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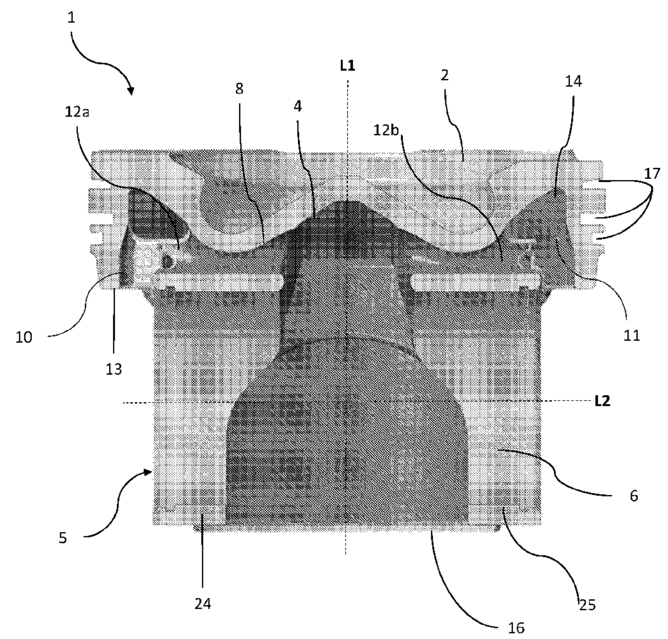

FIG. 1

(57) **Abstract:** Pistons for internal combustion engines have a cooling gallery, a pin bore, and a passthrough positioned between the cooling gallery and the pin bore to conduct cooling fluid through an undercrown region of the piston. A support structure for the crown is also provided. Internal combustion engines include an engine block with saddle jet nozzles mounted on bearing saddles of the engine block to direct cooling fluid toward a piston.

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[Continued on next page]

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INTERNAL COMBUSTION ENGINES AND PISTONS FOR INTERNAL COMBUSTION ENGINES

Cross-Reference to Related Application

[0001] The present application claims priority to, and the benefit of the filing date of, U.S. Provisional Application Ser. No. 63/508,308 filed on June 15, 2023, which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates generally to internal combustion engines and to pistons for internal combustion engines.

BACKGROUND

[0003] There is a continuing need for improvement in the fuel efficiency and durability of internal combustion engines. An approach to improving fuel efficiency is decreasing the weight of components of an internal combustion engine used to power a vehicle. Another approach to improving fuel efficiency is to design engine components that reject less heat from combustion to oil and coolant. Improvements are needed in structural piston designs to achieve the goals of having balanced cooling of piston parts and decreased weight of the piston, while also maintaining sufficient structural strength of the piston.

DISCLOSURE OF ILLUSTRATIVE EMBODIMENTS

[0004] For the purposes of clearly, concisely and exactly describing illustrative embodiments of the present disclosure, the manner, and process of making and using the same, and to enable the practice, making and use of the same, reference will now be made to certain examples, including those illustrated in the figures, and specific language will be used to describe the same. It shall nevertheless be understood that no limitation of the scope of the invention is thereby created and that the invention includes and protects such alterations, modifications, and further applications of the examples as would occur to one skilled in the art.

SUMMARY

[0005] The present disclosure includes a piston for an internal combustion engine. The piston includes a cooling gallery extending around the piston and a passthrough extending across the piston. An inlet to the cooling gallery and/or passthrough provides improved targeting of cooling fluid sprayed by a targeted saddle jet nozzle positioned on a main bearing housing. Other features of the piston are optimized for weight reduction while also lowering load and temperature distortions.

[0006] In an example, a piston for an internal combustion engine includes a body extending along a longitudinal axis. The body includes a cooling gallery for receiving a cooling fluid, a pin bore extending transversely to the longitudinal axis for receiving a piston pin, and a passthrough positioned between the cooling gallery and the pin bore to conduct cooling fluid through the body of the piston to the pin bore.

[0007] In an example, a piston for an internal combustion engine includes a body extending along a first longitudinal axis. The body includes a cooling gallery including an inlet for receiving a cooling fluid, and a pin bore extending through the body between opposite side openings along a second longitudinal axis that is transverse to the first longitudinal axis. The inlet of the cooling gallery lies on a plane define by the first longitudinal axis and the second longitudinal axis.

[0008] In an example, a piston for an internal combustion engine includes a crown, a pair of straps connected to and extending downwardly from the crown, and a skirt connected to the pair of straps. A gap formed between the crown and the skirt along the pair of straps.

[0009] In an example, an internal combustion engine includes a piston operable to reciprocally move along a range of motion between a top-dead-center position and a bottom-dead-center position. The piston includes a crown and an undercrown below the crown. The undercrown includes a cooling gallery having an inlet for receiving a cooling fluid. The piston includes a plurality of piston ring grooves on an exterior of the piston below the crown, and the piston ring grooves extend around a first longitudinal axis of the piston and are configured to receive piston rings. The piston includes a pin bore below the crown extending along second longitudinal axis transverse to the first longitudinal axis. Inlet of cooling gallery is located on the second longitudinal axis between the pin bore and the piston ring grooves. The internal combustion engine also includes a saddle jet nozzle mounted on the main bearing saddle of the

internal combustion engine. The saddle jet nozzle is configured to target a spray jet of cooling fluid into the inlet throughout at least a portion of the range of motion of the piston.

[0010] In an example, an internal combustion engine includes an engine block including a bearing saddle and a main bearing shell mounted on the bearing saddle. The bearing saddle includes a cavity, and the engine block further including an oil gallery fluidly connected to the cavity with a bore extending through the block to the cavity. The main bearing shell is mounted on the bearing saddle. The main bearing shell forms a seal around the cavity in the bearing saddle. A saddle jet nozzle is mounted to the bearing saddle. The saddle jet nozzle is in fluid communication with the cavity in order to receive oil from the oil gallery.

[0011] In an example, a piston for an internal combustion engine includes a crown and an undercrown below the crown. The undercrown defines a cooling gallery below the crown. The piston includes a first rib and a second rib spaced from the first rib. The first and second ribs each connect the crown to the undercrown to support the crown. The first rib is separated from the second rib by a passthrough that is in fluid communication with the cooling gallery.

[0012] In an example, a piston for an internal combustion engine includes a crown and an undercrown below the crown. The undercrown defines a cooling gallery below the crown. The piston includes a first pin boss strap and a second pin boss strap on opposite sides of the crown form a pin bore for receiving a piston pin. The piston includes a support structure connecting the crown to the first pin boss strap and the second pin boss strap. The piston includes a skirt connected to the first pin boss strap and the second pin boss strap. The support structure includes a first cutout where the skirt is connected to the first pin boss strap and a second cutout where the skirt is connected to the second pin boss strap.

[0013] This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter. Further examples, forms, objects, features, advantages, aspects, and benefits shall become apparent from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a cross sectional view of a piston showing crown and undercrown portions of the piston according to an example embodiment.

[0015] FIG. 2 is another cross sectional view of the piston of FIG. 1 showing the undercrown portion.

[0016] FIG. 3 is a side elevation view of an embodiment of the piston of FIG. 1.

[0017] FIG. 4 is another cross sectional view of the piston of FIG. 1 or FIG. 3 showing an interior structure of the crown and the region of a pin boss.

[0018] FIG. 5 is a perspective view looking toward an underside of the piston of FIG. 1.

[0019] FIG. 6 is a schematic diagram illustrating a cross sectional view of a portion of the piston of FIG. 1 in a state of use.

[0020] FIG. 7 is an enlarged portion of the view of FIG. 6 showing details of a trajectory of a spray jet with a piston in a top-dead-center (TDC) position.

[0021] FIG. 8 is an enlarged portion of the view of FIG. 6 showing details of a trajectory of a spray jet with a piston in a bottom-dead-center (BDC) position.

[0022] FIG. 9 is an oblique perspective side view of undercrown and pin boss regions of the piston in the TDC position as illustrated in FIG. 7.

[0023] FIG. 10 is an enlarged portion of FIG. 7 showing details of a saddle jet nozzle.

[0024] FIG. 11 is a front view of internal structural features of the piston corresponding to FIGs. 1-4.

[0025] FIG. 12 is a cross sectional view of an outer structure for the piston to receive the internal structural features in FIG. 11.

[0026] FIG. 13 is an oblique perspective side view of the piston according to examples in FIGs. 11-12.

[0027] FIG. 14 is a schematic sectional view of the piston depicting examples of piston rib structures.

[0028] FIG. 15 is another schematic sectional view of the piston depicting examples of piston rib structures.

[0029] FIG. 16 is a sectional view through a cooling gallery inlet, depicting a perspective view of a ceiling wall of a cooling gallery.

[0030] FIG. 17 is a cross-sectional diagram representing a cooling gallery of the piston according to an example embodiment.

[0031] FIG. 18 is a perspective view of example embodiment of a skirt design.

[0032] FIG. 19 is a perspective view of another example embodiment of a skirt design.

[0033] FIG. 20 is a perspective view of another example embodiment of a skirt design.

[0034] FIG. 21 is a perspective view of another example embodiment of a skirt design.

[0035] FIG. 22 is a diagram representing cross-sectional views of example rib designs.

[0036] FIG. 23 is a schematic diagram illustrating a portion of an oil feed in an engine block in accord with an example embodiment.

[0037] FIG. 24 is another schematic diagram of the oil feed and engine block of FIG. 23.

[0038] FIG. 25 is a schematic diagram showing a portion of a main bearing saddle of the engine block of FIG. 23.

[0039] FIG. 26 is a schematic diagram illustrating an example saddle jet layout.

[0040] FIG. 27 is a schematic diagram illustrating another example saddle jet layout.

[0041] FIG. 28 is a schematic diagram illustrating another example saddle jet layout.

[0042] FIG. 29 is a schematic diagram illustrating another example saddle jet layout.

[0043] FIG. 30 is a cross sectional view of another embodiment piston showing crown and undercrown portions of the piston.

[0044] FIG. 31 is another cross-sectional view of the piston of FIG. 30 illustrating the ribs and passthrough.

[0045] FIG. 32 is another cross-sectional view of the piston of FIG. 30 illustrating the ribs and passthrough.

[0046] FIG. 33 is a perspective view looking toward an underside of the piston of FIG. 30.

[0047] FIG. 34 is a diagram illustrating another embodiment saddle jet configuration.

[0048] FIG. 35 is a perspective view illustrating another embodiment piston.

[0049] FIG. 36 is a sectional view of the piston of FIG. 35.

[0050] FIG. 37 is a schematic view of another embodiment oil feed in the engine block.

[0051] FIG. 38 is another view of the oil feed and engine block of FIG. 37.

[0052] FIG. 39 is another view of the oil feed and engine block of FIG. 37.

[0053] FIG. 40 is a schematic diagram of an internal combustion engine.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0054] The present disclosure relates to an internal combustion engine and a piston for the same. FIG. 40 includes a schematic diagram of an internal combustion engine 52 that includes a block 34. Block 34 includes one or more combustion chambers 54, each housing a piston 1 for reciprocating movement therein. Block 34 also includes at least one bearing saddle 18 adjacent each combustion chamber 54 and crankcase 56. Saddle 18 includes a saddle jet nozzle 20 mounted thereto to receive cooling fluid, such as oil, and to direct the cooling fluid in a spray 22 toward piston 1 in the combustion chamber 54. Piston 1 includes an inlet 10 to a cooling gallery 14, and the cooling fluid spray 22 is targeted to be received in cooling gallery inlet 10 through movement of piston 1 between top-dead-center (TDC) and bottom-dead-center (BDC) positions.

[0055] In an example, piston 1 for internal combustion engine 52 includes a body 5 extending along a longitudinal axis L1. The body 5 includes cooling gallery 14 for receiving a cooling fluid, a pin bore 6 extending transversely to the longitudinal axis L1 for receiving a piston pin, and a passthrough 8 positioned between the cooling gallery 14 and the pin bore 6 to conduct cooling fluid through the body 5 of the piston 1 to the pin bore 6.

[0056] In an example, piston 1 for internal combustion engine 52 includes body 5 extending along a first longitudinal axis L1. The body 5 includes cooling gallery 14 including inlet 10 for receiving a cooling fluid, and pin bore 6 extending through the body 5 along a second longitudinal axis L2 that is transverse to the first longitudinal axis L1. The inlet 10 of the cooling gallery 14 lies on a plane define by the first longitudinal axis L1 and the second longitudinal axis L2.

[0057] In an example, piston 1 for internal combustion engine 52 includes a crown 2, a pair of straps 24, 25 connected to and extending downwardly from the crown 2, and a skirt 16 connected to the pair of straps 24, 25. A gap 30 formed between the crown 2 and the skirt 16 along the pair of straps 24, 25.

