming an upper combustion surface (16) and an annular ring belt (32) depending from the upper combustion surface (16); 55
the upper combustion surface (16) having first and second portions (18, 20), the first portion

(18) extending annularly along an outer periphery of the upper wall (14) and the second portion (20) forming a combustion bowl depending radially inwardly from the first portion (18);
the upper wall (14) having an undercrown surface (24) formed on an underside thereof, the undercrown surface (24) located opposite the second portion (20) of the upper combustion surface (16) and radially inwardly of the ring belt (32);
the piston body including a pair of skirt panels (48) depending from the ring belt (32);
the piston body including a pair of pin bosses (38) spaced from one another by the skirt panels (48) and providing a pair of laterally spaced pin bores (40);
the piston body being free of a cooling gallery along the undercrown surface (24); and
the undercrown surface (24) having an exposed 2-dimensional surface area (Au2D), as viewed looking along the central longitudinal axis (30), ranging from 25 to 60 percent of a cross-sectional area (AOD) defined by a maximum outer diameter (OD) of the piston body,
wherein said piston body includes undercrown pockets (50) located radially outwardly of said pin bosses (38), at least a portion of said undercrown pockets (50) form at least a portion of said undercrown surface (24), and said undercrown pockets (50) have a total 2-dimensional surface area (Ap2D) ranging from 18 to 35 percent of said cross-sectional area (AOD) defined by said maximum outer diameter (OD) of said piston body,
wherein said undercrown surface (24) is located along said underside of said upper wall (14) at a distance away from said upper combustion surface (16), and said distance is not greater than 10 mm,
characterized in that
said undercrown surface (24) has a diameter (Du) ranging from 100 to 140 percent of a diameter (Dc) of said combustion bowl.

Patentansprüche

1. Kolben (10) für einen Verbrennungsmotor, umfassend:

einen Kolbenkörper, der sich entlang einer mittleren Längsachse (30) erstreckt;
wobei der Kolbenkörper eine obere Wand (14), die eine obere Verbrennungsfläche (16) bildet, und eine kreisförmige Ringpartie (32), die von der oberen Verbrennungsfläche (16) herabhängt, aufweist;
die obere Verbrennungsfläche (16) erste und

- zweite Abschnitte (18, 20) aufweist, wobei sich der erste Abschnitt (18) kreisförmig entlang einer äußeren Peripherie der oberen Wand (14) erstreckt und der zweite Abschnitt (20) eine Verbrennungsschale bildet, die radial nach innen von dem ersten Abschnitt (18) herabhängt; die obere Wand (14) eine Innenfläche (24) aufweist, die an ihrer Unterseite gebildet ist, wobei die Innenfläche (24) gegenüber dem zweiten Abschnitt (20) der oberen Verbrennungsfläche (16) und radial nach innen von der Ringpartie (32) liegt; der Kolbenkörper ein Paar Sockelbleche (48) beinhaltet, die von der Ringpartie (32) herabhängen; der Kolbenkörper ein Paar Stiftsockel (38) beinhaltet, die durch die Sockelbleche (48) voneinander beabstandet sind und ein Paar seitlich beabstandeter Stiftbohrungen (40) bereitstellen; der Kolbenkörper frei von einem Kühlkanal entlang der Innenfläche (24) ist; und die Innenfläche (24) eine freiliegende zweidimensionale Oberfläche (Au2D) aufweist, wenn entlang der mittleren Längsachse (30) betrachtet, die von 25 bis 60 Prozent einer Querschnittsfläche (AOD) reicht, die durch einen maximalen Außendurchmesser (OD) des Kolbenkörpers definiert ist, wobei der Kolbenkörper Innentaschen (50) beinhaltet, die von den Stiftsockeln (38) radial nach außen liegen, mindestens ein Abschnitt der Innentaschen (50) mindestens einen Abschnitt der Innenfläche (24) bildet und die Innentaschen (50) eine gesamte zweidimensionale Oberfläche (Ap2D) aufweisen, die von 18 bis 35 Prozent der Querschnittsfläche (AOD) reicht, die durch den maximalen Außendurchmesser (OD) des Kolbenkörpers definiert ist, wobei die Innenfläche (24) entlang der Unterseite der oberen Wand (14) bei einem Abstand zu der oberen Verbrennungsfläche (16) liegt und der Abstand nicht größer als 10 mm ist, **dadurch gekennzeichnet, dass** die Innenfläche (24) einen Durchmesser (Du) aufweist, der von 100 bis 140 Prozent eines Durchmessers (Dc) der Verbrennungsschale reicht.
2. Kolben (10) nach Anspruch 1, wobei die zweidimensionale Oberfläche (Au2D) der Innenfläche (24) von 30 bis 55 Prozent der Querschnittsfläche (AOD) reicht, die durch den maximalen Außendurchmesser (OD) des Kolbenkörpers definiert ist.
 3. Kolben (10) nach Anspruch 1, wobei eine dreidimensionale Oberfläche (Au3D) der Innenfläche (24) von 50 bis 120 Prozent einer dreidimensionalen Oberfläche (Ac3D) der Verbrennungsschale reicht.
 4. Kolben (10) nach Anspruch 1, wobei die Innenfläche (24) eine dreidimensionale Oberfläche (Au3D) aufweist, die von 30 bis 90 Prozent der Querschnittsfläche (AOD) reicht, die durch den maximalen Außendurchmesser (OD) des Kolbenkörpers definiert ist.
 5. Kolben (10) nach Anspruch 1, wobei die Innentaschen (50) eine gesamte dreidimensionale Oberfläche (Ap3D) aufweisen, die von 50 bis 85 Prozent der Querschnittsfläche (AOD) reicht, die durch den maximalen Außendurchmesser (OD) des Kolbenkörpers definiert ist.
 6. Kolben (10) nach Anspruch 1, wobei die Abschnitte der Innentaschen (50), die den Abschnitt der Innenfläche (24) bilden, gegenüber dem zweiten Abschnitt (20) der oberen Verbrennungsfläche (16) und radial nach innen von der Ringpartie (32) und mit einem Abstand von nicht mehr als 10 mm zu der oberen Verbrennungsfläche (16) liegen.
 7. Kolben (10) nach Anspruch 1, wobei die Innenfläche (24) einen konkaven Abschnitt (52) beinhaltet, der entlang der mittleren Längsachse (30) liegt, wobei eine Länge des konkaven Abschnitts (52) größer als eine Breite des konkaven Abschnitts (52) ist.
 8. Kolben (10) nach Anspruch 1, wobei die Innenfläche (24) einen konkaven Abschnitt (52) beinhaltet, der axial von der mittleren Längsachse (30) versetzt ist.
 9. Kolben (10) nach Anspruch 8, wobei der konkave Abschnitt (52) einen Krümmungsradius aufweist, der von 30 bis 500 mm reicht.
 10. Kolben (10) nach Anspruch 1, wobei die Innenfläche (24) einen konvexen Abschnitt (56) beinhaltet, der entlang der mittleren Längsachse (30) liegt, und der konvexe Abschnitt (56) einen Krümmungsradius aufweist, der von 80 bis 300 mm reicht.
 11. Kolben (10) nach Anspruch 1, wobei die obere Wand (14) eine Dicke (t) aufweist, die sich von der Verbrennungsfläche (16) zu der Unterseite der oberen Wand (14) erstreckt, wobei die Innenfläche (24) entlang der Unterseite mit einem Abstand zu der Verbrennungsfläche (16) liegt und der Abstand nicht mehr als ein Zweifaches einer minimalen Dicke (t) der oberen Wand (14) ist.
 12. Kolben (10) nach Anspruch 1, wobei die Innenfläche (24) entlang der Unterseite der oberen Wand (14) bei einem Abstand zu der oberen Verbrennungsfläche (16) liegt und der Abstand nicht größer als 10 mm ist.