[0058] In an example, an internal combustion engine 52 includes piston 1 operable to reciprocally move along a range of motion between a top-dead-center position and a bottom-dead-center position. Piston 1 includes a crown 2 and an undercrown 4 below crown 2. Undercrown 4 includes cooling gallery 14 having inlet 10 for receiving a cooling fluid. Piston 1 includes a plurality of piston ring grooves 17 on an exterior of piston 1 below crown 2, and piston ring grooves 17 extend around first longitudinal axis L1 of piston 1 and are configured to receive piston rings. Piston 1 includes pin bore 6 below crown 2 extending along second longitudinal axis L2 transverse to first longitudinal axis L1. Inlet 10 of cooling gallery 14 is located on second longitudinal axis L2 between pin bore 10 and piston ring grooves 17. Internal combustion engine 52 also includes a saddle jet nozzle 20 mounted on bearing saddle 18 of internal combustion engine 52. Saddle jet nozzle 20 is configured to target a spray jet 22 of cooling fluid into inlet 10 throughout at least a portion of the range of motion of piston 1.

[0059] In an example, internal combustion engine 52 includes an engine block 34 including bearing saddle 18 and a main bearing shell 44 mounted on bearing saddle 18. Bearing saddle 18 includes a cavity 46, and engine block 34 further including an oil gallery fluidly 36 connected to cavity 46 with a bore 42 extending through block 34 to cavity 46. Main bearing shell 44 is mounted on bearing saddle 18. Main bearing shell 44 forms a seal around cavity 46 in bearing saddle 18. Saddle jet nozzle 20 is mounted to bearing saddle 18. Saddle jet nozzle 20 is in fluid communication with cavity 46 in order to receive oil from oil gallery 36.

[0060] In an example, piston 1 for internal combustion engine 52 includes crown 2 and undercrown 4 below crown 2. Undercrown 4 defines cooling gallery 14 below crown 2. Piston includes 1 a first rib 28 and a second rib 29 spaced from first rib 28. The first and second ribs 28, 29 each connect crown 2 to undercrown 4 to support crown 2. First rib 28 is separated from second rib 29 by passthrough 8 that is in fluid communication with cooling gallery 14.

[0061] In an example, piston 1 for internal combustion engine 52 includes crown 2 and undercrown 4 below crown 2. Undercrown 4 defines cooling gallery 14 below crown 2. Piston 1 includes a first pin boss strap 24 and a second pin boss strap 25 on opposite sides of crown 2 that form pin bore 6 for receiving a piston pin. Piston 1 includes a support structure 58 connecting crown 2 to first pin boss strap 24 and second pin boss strap 25. Piston 1 includes a skirt 16 connected to first pin boss strap 24 and second pin boss strap 25. Support structure 58 includes a first cutout 48 where skirt 16 is connected to first pin boss strap 24 and a second cutout 49 where skirt 16 is connected to second pin boss strap 25.

[0062] FIG. 1 is a diagram illustrating an axial cross section of a body 5 of piston 1. Body 5 includes crown 2 and a skirt 16 located below crown 2. The cross sectional view in FIG. 1 is taken along a longitudinal axis L1 of body 5 that extends through crown 2 and skirt 16. Piston 1 also includes an undercrown 4 positioned along the underside of crown 2 that is configured to receive cooling fluid to provide cooling of piston 1 during engine operation.

[0063] The skirt 16 includes a pin bore 6 for receiving insertion of a piston pin (not shown) into the piston 1 that couples piston 1 to a connecting rod (not shown). Within the undercrown 4, between crown 2 and the pin bore 6, is provided passthrough 8 in a region of the pin boss 9. The pin boss 9 may be seen, for example, in FIGs. 4 and 5, discussed below.

[0064] In an example embodiment, the passthrough 8 is formed as an aperture or bore that is configured to extend between an outer surface of the piston 1, and/or between an inlet 10 and an outlet 11 of the cooling gallery 14, within the undercrown 4 of piston 1. In an embodiment, the passthrough 8 is positioned to extend in a direction that is transverse to longitudinal axis L1 of piston body 5. In an embodiment, the passthrough 8 is positioned to extend in a direction that is orthogonal to longitudinal axis L1 of piston body 5. In an embodiment, passthrough 8 extends parallel to a longitudinal axis L2 of a piston pin to be inserted in the pin bore 6. In an embodiment, passthrough 8 extends parallel to a longitudinal axis L2 and intersect longitudinal axis L1.

[0065] Passthrough 8 provides an oil passage and also reduces the weight of piston. In the illustrated embodiment, passthrough 8 includes a circular shape that trumpets at the end openings of passthrough 8. However, the end openings can be circular. Other shapes for passthrough 8 are also contemplated and not precluded, including oval shapes, elliptical shapes, non-circular shapes, etc.

[0066] Crown 2 includes a deflecting 13 extending along inlet 10 at an outer perimeter of body 5. Deflecting portion 13 may extend entirely around the perimeter of body 5, along only inlet 10 and outlet 11 as shown in FIG. 1, or only along inlet 10. Deflecting portion 13 includes an inner surface along inlet 10 that is angled toward longitudinal axis L1 to facilitate directing a spray of cooling fluid into cooling gallery 14.

[0067] The cooling gallery 14 is supplied with cooling fluid with the spray of the fluid directed toward the inlet 10 of the gallery 14, either by the configuration of the spray nozzle, deflecting portion 13, or a combination thereof. The passthrough 8 is in fluid communication with inlet 10 and accommodates or conduct a flow of cooling fluid through the undercrown 4 below crown 2. The passthrough 8 has inlets/outlets 12a, 12b that are located near the inlet 10 and outlet 11, respectively of cooling gallery 14 of undercrown 4. The inlets/outlets 12a, 12b permit the introduction of cooling fluid into the passthrough 8. It is noted that the inlets/outlets 12a, 12b also serve to outlet cooling fluid exiting from the passthrough 8.

[0068] The passthrough 8 provides a benefit in that some cooling fluid that is sprayed near a gallery inlet 10 does not enter the cooling gallery 14 but is directed into passthrough 8 through and across the undercrown 4. In addition, cooling fluid that is leaving outlet 11 of the cooling gallery 14 may travel via the passthrough 8 through and across the undercrown 4. The passthrough 8 thus conducts cooling fluid in the undercrown 4 in a manner that aids cooling of the region of piston 1 centered on longitudinal axis L1 around undercrown 4, and cooling and lubrication of the joint between the piston pin and the pin bore 6. Forming piston 1 with passthrough 8, in addition to providing flow of cooling fluid through the passthrough 8, offers the beneficial effect of reducing weight of piston 1. The passage of cooling fluid through the passthrough 8 also lowers heat transfer from the crown 2 to the undercrown 4 and pin boss 9. Passthrough 8 forms additional surface area for cooling in the region of the crown 2 and undercrown 4 than is provided by cooling gallery 14 alone.

[0069] FIG. 2 is a cross sectional view of the undercrown portion 4, taken along a line orthogonal to the longitudinal axis L1, to show interior structure of body 5. FIG. 2 shows the positions of inlet 10 and outlet 11 of the cooling gallery 14 adjacent an outer perimeter of crown 2, and opening in a distal or downward direction toward the skirt 16 to receive the spray of cooling fluid. FIG. 2 also shows the positions of the inlets/outlets 12a, 12b to the passthrough 8 adjacent to and in fluid communication with inlet 10 and outlet 11. Cooling gallery 14 extends around longitudinal axis L1 adjacent to the outer perimeter of crown 2. Passthrough 8 extends radially inwardly from opposites of cooling gallery 14 to opposite sides of pin bore 6.

[0070] In the illustrated embodiment, inlet 10, outlet 11, and inlet/outlets 12a, 12b are aligned along longitudinal axis L2, on opposite ends of the pin bore 6. In an embodiment, inlet 10, outlet 11, and inlet/outlets 12a, 12b are aligned in a plane define by longitudinal axis L1 and longitudinal axis L2, on opposite ends of the pin bore 6. These alignments provide fluid communication between the inlet 10 and inlet/outlet 12a, and between the outlet 11 and inlet/outlet 12b to enables use of the cooling fluid for cooling through the gallery 14 and in the undercrown 4.

[0071] FIG. 3 is a side elevation view of an embodiment of the piston 1 showing one of the passthrough inlet/outlets 12b positioned between the crown region 2 and the pin bore 6. In the

FIG. 4 embodiment, deflecting portion 13 is not shown adjacent outlet 11 of the cooling gallery 14.

[0072] FIG. 4 is a sectional view orthogonal to the section view of FIG. 1, showing the interior structure of the crown 2 and pin boss 9 around one side opening of the pin bore 6. The passthrough 8 is located between crown 2 and pin boss 9, and opens into pin bore on both sides of longitudinal axis L1.

[0073] FIGs. 1-4 show the position of the passthrough inlets/outlets 12a, 12b in relation to the cooling gallery 14 and its inlet 10 and outlet 11. In an example embodiment, the cooling gallery inlet 10 is positioned to receive a vertical or nearly vertical targeted spray of cooling flood from a saddle jet located on saddle 18. The disclosed arrangement may also employ a shorter piston pin, to permit the inlet 10 to be positioned in alignment along longitudinal axis L2 as shown for receipt of the targeted, nearly vertical, cooling fluid spray. The structure of this example is in contrast to prior designs, wherein traditional inlet location constrains skirt design.

[0074] The pin bore 6 includes a first opening formed by a first pin boss strap 24 on a first side of the body 5 of the piston 1, and a second opening formed by a second pin boss strap 25 on a second side of the body 5 of the piston 1 opposite the first side. Inlet 10 to cooling gallery 14 is positioned adjacent the first opening of the pin bore 6 on the first side of the body 5 of the piston 1. The inlet/outlet 12a of passthrough 8 is in fluid communication with the inlet 10 of the cooling gallery adjacent the first opening of the pin bore 6 on the first side of the body 5.

[0075] FIG. 5 is a perspective view of the piston 1 as shown in FIG. 1. The view is taken from a lower side of the undercrown region 4 to show the opening of passthrough 8 into pin bore 6, and the relative position of the inlet/outlet 12a and inlet 10 to cooling gallery 14.

[0076] To illustrate the piston of the example of FIGs. 1-4 in use, FIG. 6 is a schematic diagram illustrating a cross sectional view of a portion of piston 1, in an operating environment. The view is taken along a line parallel to the longitudinal axis L1 of piston 1. Piston 1 is shown in two positions relative to a main bearing housing of the engine. The upper position is TDC and the lower position is BDC. A piston cooling spray nozzle 20 of a saddle jet type is provided on saddle 18 to deliver a spray jet 22 of a cooling fluid to cool piston 1. The cooling fluid for the spray jet 22 is delivered from an oil gallery in the block, into the saddle jet nozzle 20.

[0077] The saddle jet nozzle 20 is positioned to deliver the pressurized spray jet 22 of cooling fluid into the cooling gallery 14 positioned within undercrown 4 of crown 2 of the piston

1. As illustrated in FIG. 6, the spray jet 22 trajectory impinges into inlet 10 of the cooling gallery 14 at a position proximal to the inlet/outlet 12a of the passthrough 8. Thus, the example embodiment directs the spray jet 22 trajectory into the inlet 12 of the passthrough 8, as well as to the gallery inlet 10. The example comprises saddle jet nozzle 20 positioned and configured to deliver the spray jet 22 that is specifically targeted directly to gallery inlet 10 through the range of motion from TDC to BDC.

[0078] An example comprises saddle jet nozzle 20 targeted to deliver the spray jet 22 in a vertical or nearly vertical direction (that is, parallel or nearly parallel to longitudinal axis L1 of the piston 1), directly into gallery inlet 10. The piston 1 includes gallery inlet 10 and passthrough inlet/outlet 12a that are configured and positioned in the piston 1 to receive the directly targeted, and/or vertical or nearly vertical, spray jet 22 from the saddle jet nozzle 20. In an embodiment, spray jet 22 is vertical and oriented at a 0 degree angle relative to vertical. In an embodiment, spray jet 22 is inclined at an angle up to 5 degrees from vertical. Other orientations relative to vertical are also contemplated.

[0079] In an embodiment, saddle jet 20 extends from bearing saddle 18 toward piston 1. Saddle jet 20 has an orientation that ranges from a parallel orientation relative to the first longitudinal axis L1 to 5 degrees relative to first longitudinal axis L1. In an embodiment, saddle jet nozzle 20 is configured to target the spray jet 22 of cooling fluid into the inlet 10 throughout an entire range of motion of piston 1.

[0080] FIGs. 7 and 8 illustrate a further example wherein the piston crown 2 and undercrown 4 are cooled with a spray from targeted saddle jet nozzle 20. FIG. 7 is an enlarged portion of the view of FIG. 7 showing details of the trajectory of the spray jet 22 when the piston 1 is in its upper TDC (top dead center) position. FIG. 8 is an enlarged portion of the view of FIG. 6 showing details of the trajectory of the spray jet 22 when the piston 1 is in its lower BDC (bottom dead center) position.

[0081] In FIG. 7, at or near the TDC position of the piston 1, the major portion of the spray jet 22 trajectory intersects with inlet 10 of cooling gallery 14 at a position radially inward of the position at which the trajectory intersects with the inlet 10 when the piston 1 is in its lower BDC position. Also as seen in FIG. 7, a portion of the spray jet 22 trajectory intersects with the inlet/outlet 12a of the passthrough 8. In contrast to known saddle jet designs that spray oil generally upwards, the targeted saddle jet of the example supplies oil directly into cooling gallery 14. Also in contrast to prior designs, the targeted saddle jet nozzle 20 simultaneously supplies cooling fluid into inlet/outlet 12a of passthrough 8. The example provides a targeted and accurately aimed saddle jet nozzle 20, providing a highly targeted spray plume.

[0082] FIGs. 7 and 8 show local configurations in the example designed to maximize the amount of cooling flood captured from the spray jet 22 into the cooling gallery 14. FIG. 8 shows the spray jet 22 targeted toward with the extended outer wall of crown 2 forming deflecting portion 13 near the inlet 10, as the spray is directed closer to the cooling gallery outer diameter. FIG. 7 shows the spray targeted more towards the cooling gallery inner diameter, where a local removal of pin boss material, near where the pin boss 9, passthrough 8, and retaining clip meet, allows for more cooling fluid capture into the cooling gallery 14. In an embodiment, undercrown 4 includes a downwardly extended outer wall section forming deflecting portion 13 adjacent to inlet 10. Deflecting portion 13 assists in cooling fluid capture by inlet 10 at or near bottom-dead-center of piston 1.

[0083] In certain examples shown herein, the cooling gallery inlet 10 is configured and positioned so that the nozzle 20 of the saddle jet is specifically targeted to provide spray plume directly to the cooling gallery inlet 10. In certain examples as shown, the nozzle 20 may be minimally angled from vertical (that is, angled relative to a longitudinal axis L1 of the piston 1), and therefore the nozzle design and angle may be configured so that the plume may hit its intended target, the cooling gallery inlet 10, throughout the range of motion of the piston between TDC and BDC. It may be appreciated that the targeted saddle jet cooling nozzle 20 of the example produces a high quality spray plume that hits its target so as to directly reach the cooling gallery.

[0084] FIG. 9 is an oblique perspective side view of the undercrown 4 and pin boss 9 regions of the piston 1 in its TDC position as illustrated in FIG. 7. The region is shown with oil spray jet 22 directed by saddle jet nozzle 20. At this point in the travel of the piston 1, the trajectory of the spray jet 22 intersects with inlet 10 of cooling gallery 14 at a point radially inwardly within the cooling gallery inlet 10, that is, at a point nearer to the cooling gallery 14 inner diameter wall than to the cooling gallery 14 outer diameter wall.

[0085] FIG. 9 shows structural features wherein local geometry of the spray access point is improved to aid capture of the cooling fluid sprayed into inlet 10 and inlet/outlet 12a. The structural features include a pin boss strap 24, and the pin boss strap 24 includes a scallop 26 at the upper end of pin boss strap 24. Scallop 26 may be formed in the nature of an indented or recessed portion in an outer side of the strap 24 that extends along longitudinal axis L1. The scallop 26 is formed near the point where the spray jet 22 path meets with the area of the pin boss strap 24. The recessed scallop 26 portion of the strap 24 allows passage of the spray jet 22 to reach the cooling gallery inlet 10 and/or inlet/outlet 12a, even at TDC when the spray jet 22 intersects with the cooling gallery inlet 10 at a point near the inner wall of the cooling gallery inlet 10.

[0086] In an embodiment, piston 1 includes one or more pin boss straps 24, 25 extending around pin bore 8. At least one of the pin boss straps 24, 25 includes scallop 26 at an upper end of the pin boss strap 24, 25 and adjacent to inlet 10 to assist in cooling fluid capture by inlet 10 at or near top-dead-center of piston 1.

[0087] FIG. 10 is an enlarged portion of the view of FIG. 7 showing details of the saddle jet nozzle 20 of FIG. 6. The present disclose eliminates a need for a J-jet style piston cooling nozzle. An embodiment of a saddle jet nozzle 20 is provided in U.S. Provisional Patent App. Ser. No. 63/492,383 filed March 27, 2023, which is incorporated herein by reference.

[0088] FIGs. 11 and 12 illustrate details of internal structures of the piston 1. FIG. 11 is a schematic view of internal structural features of the piston. FIG. 13 shows a cross sectional view of the piston 1 taken along a line parallel to the longitudinal axis L1 of the piston 1, rotated 90 degrees from the view of FIG. 11. FIGs. 11 and 12 show ribs 28, 29 connected to crown 2 and to the region abutting the pin boss 9. Ribs 28, 29 slope inwardly toward longitudinal L1 from crown 2 to each pin boss 9.

[0089] Ribs 28, 29 serve as supports and connectors between the crown 2 and the portion of the undercrown 4 that abuts the pin boss 9. The ribs 28, 29 are undercut so that they avoid skirt 16, sloping inwardly and downwardly from a point at which the ribs 28, 29 connect to and abut the lower side (as depicted in FIGs. 11-12) of the crown 2 towards the pin boss 9. The support ribs 28, 29 are arched between the pin bosses 9 forming the opposite sides of pin bore 6. Ribs 28, 29 may be formed with or without webbing, and may taper cylindrically, narrowing toward the lower side of piston 1 as depicted in FIGs. 11-12, reducing the weight of piston 1 while providing increased strength.

[0090] The ribs 28, 29 provide internal support between the crown 2 and pin boss 9 region, while also leaving one or more open gaps 30 between the skirt 16 and the crown 2. The gaps 30 help to reduce the transfer of load to the skirt from cylinder pressure on the crown 2. The gaps 30 also help to reduce the transfer of heat and distortion from the crown 2 to the skirt 16. The gaps 30 also help to reduce overall weight of the piston 1. Thus, the examples herein incorporating the ribs 28, 29 and gaps 30 relieve the skirt 16 of at least some of the pressure loads. In turn, the reduced pressure loading relieves thermal and mechanical load-based distortion of the skirt 16. The ribs 28, 29 also allow the skirt 16 to be disconnected from the crown 2, allowing for a more geometrically stable skirt design, while providing a supported crown 2.

[0091] FIG. 13 shows an oblique perspective side view of the piston 1 according to the FIGs. 11 and 12 example. Skirt 16 is designated as skirt segments 16a, 16b that extend only partially around portions of the circumference of the piston 1. In this manner, the skirt region is undercut or omitted in front of the outer side of the pin boss strap 24, as may be contrasted with a skirt that would extend almost all or all the way around the circumference of the piston in the skirt region. The undercut permits reduction of materials needed to manufacture the piston 1, and reduction of weight of the manufactured piston 1. The undercut also facilitates the spray jet 22 in reaching the gallery inlet 10 and the inlet/outlet 12a to the passthrough 8 as described above.

[0092] FIGs. 14-15 show schematic diagrams depicting an example of the piston 1 wherein ribs 28, 29 are provided that extend to support the crown 2 while forming gaps 30. The ribs 28, 29 have outwardly or convexly curved outer surfaces. Ribs 28, 29 are also spaced radially inwardly from skirt 16. In an embodiment, first pin boss strap 24 and second pin boss strap 25 are on opposite sides of crown 2. First and second pin boss straps 24, 25 form pin bore 6 for receiving a piston pin. First rib 28 and second rib 29 each connect crown 2 to respective ones of the first pin boss strap 24 and the second pin boss strap 25.

[0093] FIG. 16 illustrates a sectional view through the cooling gallery inlet 10 into the interior of the cooling gallery 14. A projection extends outwardly from a ceiling or upper wall 14a of cooling gallery 1, forming a flow splitting deflector 32. FIG. 17 is a cross-sectional diagram showing the arrangement of cooling gallery 14, deflector 32, inlet 10, and outlet 11 around crown 2.

[0094] The deflector 32 is configured and positioned as a ridge-shaped protrusion from the ceiling wall, having opposite side surfaces angled from one another as seen in FIG. 16. The geometry of the deflector 32 is configured and positioned to aid transfer of cooling fluid from the oil spray jet 22 into opposite directions around the cooling gallery 14. The deflector 32 is configured and positioned on the upper wall 14A in a region of the cooling gallery inlet 10 such that a spray of oil aimed directly at the ceiling wall 14A of the cooling gallery 14 is redirected and distributed into an angled or lateral direction relative to the plane of the upper wall 14A in the region of the inlet 10 to the cooling gallery 14. In an embodiment, undercrown 4 of piston 1 includes flow splitting deflector 32 in cooling gallery 14 aligned with inlet 10 to cooling gallery 14. The flow splitting deflector 32 is configured to deflect the spray jet 22 of cooling fluid into cooling gallery 14 in opposite directions.

[0095] FIGs. 18 -21 show, respectively, perspective views of four examples of skirt designs featuring gaps 30 between the skirts and the crown 2. The skirts are configured to include gaps 30 that offer benefits as described herein of lowering the transfer of loads and transfer of heat between the crown and the skirt. By disconnecting the skirts from the crowns 2 as described and shown in FIGs. 18-21, the skirt area can be optimized for lower friction and further reduced mass. The size of gap 30 can be adjusted to be bigger or smaller depending on piston design considerations

[0096] In FIG. 18, skirt 160 includes a spanning portion 164 and connecting portions 162 that connect spanning portion 164 to ribs 28, 29 and the straps 24, 25 defining pin bore 6. Spanning portion 164 has a constant width between connecting portions 162. Connecting portions 162 are arranged at substantially transversely or orthogonally-oriented relationships with spanning portion 164. Gaps 30 are formed between the upper end of skirt 160 and the lower end of crown 2.

[0097] In FIG. 19, skirt 260 includes a spanning portion 264 and connecting portions 262 that connect spanning portion 264 to ribs 28, 29 and the straps 24. Spanning portion 264 has a constant width between connecting portions 262, but is smaller in width than spanning portion 164. Connecting portions 262 are arranged at substantially obtuse angles with spanning portion 264 in order to connect with straps 24 and ribs 28, 29. Gaps 30 are formed between the upper end of skirt 260 and the lower end of crown 2.

[0098] In FIG. 20, skirt 360 includes a spanning portion 364 and connecting portions 362 that connect spanning portion 364 to ribs 28, 29 and the straps 24. Spanning portion 264 has a width that tapers toward crown 2. Connecting portions 262 are arranged accordingly to connect spanning portion 264 with straps 24, 25 and ribs 28, 29. Gaps 30 are formed between the upper end of skirt 360 and the lower end of crown 2.

[0099] In FIG. 21, skirt 460 includes a spanning portion 464 and connecting portions 462 that connect spanning portion 464 to straps 24, 25. Spanning portion 264 has a constant width between connecting portions 462, but is smaller in height and therefore is not connected to ribs 28, 29. Gaps 30 are formed between the upper end of skirt 460 and the lower end of crown 2.

[00100] FIG. 22 shows cross-sectional views illustrating six examples of configurations for the ribs 28, 29. The views represent examples of the piston 1 in iterations of rib structures aimed at maximizing structural strength while also serving purposes of lowering overall piston weight, and lowering the transfer of heat between the crown 2 and the skirt 16. The rib structures provide support to the crown 2 while also allowing for a disconnected skirt structure, resulting in a thermally/geometrically stable piston skirt and pin bore while maintaining crown support.

[00101] To manufacture example pistons as shown in FIG. 22, a printed sand core process is used. Employing a printed sand core process allows for variations of the pin boss region and rib structure which are not feasible using a traditional sand casting process

[00102] FIGs. 23 and 24 show schematic diagrams illustrating a portion of an engine block 34 in accord with an example. The engine block 34 includes a dedicated oil feed to the saddle jet nozzle 20. A bearing oil gallery 36 supplies oil to be fed through a main bearing oil bore 38 to the main bearing. A spray nozzle oil gallery 40 supplies oil to be fed through a nozzle oil supply bore 42 to supply oil to the saddle jet nozzle 20. FIG. 24 shows machining geometry in the main bearing saddle 18 of the engine block 34, connecting the terminal end of the nozzle oil supply bore 42 to a bore for receiving insertion of the saddle jet nozzle 20.

[00103] The design depicted in FIGs. 23-24, 37-39 uses the main bearing shell 44 to seal the nozzle oil feed. As the main bearing shell 44 is installed into the housing, the main bearing shell 44 forms a seal around the perimeter of a machined-in cavity 46. Thus, the installation forms a sealed reservoir for holding an oil supply. The seal is formed due to the surface pressure between the two metallic components. There is no separate component or gasket-like material involved. The improved design provides a complete, isolated passage dedicated to feeding oil to the spray jet nozzle 20. Having such a dedicated nozzle oil passage allows control of oil supply to the spray jet nozzle 20, without affecting oil flow to the bearings. With this design, it is possible to increase, reduce, or eliminate flow to the spray jet nozzle 20 with mechanical or electrical (controlled by the ECM) components. A single valve may control flow to all of the spray jet nozzles 20.

[00104] FIG. 25 shows machining geometry (forming cavity 46) in the main bearing saddle 18 of the engine block 34. Saddle 18 is configured for installation of two spray jet nozzles 20, 20 that spray toward two adjacent pistons, like in FIG. 29, at a terminal end of a nozzle oil supply bore 42. As shown in this view, the two nozzles 20, 20 each may be fed from a single nozzle oil supply bore 42.