13. Verfahren zum Konstruieren eines Kolbens (10), das den folgenden Schritt umfasst:

Bilden eines Kolbenkörpers, der sich entlang einer mittleren Längsachse (30) erstreckt, durch mindestens eines von maschinell Bearbeiten, Schmieden und Gießen;

wobei der Kolbenkörper eine obere Wand (14), die eine obere Verbrennungsfläche (16) bildet, und eine kreisförmige Ringpartie (32), die von der oberen Verbrennungsfläche (16) herabhängt, aufweist;

die obere Verbrennungsfläche (16) erste und zweite Abschnitte (18, 20) aufweist, wobei sich der erste Abschnitt (18) kreisförmig entlang einer äußeren Peripherie der oberen Wand (14) erstreckt und der zweite Abschnitt (20) eine Verbrennungsschale bildet, die radial nach innen von dem ersten Abschnitt (18) herabhängt; die obere Wand (14) eine Innenfläche (24) aufweist, die an ihrer Unterseite gebildet ist, wobei die Innenfläche (24) gegenüber dem zweiten Abschnitt (20) der oberen Verbrennungsfläche (16) und radial nach innen von der Ringpartie (32) liegt;

der Kolbenkörper ein Paar Sockelbleche (48) beinhaltet, die von der Ringpartie (32) herabhängen;

der Kolbenkörper ein Paar Stiftsockel (38) beinhaltet, die durch die Sockelbleche (48) voneinander beabstandet sind und ein Paar seitlich beabstandeter Stiftbohrungen (40) bereitstellen;

der Kolbenkörper frei von einem Kühlkanal entlang der Innenfläche (24) ist; und

die Innenfläche (24) eine freiliegende zweidimensionale Oberfläche (Au2D) aufweist, wenn entlang der mittleren Längsachse (30) betrachtet, die von 25 bis 60 Prozent einer Querschnittsfläche (AOD) reicht, die durch einen maximalen Außendurchmesser (OD) des Kolbenkörpers definiert ist,

wobei der Kolbenkörper Innentaschen (50) beinhaltet, die von den Stiftsockeln (38) radial nach außen liegen, mindestens ein Abschnitt der Innentaschen (50) mindestens einen Abschnitt der Innenfläche (24) bildet und die Innentaschen (50) eine gesamte zweidimensionale Oberfläche (Ap2D) aufweisen, die von 18 bis 35 Prozent der Querschnittsfläche (AOD) reicht, die durch den maximalen Außendurchmesser (OD) des Kolbenkörpers definiert ist,

wobei die Innenfläche (24) entlang der Unterseite der oberen Wand (14) bei einem Abstand zu der oberen Verbrennungsfläche (16) liegt und der Abstand nicht größer als 10 mm ist,

dadurch gekennzeichnet, dass

die Innenfläche (24) einen Durchmesser (Du)

aufweist, der von 100 bis 140 Prozent eines Durchmessers (Dc) der Verbrennungsschale reicht.

Revendications

1. Piston (10) pour un moteur à combustion interne, comprenant :

un corps de piston s'étendant le long d'un axe longitudinal central (30) ;

ledit corps de piston ayant une paroi supérieure (14) formant une surface de combustion supérieure (16) et une ceinture annulaire périphérique (32) dépendant de ladite surface de combustion supérieure (16) ;

ladite surface de combustion supérieure (16) ayant des première et seconde parties (18, 20), ladite première partie (18) s'étendant de façon annulaire le long d'une périphérie extérieure de ladite paroi supérieure (14) et ladite seconde partie (20) formant une cuvette de combustion dépendant, radialement vers l'intérieur, de ladite première partie (18) ;

ladite paroi supérieure (14) ayant une surface de sous-calotte (24) formée sur un côté inférieur de celle-ci, ladite surface de sous-calotte (24) étant située en face de ladite seconde partie (20) de ladite surface de combustion supérieure (16) et radialement vers l'intérieur de ladite ceinture annulaire (32) ;

ledit corps de piston incluant une paire de panneaux de jupe (48) dépendant de ladite ceinture annulaire (32) ;

ledit corps de piston incluant une paire de bossages de goupille (38) espacés l'un de l'autre par lesdits panneaux de jupe (48) et fournissant une paire d'alésages de goupille espacés latéralement (40) ;

ledit corps de piston étant dépourvu d'une galerie de refroidissement le long de ladite surface de sous-calotte (24) ; et

ladite surface de sous-calotte (24) ayant une superficie de surface bidimensionnelle exposée (Au2D), en vue le long dudit axe longitudinal central (30), variant de 25 à 60 pour cent d'une superficie de section transversale (AOD) définie par un diamètre extérieur maximum (OD) dudit corps de piston,

dans lequel ledit corps de piston inclut des poches de sous-calotte (50) situées radialement vers l'extérieur desdits bossages de goupille (38), au moins une partie desdites poches de sous-calotte (50) forme au moins une partie de ladite surface de sous-calotte (24), et lesdites poches de sous-calotte (50) ont une superficie de surface bidimensionnelle totale (Ap2D) va-