[00105] FIGs. 26-29 are schematic diagrams illustrating comparisons of saddle jet layouts. The layouts were analyzed with reference to a piston having a rear facing cooling gallery inlet. FIG. 26 is an example of a saddle jet layout. FIG. 27 is an enlarged view of a portion of FIG. 26. As illustrated in the diagrams of FIGs. 26 and 27, the piston design and saddle jet layout are not limited to oil being supplied to each piston by a single saddle jet. As shown in the example of FIG. 27, two saddle jets are arranged to cool one piston. This layout improves cooling capacity.

[00106] FIG. 28 shows a saddle jet layout configured to spray oil to inlets on the pistons that are on opposite sides of the inlets for the pistons in FIG. 26. FIG. 29 shows another saddle jet arrangement in which sets of two saddle jets are arranged adjacent to one another to spray oil to inlets of respective ones of adjacent pistons. The two adjacent saddle jets can be fed from a single supply bore.

[00107] In an embodiment, oil gallery 36 and bore 38 are dedicated to providing oil only to saddle jet nozzle 20. In an embodiment, engine block 34 includes a plurality of bearing saddles 18 that each include a cavity 46 connected to an oil gallery 36 with a bore 38. A plurality of main bearing shells 44 are mounted on respective ones of the plurality of bearing saddles 18 to form a seal around the cavity 46 in the respective bearing saddle 18. At least one saddle jet nozzle 20 is mounted to a corresponding one of each of the bearing saddles 18 to receive oil from the oil gallery 36 thereof. In a further embodiment, the at least one saddle jet nozzle 20 includes two saddle jet nozzles 20 for at least a portion of the bearing saddles 18, such as shown in FIGs. 26 and 27.

[00108] In an embodiment, each of the bearing saddles 18 includes a front side positioned towards a front of internal combustion engine 52 and a rear side positioned toward a rear of internal combustion engine 52. Each of the at least one saddle jet nozzles 20 is mounted on the corresponding bearing saddle 18 toward either the front side or the rear side thereof. In a further embodiment, each of the at least one saddle jet nozzles 20 is mounted toward the front side of the corresponding bearing saddle 18, such as shown in FIG. 28. In a further embodiment, each of the at least one saddle jet nozzles 20 is mounted toward the rear side of the corresponding bearing saddle 18, such as shown in FIG. 26 (except for rear cylinder B, which has two saddle jet nozzles 20).

[00109] In yet a further embodiment, a first portion of the at least one saddle jet nozzles 20 are mounted toward the rear side of the corresponding bearing saddles 18 and a second portion of the at least one saddle jet nozzles 20 are mounted toward the front side of the corresponding bearing saddles 18, such as shown in FIG. 29. In still a further embodiment, adjacent ones of the plurality of bearing saddles 18 include a first saddle jet nozzle 20 mounted toward the rear side the corresponding bearing saddle 18 and a second saddle jet nozzle 20 mounted toward the front side corresponding bearing saddle 18 so that the first and second saddle jet nozzles 20 are positioned next to one another as shown in FIG. 29.

[00110] FIG. 30 is a section view illustrating an example of the piston 1 containing variations from the example depicted in FIG. 1. The FIG. 30 example has a less symmetrical gallery inlet 10 and gallery outlet 11 configuration. The gallery inlet 10 includes a deflecting projection 13 formed by a distal or downward extension of crown 2. The deflecting projection 13 is configured with a funneling geometry that guides and deflects the sprayed cooling fluid toward the gallery inlet 10. As described above with respect to FIG. 16, the ceiling 14a of the cooling gallery 14 in the area of the gallery inlet 10 also includes a flow-splitting feature, such as a projection in the nature of a flow splitting deflector 32. Deflector 32 is aligned with inlet 10. The cooling gallery 14 has a dedicated outlet 11 that includes a reduced cross-sectional area compared to inlet 10. Outlet 11 is configured to guide exiting cooling fluid towards the passthrough 8. However, outlet 11 does not include a deflecting projection. The rib 28 has a variation with an oval-shaped hole 33 in the middle portion thereof along axis L1 that is provided for mass reduction.

[00111] FIGs. 31-33 further illustrate the configuration of the ribs 28, 29 and passthrough 8. The features vary in their geometry from corresponding features shown in the example of FIG. 1. FIG. 31 is a cross-sectional view taken along a plane perpendicular to longitudinal axis L1 of the piston 1, showing ribs 28, 29 according to the example of FIGs. 31-33. FIG. 32 is a cross-sectional view taken along a plane parallel to the longitudinal axis L1. FIG. 33 is a perspective looking toward a bottom of piston 1.

[00112] FIG. 34 is a diagram illustrating an example of a saddle jet configuration containing variations from the examples depicted in FIG. 6 and FIG. 10. The FIG. 34 example is a configuration including two saddle jets 20, 20 mounted on a single main bearing saddle 18, such as shown in FIG. 29. The two saddle jets 20, 20 are fed by a single cavity 46 and nozzle oil supply bore 42. The main bearing shell 44 is sealing engaged against the main bearing saddle 18 to create the dedicated passage to the saddle jet nozzles 20.

[00113] FIGs. 35 and 36 are diagrams illustrating an example of the piston 1 containing variations from the example of the piston depicted in FIGs. 1-4. FIG. 35 is a perspective view of the piston 1 containing such variations, and FIGs. 36 is a sectional view of the example showing details of the support structure 58. As compared to the FIGs. 1-4 configuration, the configuration of the piston 1 of FIGs. 35 and 36 has variations in the junction between a skirt support or connecting portion 50 and the rib 28. In this example, a first cutout 48 is created in the outer portion of first rib 28 to avoid complex geometry between the union of the first rib 28, skirt connecting portion 50, and pin boss 9. A second cutout 49 can be provided at the junction of second rib 29, skirt connecting portion 50, and pin boss 9. Complex geometry can create stress concentrations, which is avoided using the design in FIGs. 35 and 36.

[00114] In an embodiment, support structure 58 includes first rib 28 and second rib 29 spaced from first rib 28. First and second ribs 28, 29 each connect crown 2 to first pin boss strap 24 and second pin boss strap 25. In a further embodiment, skirt 16 is connected to first pin boss strap 24 with a first skirt connecting portion 50 that extends from skirt 16 to first pin boss strap 24. Skirt 16 is connected to second pin boss strap 25 with a second skirt connecting portion 51 that extends from skirt 16 to second pin boss strap 25. The first and second cutouts 48, 49 are located so that the first and second ribs 28, 29, respectively, do not join with the connection of the first and second skirt connecting portions 50, 51 and the first and second pin boss straps 24, 25.

[00115] FIGs. 37-39 are diagrams illustrating an example of the engine block 34 with variations as compared to the engine block 34 shown in FIGs. 23-24. The FIGs. 37-39 example includes different geometry between the oil supply drilling and the saddle jet passage, as compared to the example of FIGs. 23-24. FIGs. 37-39 illustrate the function of the main bearing acting as a sealing feature for the nozzle oil supply bore 42, thereby containing the oil flow and directing the dedicated feed of oil to the nozzle 20.

[00116] In an example, a method of forming one or more of the pistons disclosed herein uses additive manufacturing to configure a piston that includes one or more of the features as described herein. The example embodiments of the pistons as described herein may be formed by manufacturing methods employing additive manufacturing techniques such as sand core printing technology. The example embodiments of the pistons disclosed herein may be formed from cast iron using such additive manufacturing technology. The additive manufacturing method permits the formation of structures, gaps, cavities, cutouts, openings, and bores that would not be feasible to create using traditional metal casting methods. The sand core method improves ability to form such structures that otherwise are difficult to form. Other manufacturing techniques, however, are also contemplated and not excluded.

[00117] In an example, a piston for an internal combustion engine includes a body extending along a longitudinal axis. The body includes a cooling gallery for receiving a cooling fluid, a pin bore extending transversely to the longitudinal axis for receiving a piston pin, and a passthrough positioned between the cooling gallery and the pin bore to conduct cooling fluid through the body of the piston to the pin bore.

[00118] In an example, the cooling gallery includes an inlet adjacent an outer perimeter of the piston body. The passthrough includes an inlet/outlet in fluid communication with the inlet of the cooling gallery. In yet a further example, the cooling gallery includes an outlet adjacent the outer perimeter of the piston body opposite the inlet to the cooling gallery. The passthrough includes a second inlet/outlet in fluid communication with the outlet of the cooling gallery.

[00119] In an example, the passthrough extends along the pin bore transversely to the longitudinal axis of the body of the piston. In a further example, the passthrough opens into opposite sides of the pin bore.

[00120] In an embodiment, the body of the piston includes a crown, an undercrown below the crown, and the cooling gallery and passthrough are located within the undercrown between the crown and the pin bore. In an example, the cooling gallery extends around the longitudinal axis.

[00121] In an example, the pin bore includes a first opening on a first side of the body of the piston and a second opening on a second side of the body of the piston opposite the first side. The cooling gallery has an inlet to receive the cooling fluid. The inlet positioned adjacent the first opening of the pin bore on the first side of the body of the piston. In a further example, the passthrough includes an inlet/outlet in fluid communication with the inlet of the cooling gallery adjacent the first opening of the pin bore on the first side of the body.

[00122] In an example, a piston for an internal combustion engine includes a body extending along a first longitudinal axis. The body includes a cooling gallery including an inlet for receiving a cooling fluid, and a pin bore extending through the body between opposite side openings along a second longitudinal axis that is transverse to the first longitudinal axis. The inlet of the cooling gallery lies on a plane define by the first longitudinal axis and the second longitudinal axis.

[00123] In a further example, the body of the piston include a crown, an undercrown below the crown, and the cooling gallery is located within the undercrown between the crown and the pin bore. In yet a further example, the crown includes a deflecting portion extending downwardly along the inlet to the cooling gallery to direct the cooling fluid in an angled direction relative to the first longitudinal axis.

[00124] In a further example, the inlet of the cooling gallery is configured to receive the cooling fluid throughout a range of motion of the piston within a combustion chamber of the engine.

[00125] In a further example the body of the piston includes a pin boss strap around at least one of opposite side openings, the pin boss strap including a scallop along one side of the inlet to the cooling gallery.

[00126] In a further example, a passthrough is positioned between the cooling gallery and the pin bore. The passthrough conducts cooling fluid from the inlet of the cooling gallery through the body of the piston to the pin bore. In yet a further example, the cooling gallery includes an outlet adjacent the outer perimeter of the piston body opposite the inlet to the cooling gallery. The passthrough includes a first inlet/outlet in fluid communication with the inlet of the cooling gallery and a second inlet/outlet in fluid communication with the outlet of the cooling gallery.

[00127] In an example, a piston for an internal combustion engine includes a crown, a pair of straps connected to and extending downwardly from the crown, and a skirt connected to the pair of straps. A gap formed between the crown and the skirt along the pair of straps.

[00128] In a further example, the piston includes a second skirt connected to the pair of straps on a side of the crown opposite the skirt, and a second gap is formed between the crown and the second skirt along the pair of straps. In yet a further example, the pair of straps define a pin bore for receiving a piston pin, and the pair of straps are connected to the crown with ribs.

[00129] In an example, an internal combustion engine includes an engine block including at least one combustion chamber and a piston in the at least one combustion chamber. The piston is configured to include one or more of the features disclosed herein.

[00130] In an example, an internal combustion engine includes a piston operable to reciprocally move along a range of motion between a top-dead-center position and a bottom-dead-center position and a saddle jet nozzle mounted on a bearing saddle of the internal combustion engine. The piston includes a crown and an undercrown below the crown, and the undercrown includes a cooling gallery having an inlet for receiving a cooling fluid. The piston includes a plurality of piston ring grooves on an exterior of the piston below the crown. The piston ring grooves extend around a first longitudinal axis of the piston and are configured to receive piston rings. The piston includes a pin bore below the crown extending along a second longitudinal axis that is transverse to the first longitudinal axis. The inlet of the cooling gallery is located on the second longitudinal axis between the pin bore and the piston ring grooves. The saddle jet nozzle is configured to target a spray jet of cooling fluid into the inlet throughout at least a portion of the range of motion of the piston.

[00131] In a further example, the saddle jet extends from the bearing saddle toward the piston. The saddle jet has an orientation that ranges from a parallel orientation relative to the first longitudinal axis to 5 degrees relative to the first longitudinal axis.

[00132] In a further example, the saddle jet nozzle is configured to target the spray jet of cooling fluid into the inlet throughout an entire range of motion of the piston.

[00133] In a further example, the undercrown of the piston includes a flow splitting deflector in the cooling gallery aligned with the inlet to the cooling gallery. The flow splitting deflector is configured to deflect the spray jet of cooling fluid into the cooling gallery in opposite directions.

[00134] In a further example, the undercrown includes a downwardly extended outer wall section forming a deflecting portion adjacent to the inlet. The deflecting portion assists in cooling fluid capture by the inlet at or near bottom-dead-center of the piston.

[00135] In a further example, the piston includes a pin boss strap extending around the pin bore. The pin boss strap includes a scallop at an upper end of the pin boss strap and adjacent to the inlet to assist in cooling fluid capture by the inlet at or near top-dead-center of the piston.

[00136] In an example, an internal combustion engine includes an engine block including a bearing saddle. The bearing saddle includes a cavity. The engine block further includes an oil gallery fluidly connected to the cavity with a bore extending through the block to the cavity. The internal combustion engine also includes a main bearing shell mounted on the bearing saddle. The main bearing shell forms a seal around the cavity in the bearing saddle. The internal combustion engine also includes a saddle jet nozzle mounted to the bearing saddle. The saddle jet nozzle is in fluid communication with the cavity in order to receive oil from the oil gallery.

[00137] In a further example, the oil gallery and the bore are dedicated to providing oil only to the saddle jet nozzle.

[00138] In a further example, the engine block includes a plurality of bearing saddles that each include a cavity connected to an oil gallery with a bore. A plurality of main bearing shells are mounted on respective ones of the plurality of bearing saddles to form a seal around the cavity in the respective bearing saddle. At least one saddle jet nozzle is mounted to a corresponding one of each of the bearing saddles to receive oil from the oil gallery thereof.

[00139] In yet a further example, the at least one saddle jet nozzle includes two saddle jet nozzles for at least a portion of the bearing saddles. In yet a further example, each of the bearing saddles includes a front side positioned towards a front of the internal combustion engine and a rear side positioned toward a rear of the internal combustion engine. Each of the at least one saddle jet nozzles is mounted on the corresponding bearing saddle toward either the front side or the rear side thereof.

[00140] In still a further example, each of the at least one saddle jet nozzles is mounted toward the front side of the corresponding bearing saddle. In still a further example, each of the at least one saddle jet nozzles is mounted toward the rear side of the corresponding bearing saddle.

[00141] In still a further example, a first portion of the at least one saddle jet nozzles are mounted toward the rear side of the corresponding bearing saddles and a second portion of the at least one saddle jet nozzles are mounted toward the front side of the corresponding bearing saddles.

[00142] In yet a further example, adjacent ones of the plurality of bearing saddles include a first saddle jet nozzle mounted toward the rear side the corresponding bearing saddle and a second saddle jet nozzle mounted toward the front side corresponding bearing saddle so that the first and second saddle jet nozzles are positioned next to one another.

[00143] In an example, a piston for an internal combustion engine includes a crown and an undercrown below the crown. The undercrown defines a cooling gallery below the crown. The piston includes a first rib and a second rib spaced from the first rib. The first and second ribs each connect the crown to the undercrown to support the crown. The first rib is separated from the second rib by a passthrough that is in fluid communication with the cooling gallery.

[00144] In a further example, the piston includes a first pin boss strap and a second pin boss strap on opposite sides of the crown. The first and second pin boss straps form a pin bore for receiving a piston pin. The first rib and the second rib each connect the crown to respective ones of the first pin boss strap and the second pin boss strap.

[00145] In an example, a piston for an internal combustion engine includes a crown and an undercrown below the crown. The undercrown defines a cooling gallery below the crown. The piston includes a first pin boss strap and a second pin boss strap on opposite sides of the crown that form a pin bore for receiving a piston pin. The piston includes a support structure connecting the crown to the first pin boss strap and the second pin boss strap. The piston includes a skirt connected to the first pin boss strap and the second pin boss strap. The support structure includes a first cutout where the skirt is connected to the first pin boss strap and a second cutout where the skirt is connected to the second pin boss strap.

[00146] In a further example, the support structure includes a first rib and a second rib spaced from the first rib. The first and second ribs each connect the crown to the first pin boss strap and the second pin boss strap.

[00147] In yet a further example, the skirt is connected to the first pin boss strap with a first skirt connecting portion that extends from the skirt to the first pin boss strap. The skirt is connected to the second pin boss strap with a second skirt connecting portion that extends from the skirt to the second pin boss strap. The first and second cutouts are located so that the first and second ribs, respectively, do not join with the connection of the first and second skirt connecting portions and the first and second pin boss straps.

[00148] While illustrative examples of the disclosure have been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only certain examples have been shown and described and that all changes and modifications that come within the spirit of the claimed invention are desired to be protected. It should be understood that while the use of words such as preferable, preferably, preferred or more preferred utilized in the description above indicates that the feature so described may be more desirable, it nonetheless may not be necessary and examples lacking the same may be contemplated as within the scope of the invention, the scope being defined by the claims that follow. In reading the claims, it is intended that when words such as "a," "an," "at least one," or "at least one portion" are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language "at least a portion" and/or "a portion" is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

[00149] One of skill in the art may appreciate from the foregoing that unexpected benefits may be derived from one or more of the features of the pistons according to the present disclosure, without the need for additional components or parts, or other changes in the configuration of associated engine features that interact with the disclosed pistons. The pistons of the present disclosure may be manufactured with reduced costs, weight, and complexity, and also provide reduced costs for operation and maintenance.

[00150] In an embodiment, the present disclosure provides an improved piston structure without any additional components or changes in structural features of the pistons disclosed herein. In this exclusion, maximum cost containment may be effected. Accordingly, the substantial benefits of simplicity of manufacture, operation, and maintenance may reside in one or more of the exemplary embodiments consisting of or consisting essentially of features of the piston features disclosed herein. Thus, certain embodiments of the present disclosure contemplate the exclusion of features, parts, and components beyond those set forth herein.

WHAT IS CLAIMED IS:

1. A piston for an internal combustion engine, the piston comprising:

a body extending along a longitudinal axis, the body including:

a cooling gallery for receiving a cooling fluid;

a pin bore extending transversely to the longitudinal axis for receiving a piston pin; and

a passthrough positioned between the cooling gallery and the pin bore to conduct cooling fluid through the body of the piston to the pin bore.

2. The piston of claim 1, wherein:

the cooling gallery includes an inlet adjacent an outer perimeter of the piston body; and

the passthrough includes an inlet/outlet in fluid communication with the inlet of the cooling gallery.

3. The piston of claim 2, wherein:

the cooling gallery includes an outlet adjacent the outer perimeter of the piston body opposite the inlet to the cooling gallery; and

the passthrough includes a second inlet/outlet in fluid communication with the outlet of the cooling gallery.

4. The piston of claim 1, wherein the passthrough extends along the pin bore transversely to the longitudinal axis of the body of the piston.

5. The piston of claim 4, wherein the passthrough opens into opposite sides of the pin bore.

6. The piston of claim 1, wherein the body of the piston includes:

a crown;

an undercrown below the crown; and

the cooling gallery and passthrough are located within the undercrown between the crown and the pin bore.

7. The piston of claim 1, wherein the cooling gallery extends around the longitudinal axis.

8. The piston of claim 1, wherein:

the pin bore includes a first opening on a first side of the body of the piston;

the pin bore includes a second opening on a second side of the body of the piston opposite the first side; and

the cooling gallery has an inlet to receive the cooling fluid, the inlet positioned adjacent the first opening of the pin bore on the first side of the body of the piston.

9. The piston of claim 8, wherein the passthrough includes an inlet/outlet in fluid communication with the inlet of the cooling gallery adjacent the first opening of the pin bore on the first side of the body.

10. A piston for an internal combustion engine, the piston comprising:

a body extending along a first longitudinal axis, the body including:

a cooling gallery including an inlet for receiving a cooling fluid; and

a pin bore extending through the body between opposite side openings along a second longitudinal axis that is transverse to the first longitudinal axis, wherein the inlet of the cooling gallery lies on a plane define by the first longitudinal axis and the second longitudinal axis.

11. The piston of claim 10, wherein the body of the piston includes:

a crown;

an undercrown below the crown; and

the cooling gallery is located within the undercrown between the crown and the pin bore.

12. The piston of claim 11, wherein the crown includes a deflecting portion extending downwardly along the inlet to the cooling gallery to direct the cooling fluid in an angled direction relative to the first longitudinal axis.

13. The piston of claim 10, wherein the inlet of the cooling gallery is configured to receive the cooling fluid throughout a range of motion of the piston within a combustion chamber of the engine.

14. The piston of claim 10, wherein the body of the piston includes a pin boss strap around at least one of opposite side openings, the pin boss strap including a scallop along one side of the inlet to the cooling gallery.

15. The piston of claim 10, further comprising a passthrough positioned between the cooling gallery and the pin bore, the passthrough to conduct cooling fluid from the inlet of the cooling gallery through the body of the piston to the pin bore.

16. The piston of claim 15, wherein:

the cooling gallery includes an outlet adjacent the outer perimeter of the piston body opposite the inlet to the cooling gallery; and

the passthrough includes a first inlet/outlet in fluid communication with the inlet of the cooling gallery and a second inlet/outlet in fluid communication with the outlet of the cooling gallery.

17. An internal combustion engine, comprising:

a piston operable to reciprocally move along a range of motion between a top-dead-center position and a bottom-dead-center position, the piston including:

a crown and an undercrown below the crown, the undercrown including a cooling gallery having an inlet for receiving a cooling fluid;

a plurality of piston ring grooves on an exterior of the piston below the crown, the piston ring grooves extending around a first longitudinal axis of the piston and are configured to receive piston rings;

a pin bore below the crown extending along a second longitudinal axis that is transverse to the first longitudinal axis, wherein the inlet of the cooling gallery is located on the second longitudinal axis between the pin bore and the piston ring grooves; and a saddle jet nozzle mounted on a bearing saddle of the internal combustion engine, the saddle jet nozzle configured to target a spray jet of cooling fluid into the inlet throughout at least a portion of the range of motion of the piston.

18. The internal combustion engine of claim 17, wherein the saddle jet extends from the bearing saddle toward the piston, the saddle jet having an orientation that ranges from a parallel orientation relative to the first longitudinal axis to 5 degrees relative to the first longitudinal axis.

19. The internal combustion engine of claim 17, wherein the saddle jet nozzle is configured to target the spray jet of cooling fluid into the inlet throughout an entire range of motion of the piston.

20. The internal combustion engine of claim 17, wherein the undercrown of the piston includes a flow splitting deflector in the cooling gallery aligned with the inlet to the cooling gallery, the flow splitting deflector configured to deflect the spray jet of cooling fluid into the cooling gallery in opposite directions.

21. The internal combustion engine of claim 17, wherein the undercrown includes a downwardly extended outer wall section forming a deflecting portion adjacent to the inlet, the deflecting portion assisting in cooling fluid capture by the inlet at or near bottom-dead-center of the piston.

22. The internal combustion engine of claim 17, wherein the piston includes a pin boss strap extending around the pin bore, the pin boss strap including a scallop at an upper end of the pin boss strap and adjacent to the inlet to assist in cooling fluid capture by the inlet at or near top-dead-center of the piston.

23. An internal combustion engine, comprising:

an engine block including a bearing saddle, the bearing saddle including a cavity, the engine block further including an oil gallery fluidly connected to the cavity with a bore extending through the block to the cavity;

a main bearing shell mounted on the bearing saddle, the main bearing shell forming a seal around the cavity in the bearing saddle; and

a saddle jet nozzle mounted to the bearing saddle, the saddle jet nozzle in fluid communication with the cavity in order to receive oil from the oil gallery.

24. The internal combustion engine of claim 23, wherein the oil gallery and the bore are dedicated to providing oil only to the saddle jet nozzle.

25. The internal combustion engine of claim 23, wherein:

the engine block includes a plurality of bearing saddles that each include a cavity connected to an oil gallery with a bore;

a plurality of main bearing shells mounted on respective ones of the plurality of bearing saddles to form a seal around the cavity in the respective bearing saddle; and

at least one saddle jet nozzle mounted to a corresponding one of each of the bearing saddles to receive oil from the oil gallery thereof.

26. The internal combustion engine of claim 25, wherein the at least one saddle jet nozzle includes two saddle jet nozzles for at least a portion of the bearing saddles.

27. The internal combustion engine of claim 25, wherein each of the bearing saddles includes a front side positioned towards a front of the internal combustion engine and a rear side positioned toward a rear of the internal combustion engine, and each of the at least one saddle jet nozzles is mounted on the corresponding bearing saddle toward either the front side or the rear side thereof.

28. The internal combustion engine of claim 27, wherein each of the at least one saddle jet nozzles is mounted toward the front side of the corresponding bearing saddle.

29. The internal combustion engine of claim 27, wherein each of the at least one saddle jet nozzles is mounted toward the rear side of the corresponding bearing saddle.

30. The internal combustion engine of claim 27, wherein a first portion of the at least one saddle jet nozzles are mounted toward the rear side of the corresponding bearing saddles and a second portion of the at least one saddle jet nozzles are mounted toward the front side of the corresponding bearing saddles.

31. The internal combustion engine of claim 30, wherein adjacent ones of the plurality of bearing saddles include a first saddle jet nozzle mounted toward the rear side the corresponding bearing saddle and a second saddle jet nozzle mounted toward the front side corresponding bearing saddle so that the first and second saddle jet nozzles are positioned next to one another.

32. A piston for an internal combustion engine, the piston comprising:

a crown and an undercrown below the crown, the undercrown defining a cooling gallery below the crown; and

a first rib and a second rib spaced from the first rib, the first and second ribs each connecting the crown to the undercrown to support the crown, wherein the first rib is separated from the second rib by a passthrough that is in fluid communication with the cooling gallery.

33. The piston of claim 32, further comprising a first pin boss strap and a second pin boss strap on opposite sides of the crown, the first and second pin boss straps forming a pin bore for receiving a piston pin, wherein the first rib and the second rib each connect the crown to respective ones of the first pin boss strap and the second pin boss strap.