- ariant de 18 à 35 pour cent de ladite superficie de section transversale (AOD) définie par ledit diamètre extérieur maximum (OD) dudit corps de piston,
- dans lequel ladite surface de sous-calotte (24) est située le long dudit côté inférieur de ladite paroi supérieure (14) à une distance de ladite surface de combustion supérieure (16), et ladite distance n'est pas supérieure à 10 mm,
- caractérisé en ce que**
- ladite surface de sous-calotte (24) a un diamètre (Du) variant de 100 à 140 pour cent d'un diamètre (Dc) de ladite cuvette de combustion.
2. Piston (10) selon la revendication 1, dans lequel ladite superficie de surface bidimensionnelle (Au2D) de ladite surface de sous-calotte (24) varie de 30 à 55 pour cent de ladite superficie de section transversale (AOD) définie par ledit diamètre extérieur maximum (OD) dudit corps de piston.
 3. Piston (10) selon la revendication 1, dans lequel une superficie de surface tridimensionnelle (Au3D) de ladite surface de sous-calotte (24) varie de 50 à 120 pour cent d'une superficie de surface tridimensionnelle (Ac3D) de ladite cuvette de combustion.
 4. Piston (10) selon la revendication 1, dans lequel ladite surface de sous-calotte (24) a une superficie de surface tridimensionnelle (Au3D) variant de 30 à 90 pour cent de ladite superficie de section transversale (AOD) définie par ledit diamètre extérieur maximum (OD) dudit corps de piston.
 5. Piston (10) selon la revendication 1, dans lequel lesdites poches de sous-calotte (50) ont une superficie de surface tridimensionnelle (Ap3D) variant de 50 à 85 pour cent de ladite superficie de section transversale (AOD) définie par ledit diamètre extérieur maximum (OD) dudit corps de piston.
 6. Piston (10) selon la revendication 1, dans lequel lesdites parties desdites poches de sous-calotte (50) formant ladite partie de ladite surface de sous-calotte (24) sont situées en face de ladite seconde partie (20) de ladite surface de combustion supérieure (16) et radialement vers l'intérieur de ladite ceinture annulaire (32) et à une distance non supérieure à 10 mm de ladite surface de combustion supérieure (16).
 7. Piston (10) selon la revendication 1, dans lequel ladite surface de sous-calotte (24) inclut une partie concave (52) située le long dudit axe longitudinal central (30), dans lequel une longueur de ladite partie concave (52) est supérieure à une largeur de ladite partie concave (52).
 8. Piston (10) selon la revendication 1, dans lequel ladite surface de sous-calotte (24) inclut une partie concave (52) axialement décalée par rapport audit axe longitudinal central (30).
 9. Piston (10) selon la revendication 8, dans lequel ladite partie concave (52) a un rayon de courbure variant de 30 à 500 mm.
 10. Piston (10) selon la revendication 1, dans lequel ladite surface de sous-calotte (24) inclut une partie convexe (56) située le long dudit axe longitudinal central (30), et ladite partie convexe (56) a un rayon de courbure variant de 80 à 300 mm.
 11. Piston (10) selon la revendication 1, dans lequel ladite paroi supérieure (14) a une épaisseur (t) s'étendant depuis ladite surface de combustion (16) jusqu'àudit côté inférieur de ladite paroi supérieure (14), ladite surface de sous-calotte (24) est située le long dudit côté inférieur à une distance de ladite surface de combustion (16), et ladite distance n'est pas supérieure à deux fois une épaisseur minimum (t) de ladite paroi supérieure (14).
 12. Piston (10) selon la revendication 1, dans lequel ladite surface de sous-calotte (24) est située le long dudit côté inférieur de ladite paroi supérieure (14) à une distance de ladite surface de combustion supérieure (16), et ladite distance n'est pas supérieure à 10 mm.
 13. Procédé de construction d'un piston (10), comprenant l'étape de :

la formation d'un corps de piston s'étendant le long d'un axe longitudinal central (30) par au moins un d'usinage, de forgeage, et de coulage ; le corps de piston ayant une paroi supérieure (14) formant une surface de combustion supérieure (16) et une ceinture annulaire périphérique (32) dépendant de la surface de combustion supérieure (16) ;

la surface de combustion supérieure (16) ayant des première et seconde parties (18, 20), la première partie (18) s'étendant de façon annulaire le long d'une périphérie extérieure de la paroi supérieure (14) et la seconde partie (20) formant une cuvette de combustion dépendant, radialement vers l'intérieur, de la première partie (18) ; la paroi supérieure (14) ayant une surface de sous-calotte (24) formée sur un côté inférieur de celle-ci, la surface de sous-calotte (24) étant située en face de la seconde partie (20) de la surface de combustion supérieure (16) et radialement vers l'intérieur de la ceinture annulaire (32) ;

le corps de piston incluant une paire de panneaux de jupe (48) dépendant de la ceinture an-

nulaire (32) ;
 le corps de piston incluant une paire de bossages de goupille (38) espacés l'un de l'autre par les panneaux de jupe (48) et fournissant une 5
 paire d'alésages de goupille espacés latéralement (40) ;
 le corps de piston étant dépourvu d'une galerie de refroidissement le long de la surface de sous-calotte (24) ; et
 la surface de sous-calotte (24) ayant une superficie 10
 de surface bidimensionnelle exposée (Au2D), en vue le long de l'axe longitudinal central (30), variant de 25 à 60 pour cent d'une superficie de section transversale (AOD) définie 15
 par un diamètre extérieur maximum (OD) du corps de piston,
 dans lequel ledit corps de piston inclut des poches de sous-calotte (50) situées radialement vers l'extérieur desdits bossages de goupille 20
 (38), au moins une partie desdites poches de sous-calotte (50) forme au moins une partie de ladite surface de sous-calotte (24), et lesdites poches de sous-calotte (50) ont une superficie 25
 de surface bidimensionnelle totale (Ap2D) variant de 18 à 35 pour cent de ladite superficie de section transversale (AOD) définie par ledit diamètre extérieur maximum (OD) dudit corps 30
 de piston,
 dans lequel ladite surface de sous-calotte (24) est située le long dudit côté inférieur de ladite 30
 paroi supérieure (14) à une distance de ladite surface de combustion supérieure (16), et ladite distance n'est pas supérieure à 10 mm,
caractérisé en ce que
 ladite surface de sous-calotte (24) a un diamètre 35
 (Du) variant de 100 à 140 pour cent d'un diamètre (Dc) de ladite cuvette de combustion.