34. A piston for an internal combustion engine, the piston comprising:

a crown;

a pair of straps connected to and extending downwardly from the crown; and

a skirt connected to the pair of straps, wherein a gap formed between the crown and the skirt along the pair of straps.

35. The piston of claim 34, further comprising a second skirt connected to the pair of straps on a side of the crown opposite the skirt, and wherein a second gap is formed between the crown and the second skirt along the pair of straps.

36. The piston of claim 35, wherein the pair of straps define a pin bore for receiving a piston pin, and the pair of straps are connected to the crown with ribs.

37. A piston for an internal combustion engine, the piston comprising:

a crown and an undercrown below the crown, the undercrown defining a cooling gallery below the crown;

a first pin boss strap and a second pin boss strap on opposite sides of the crown that form a pin bore for receiving a piston pin;

a support structure connecting the crown to the first pin boss strap and the second pin boss strap; and

a skirt connected to the first pin boss strap and the second pin boss strap, wherein the support structure includes a first cutout where the skirt is connected to the first pin boss strap and a second cutout where the skirt is connected to the second pin boss strap.

38. The piston of claim 37, wherein the support structure includes a first rib and a second rib spaced from the first rib, the first and second ribs each connecting the crown to the first pin boss strap and the second pin boss strap.

39. The piston of claim 38, wherein:

the skirt is connected to the first pin boss strap with a first skirt connecting portion that extends from the skirt to the first pin boss strap;

the skirt is connected to the second pin boss strap with a second skirt connecting portion that extends from the skirt to the second pin boss strap; and

the first and second cutouts are located so that the first and second ribs, respectively, do not join with the connection of the first and second skirt connecting portions and the first and second pin boss straps.

40. An internal combustion engine, comprising:

an engine block including at least one combustion chamber; and a piston in the at least one combustion chamber, wherein the piston is configured according to any of claims 1-16 and 32-39.

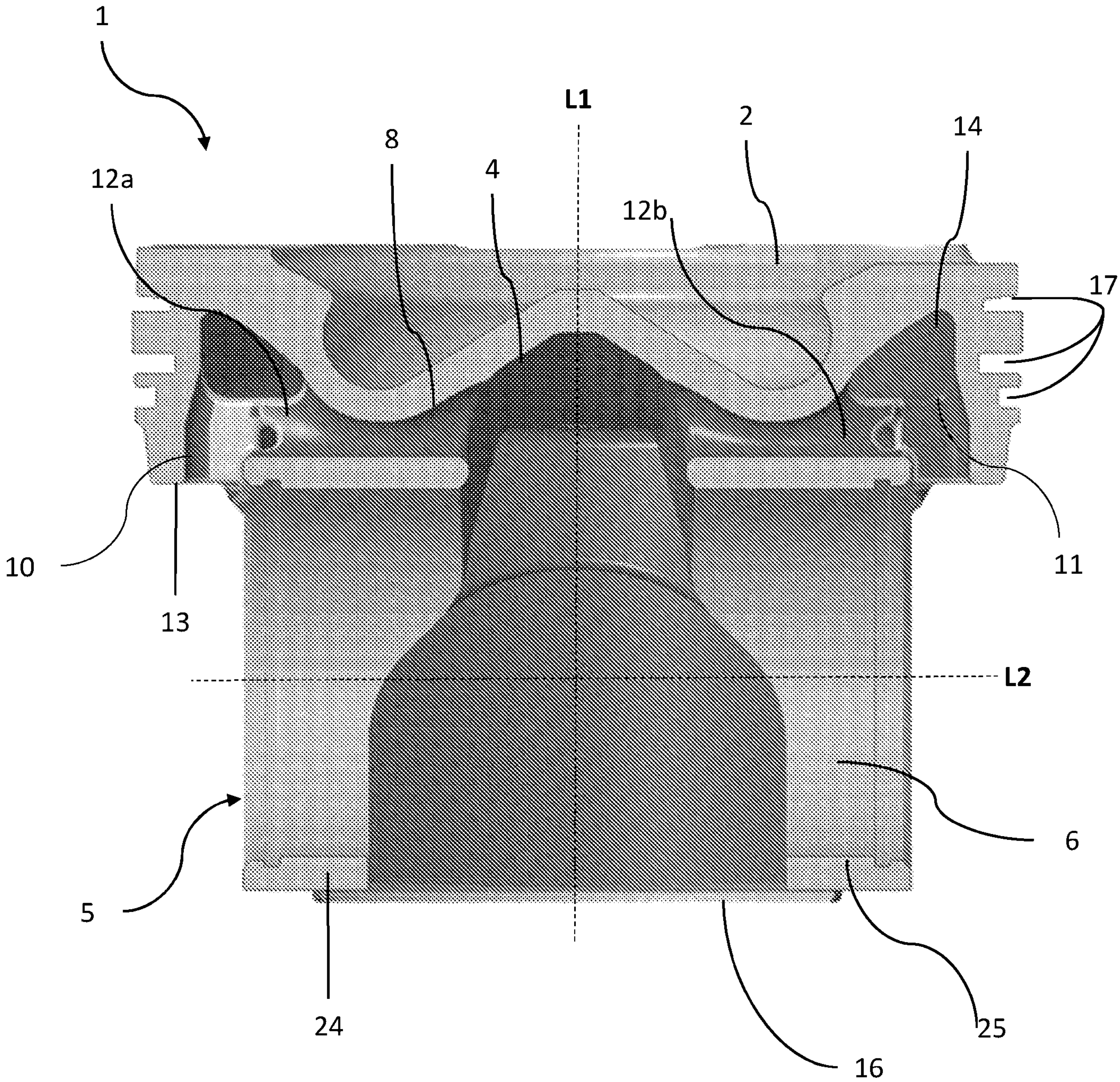


FIG. 1

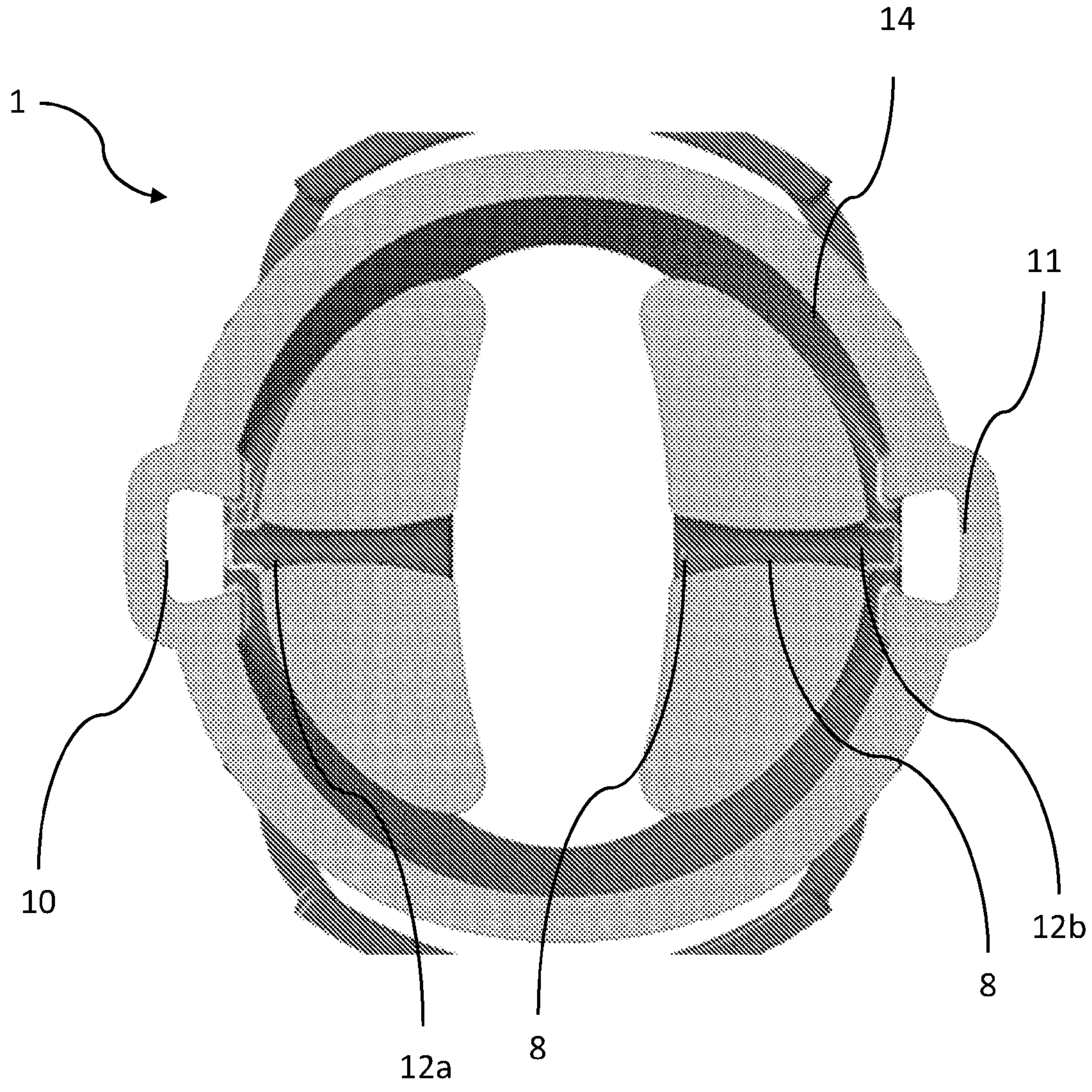


FIG. 2

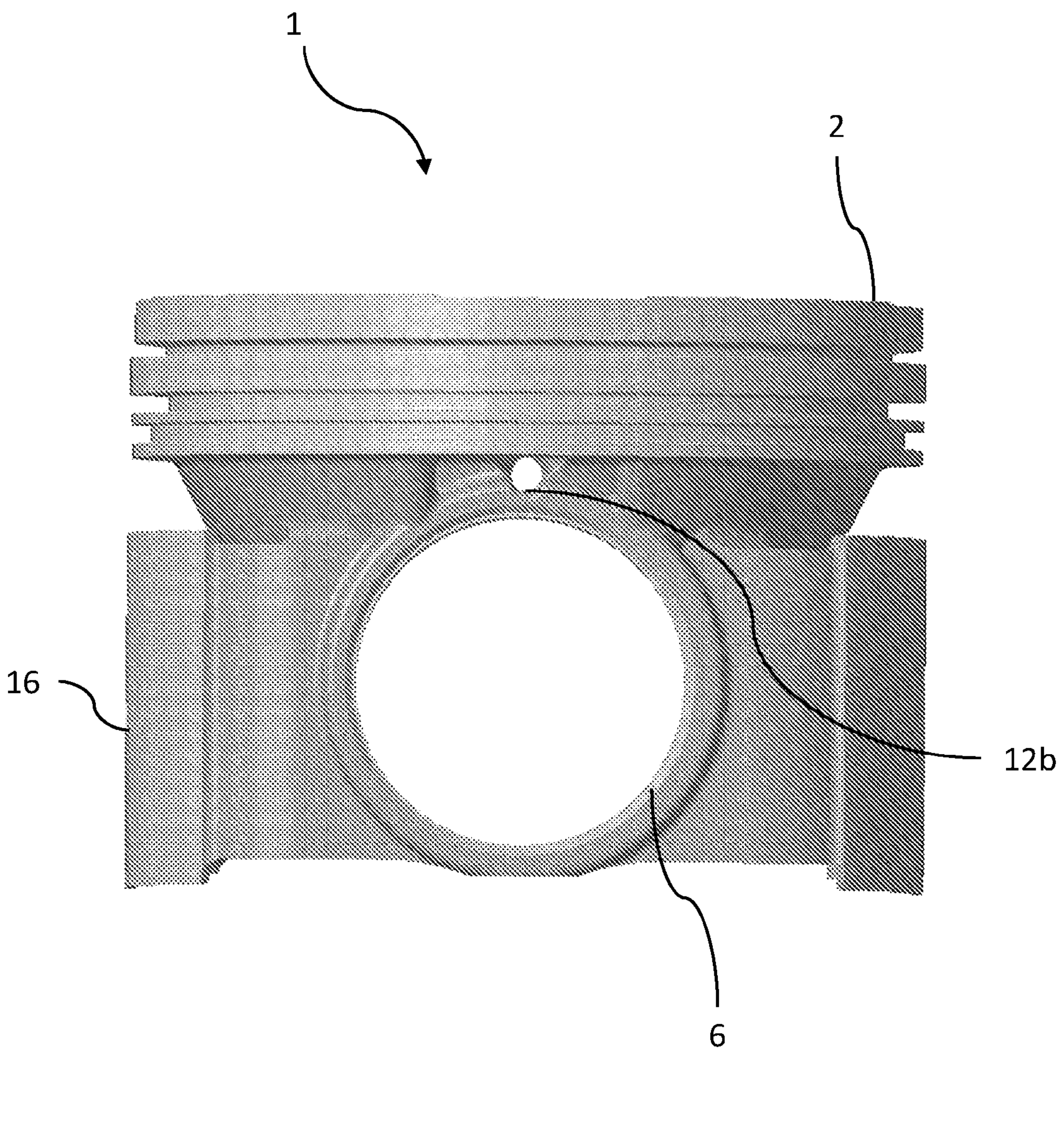


FIG. 3

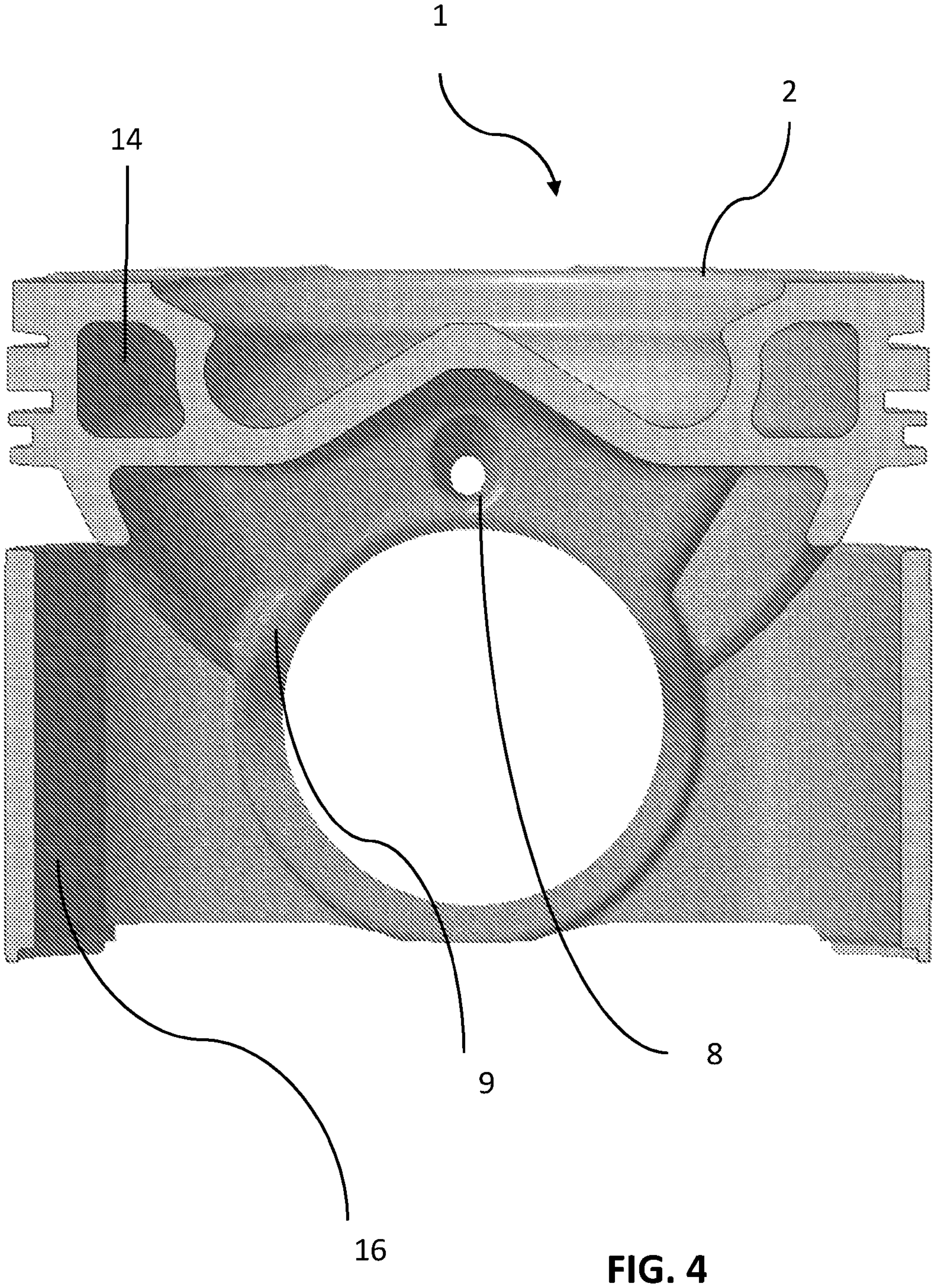


FIG. 4

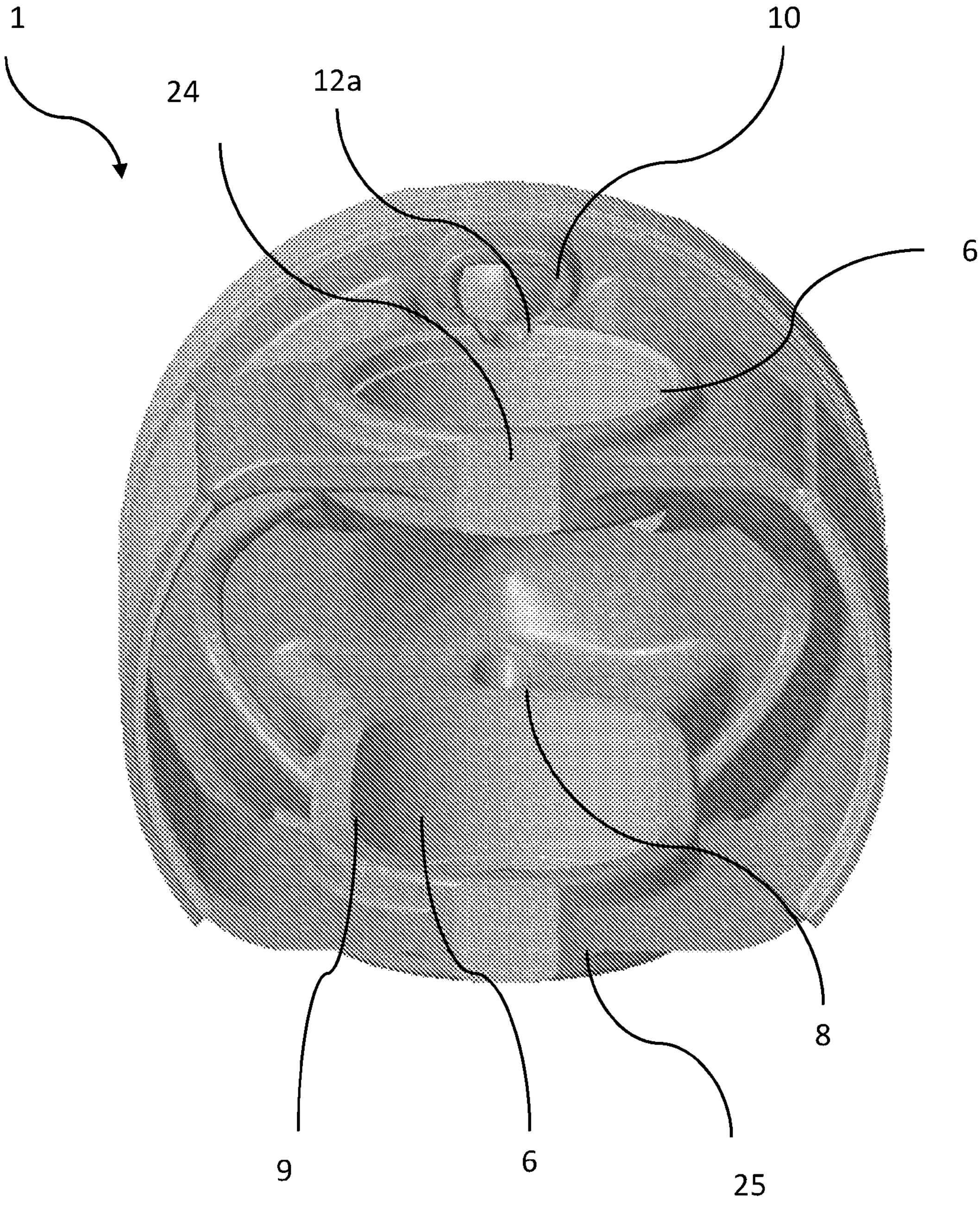


FIG. 5

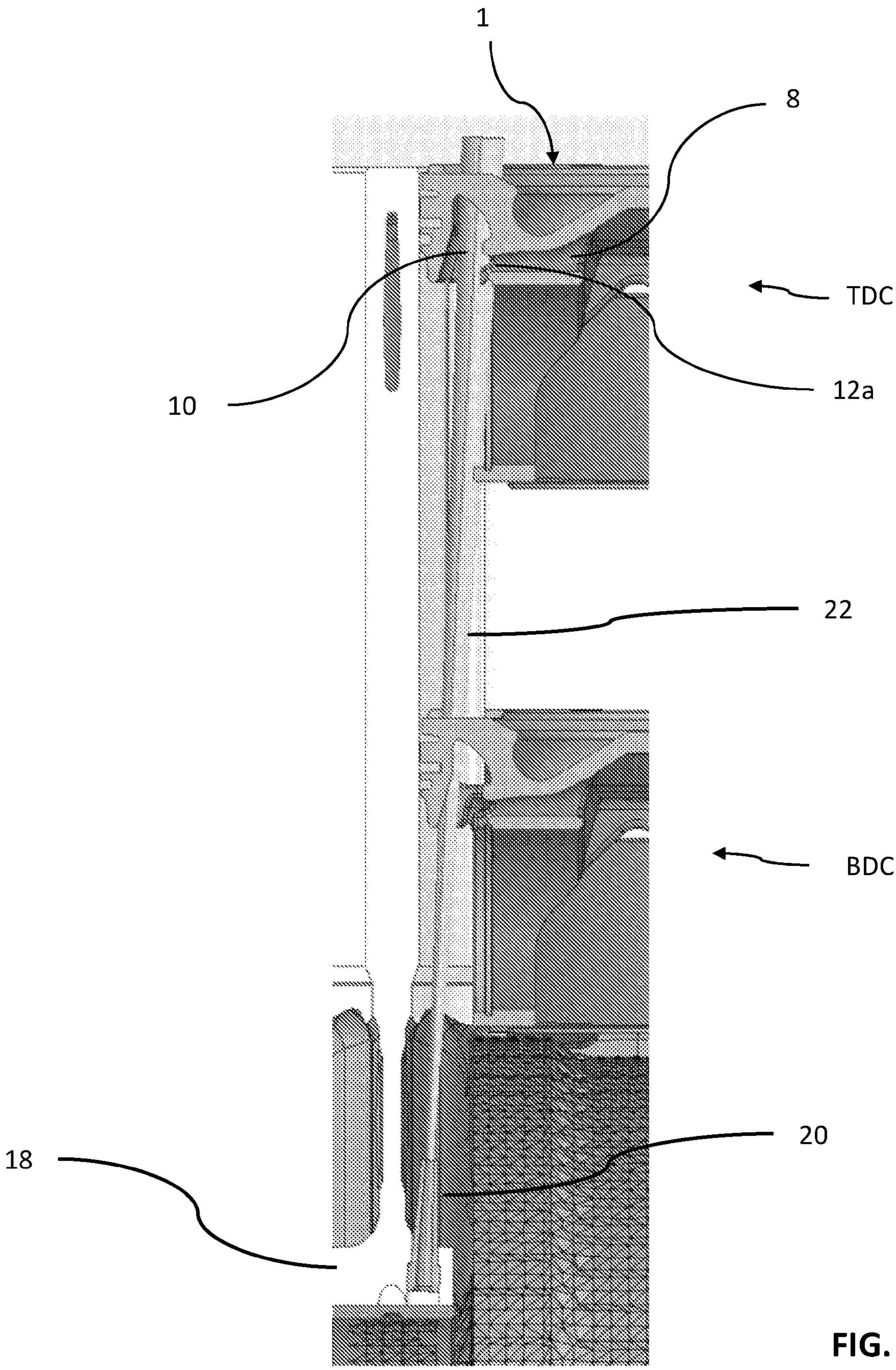