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FIG. 1

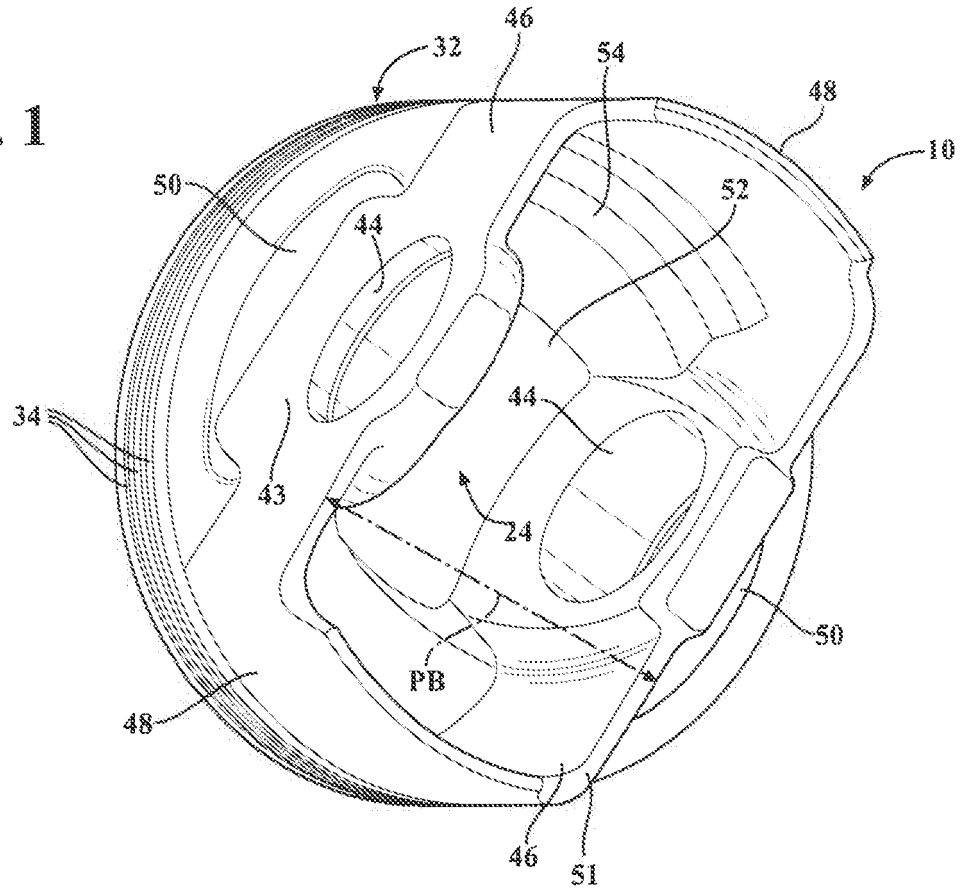
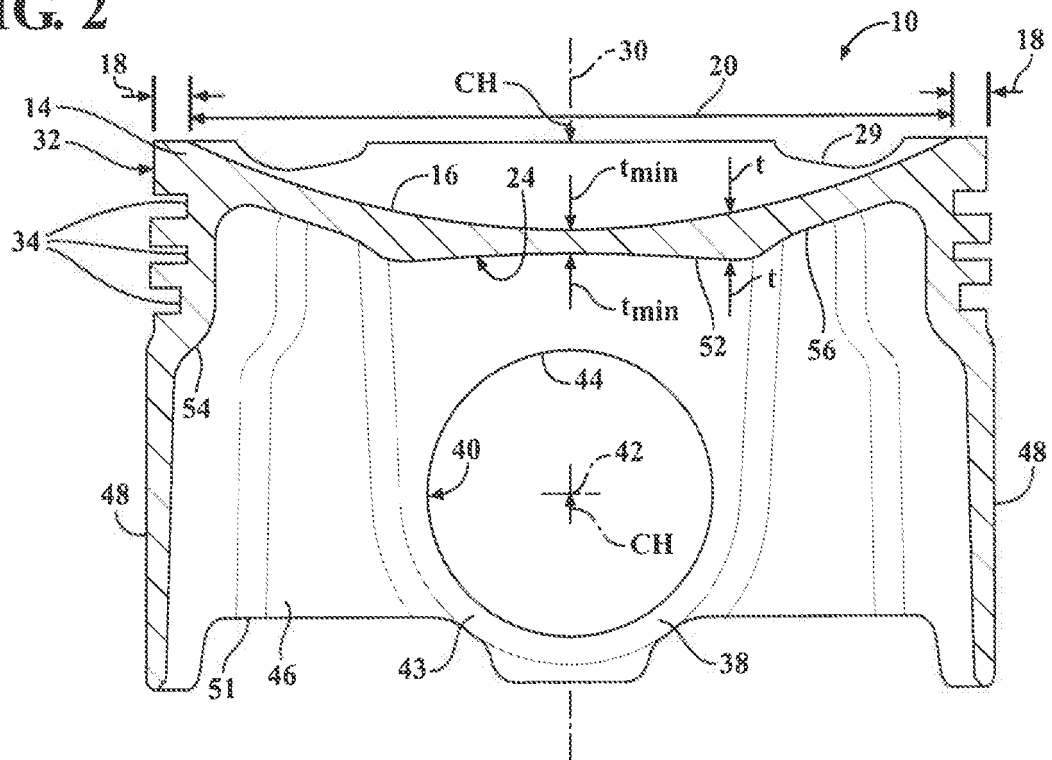


FIG. 2



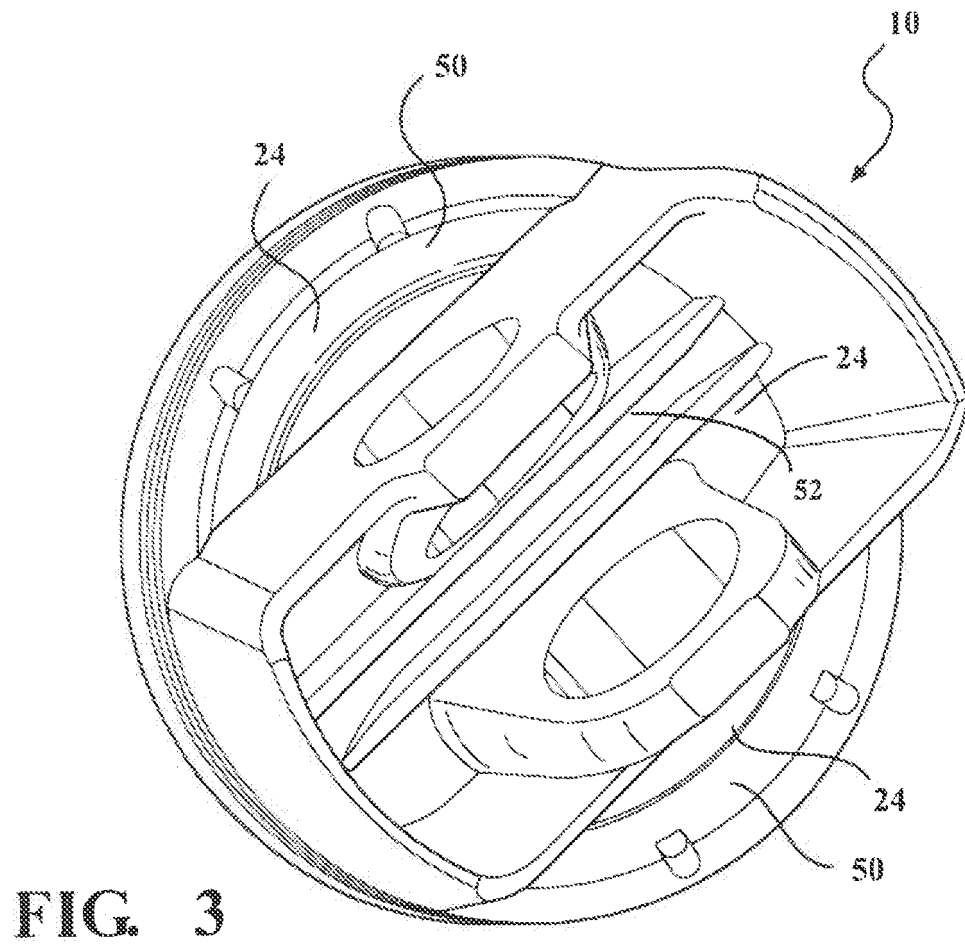


FIG. 4

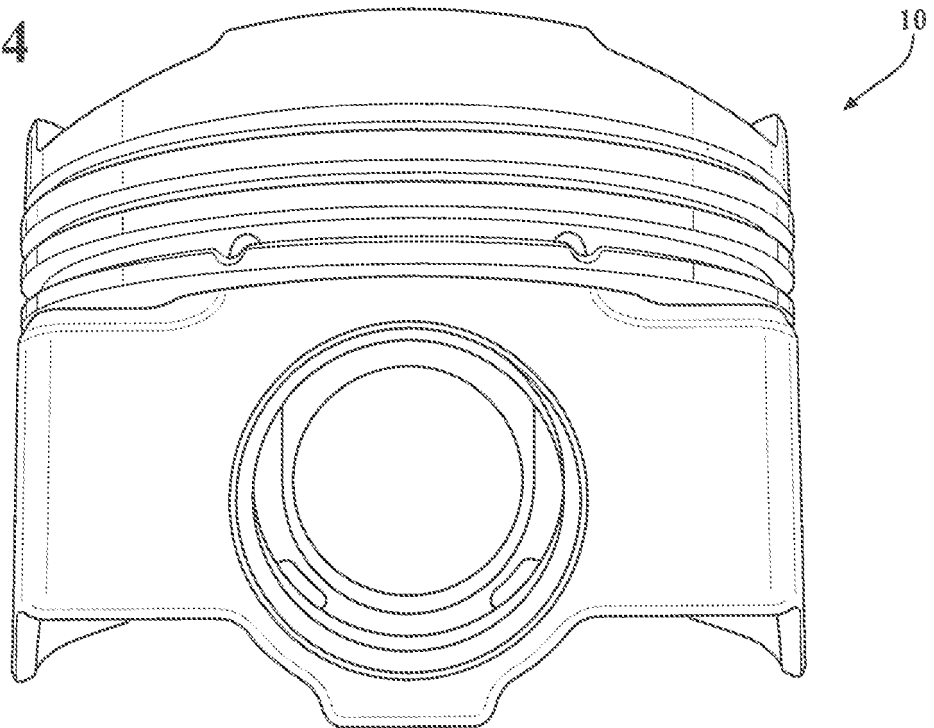


FIG. 5

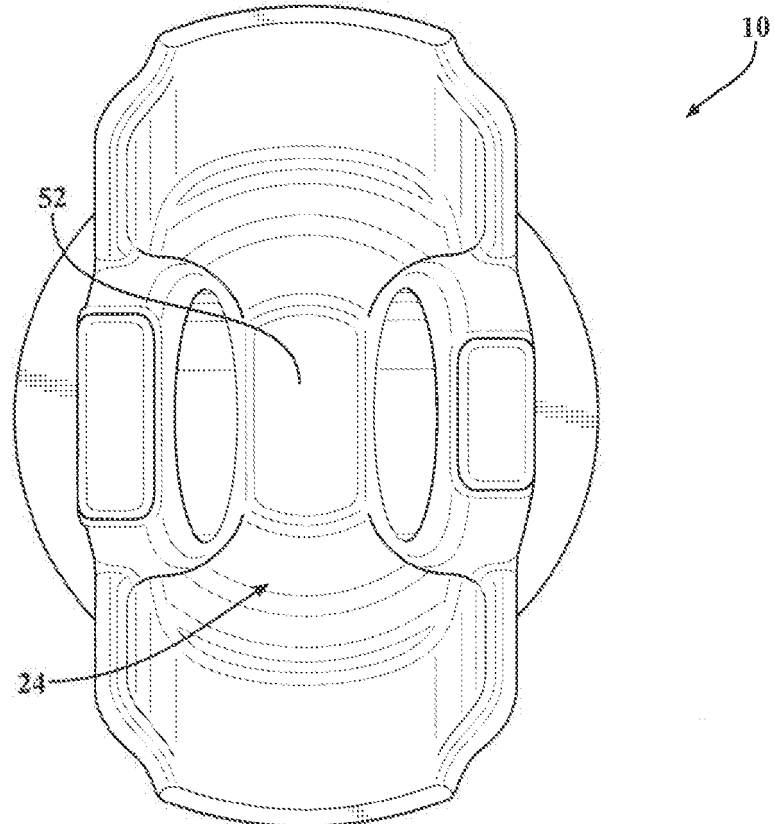


FIG. 6

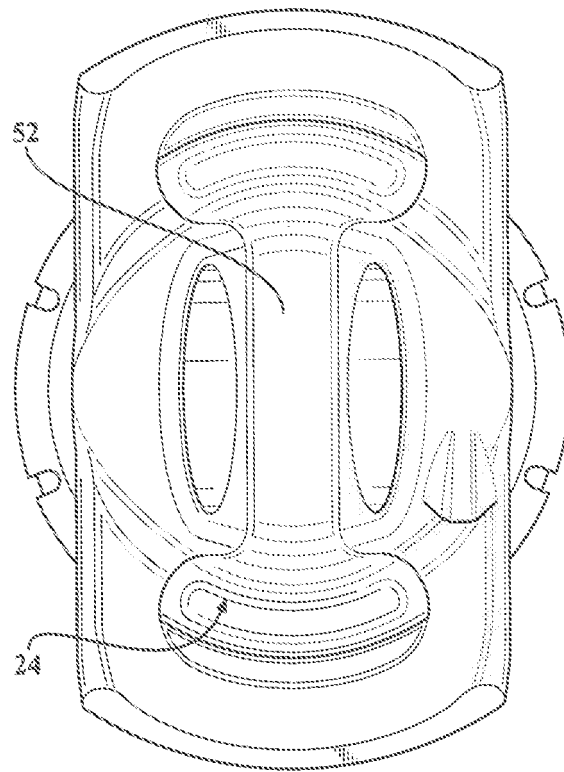


FIG. 7

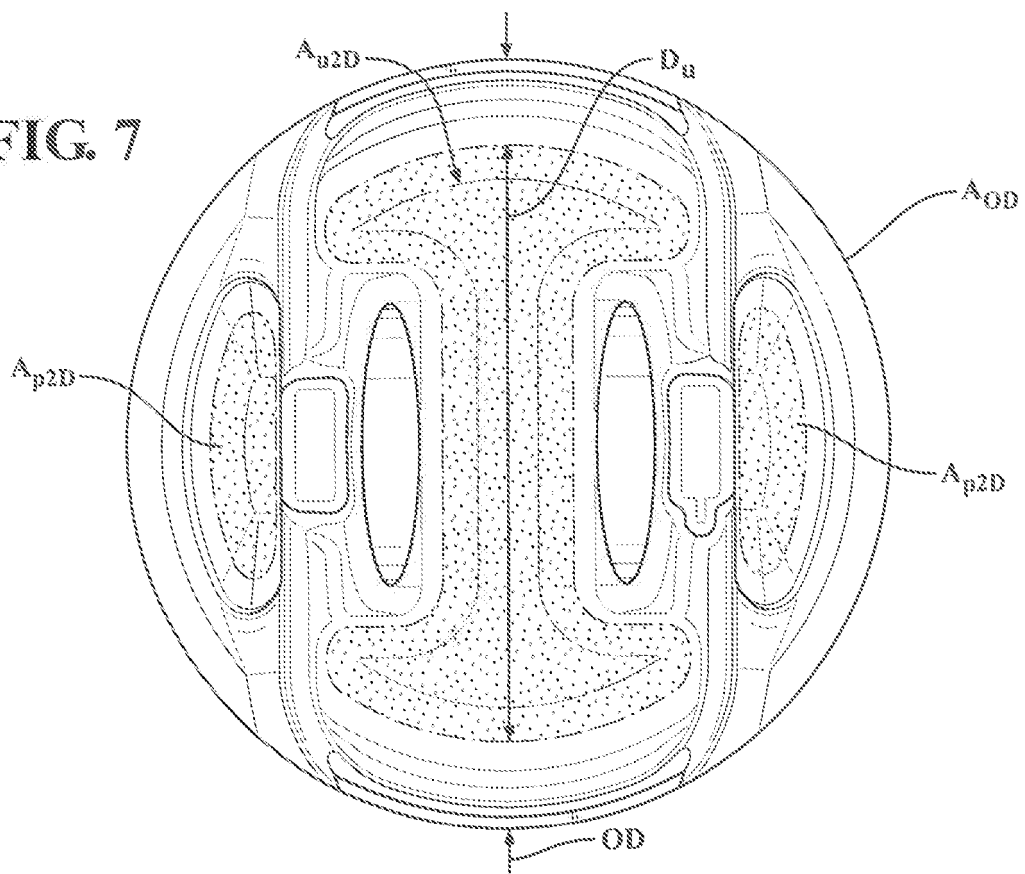


FIG. 8

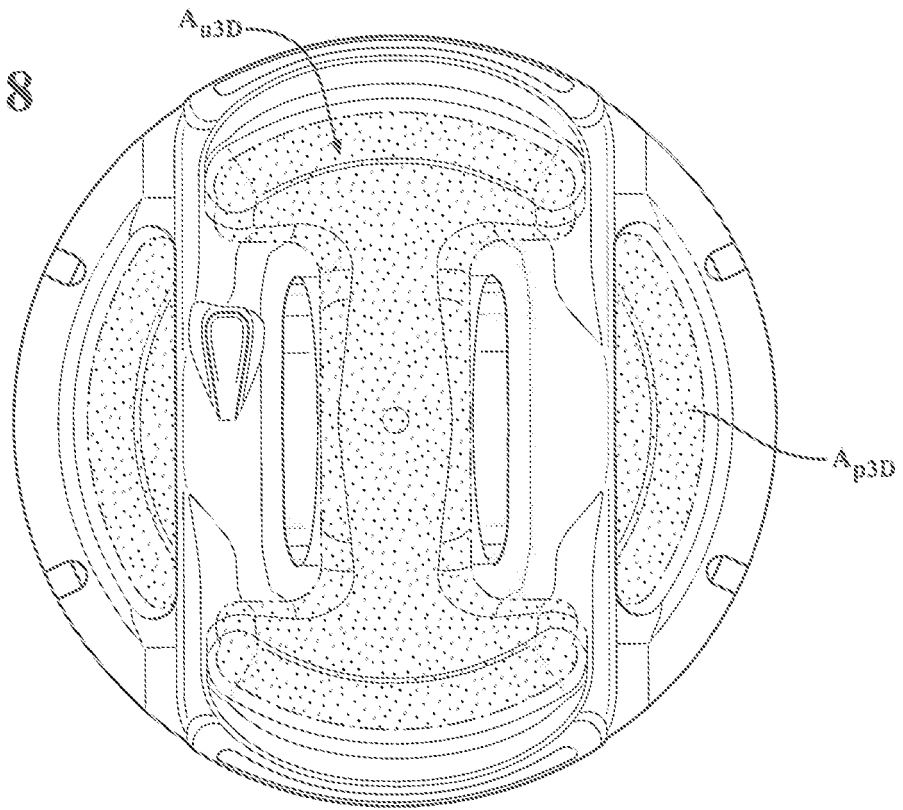


FIG. 9

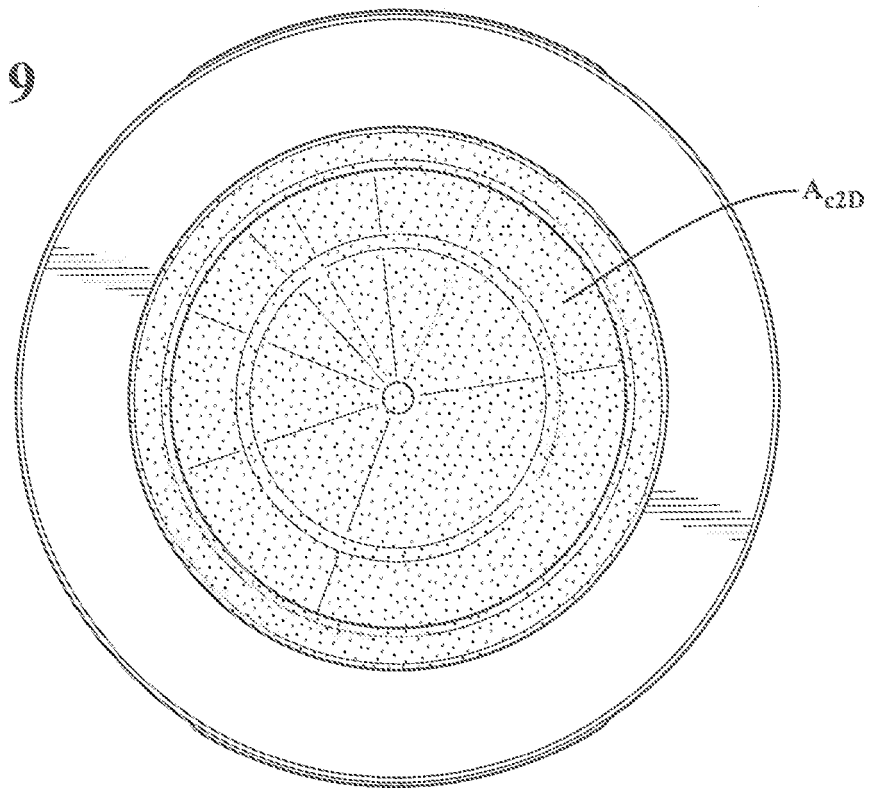


FIG. 10

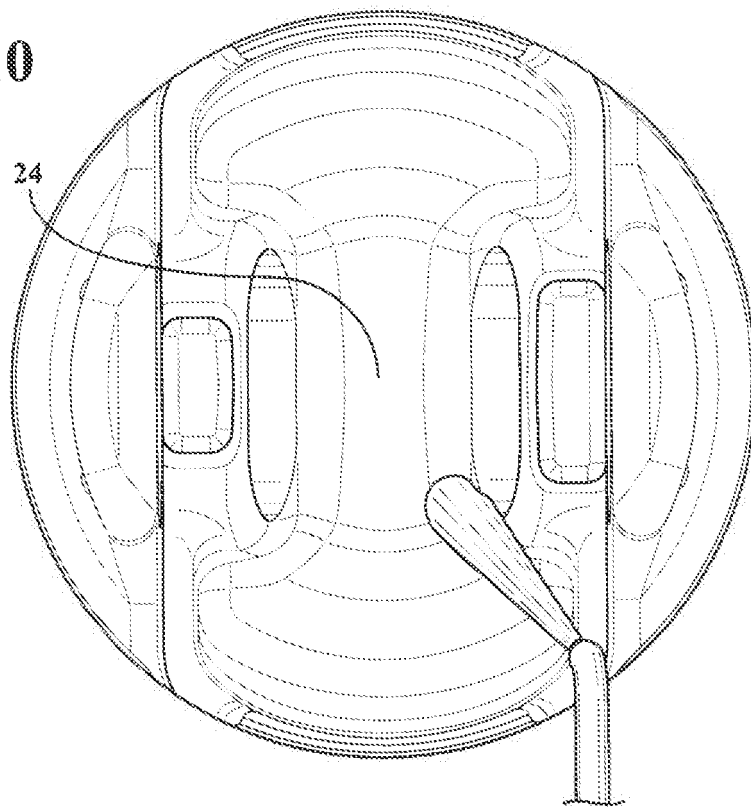


FIG. 11

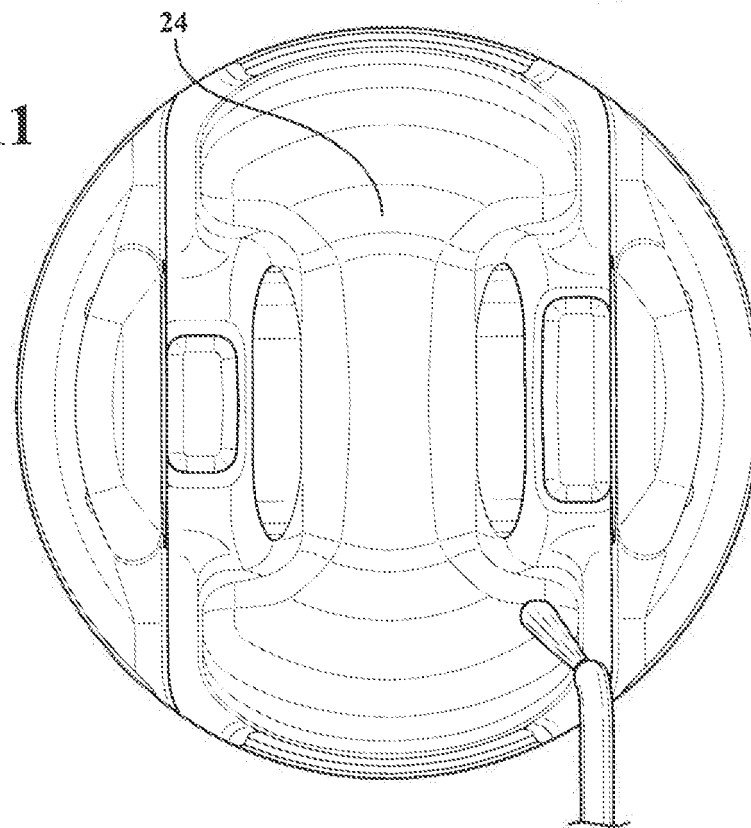


FIG. 12

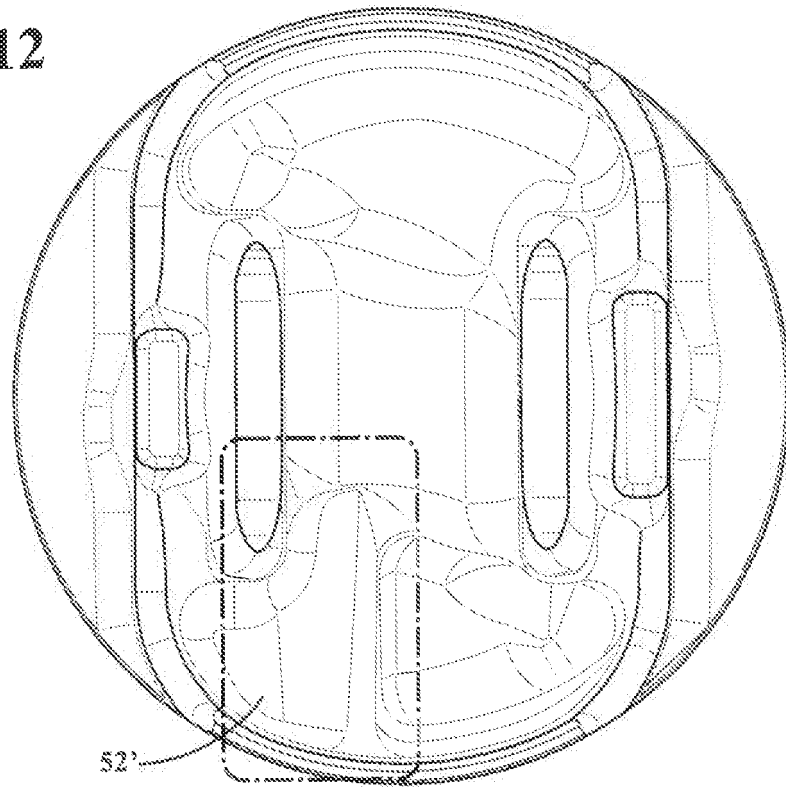
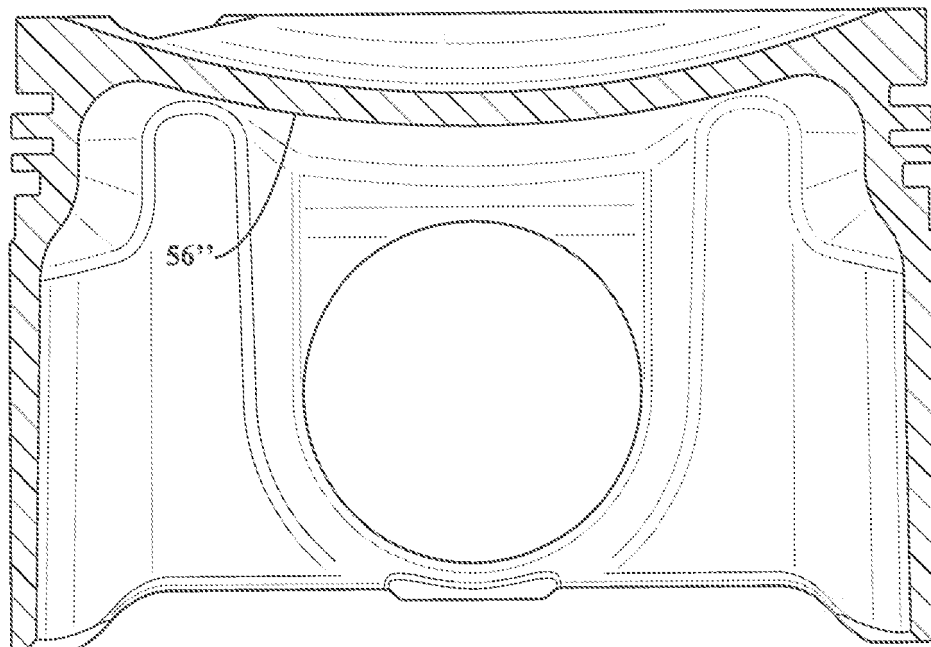


FIG. 13



REFERENCES CITED IN THE DESCRIPTION

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