FIG. 6

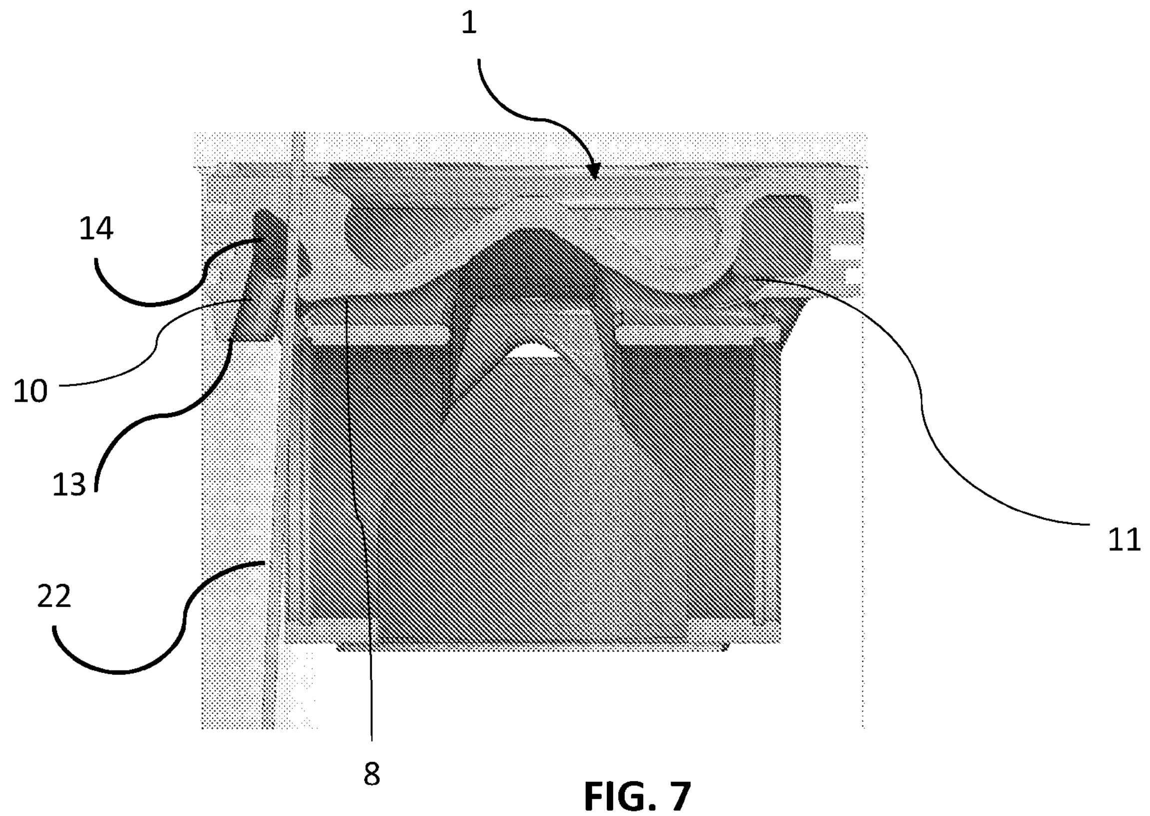


FIG. 7

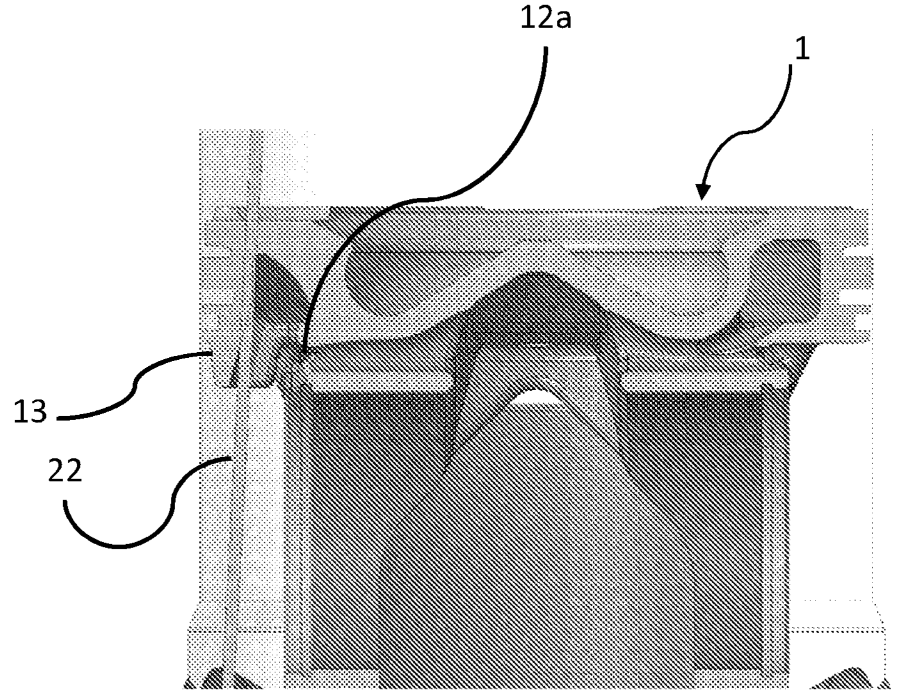


FIG. 8

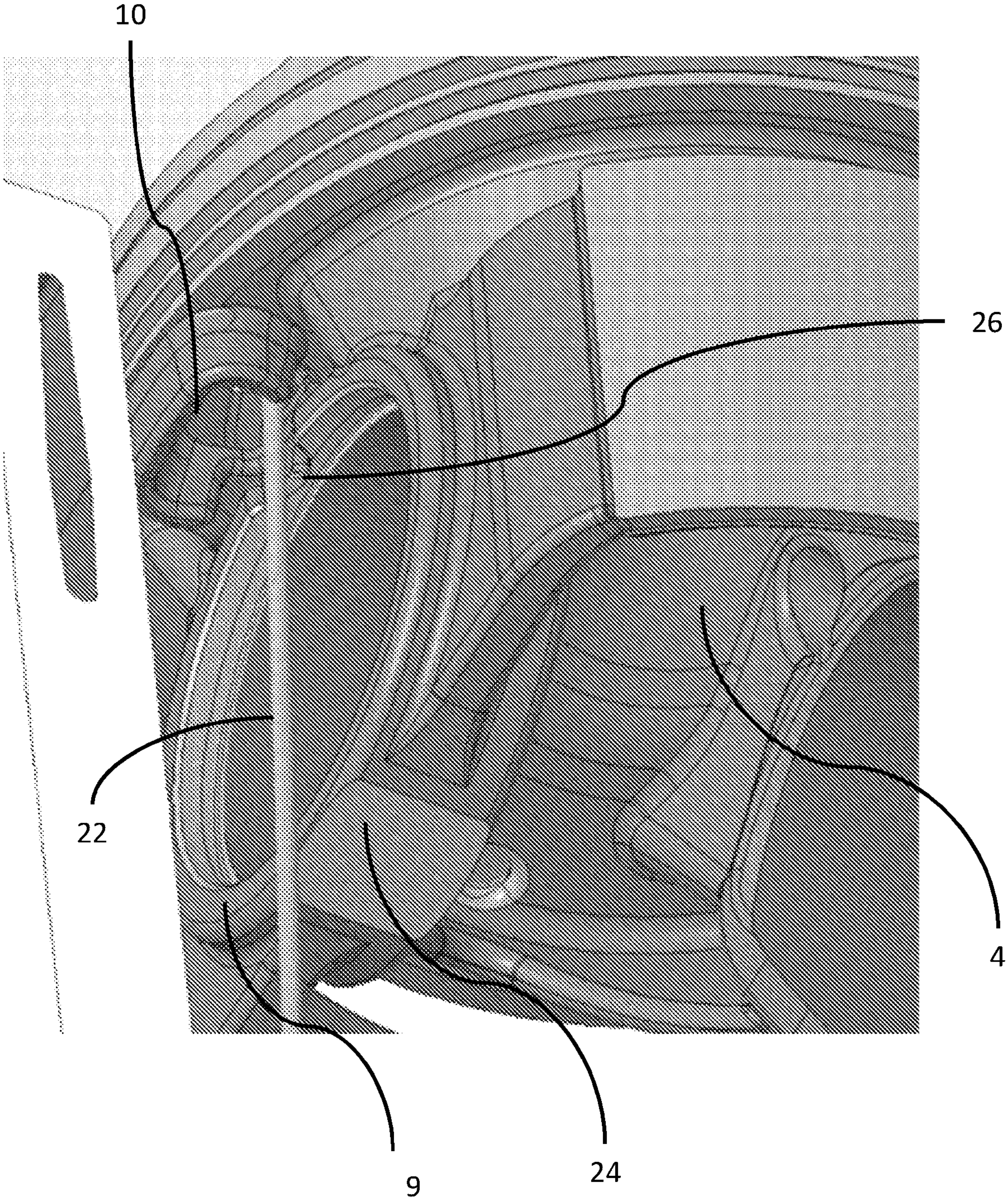


FIG. 9

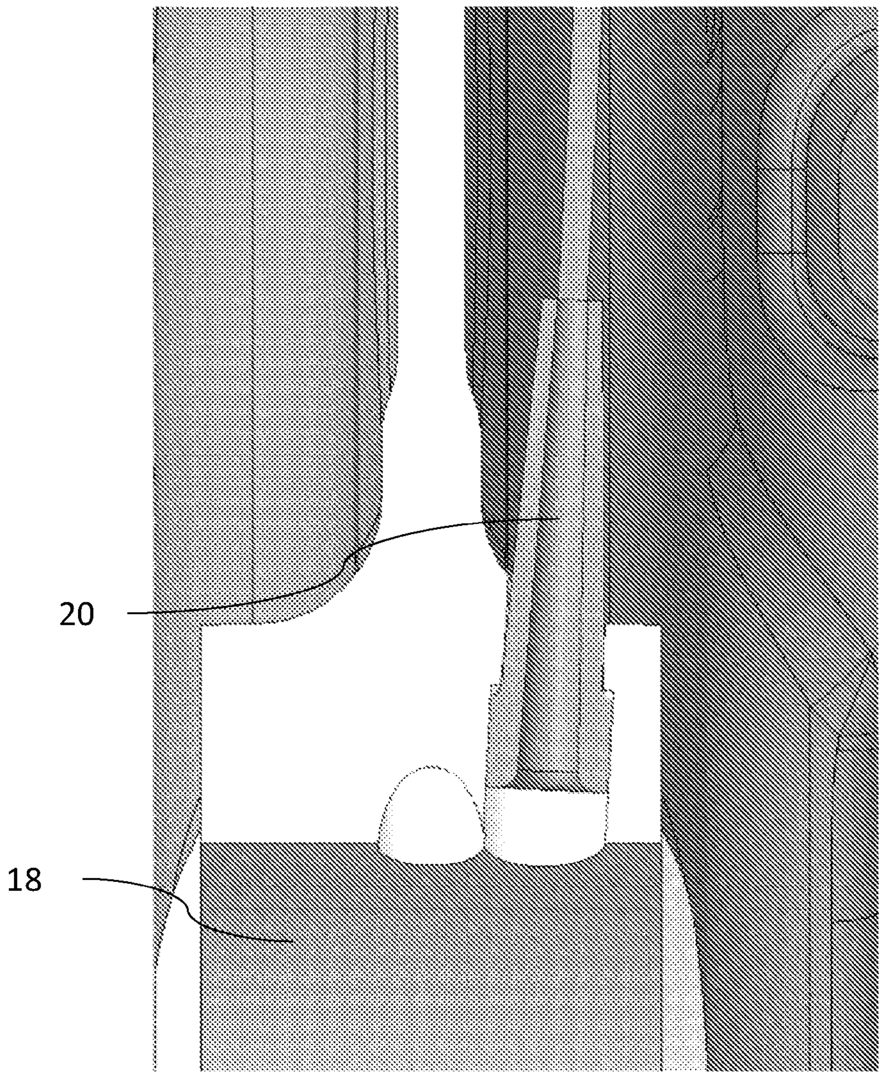


FIG. 10

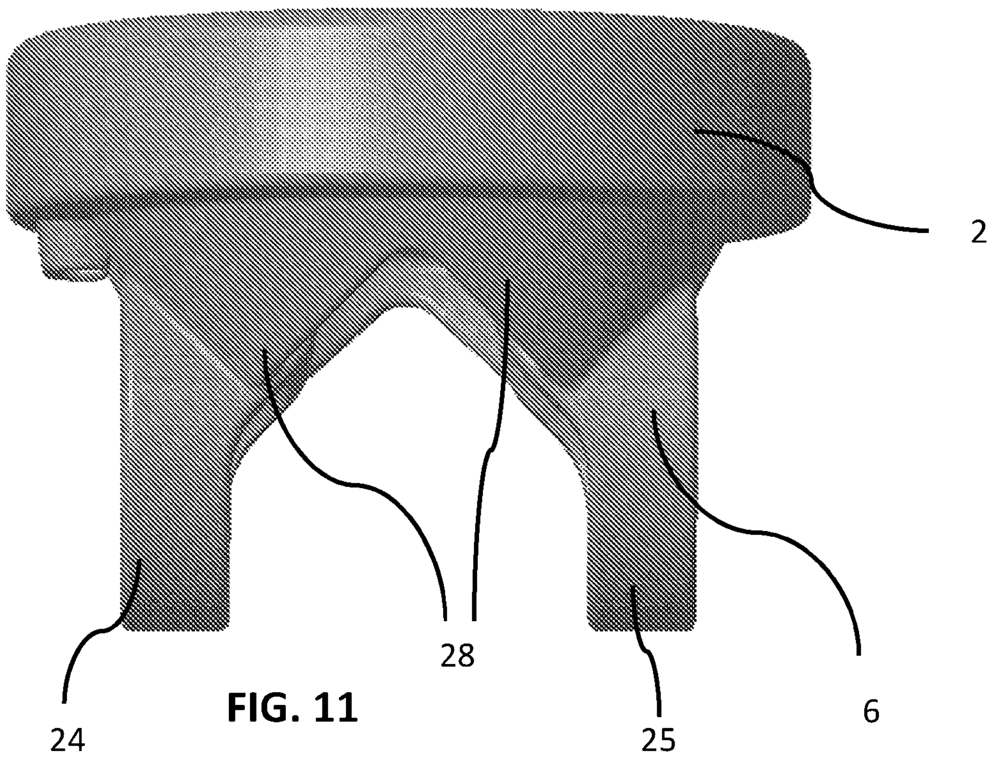


FIG. 11

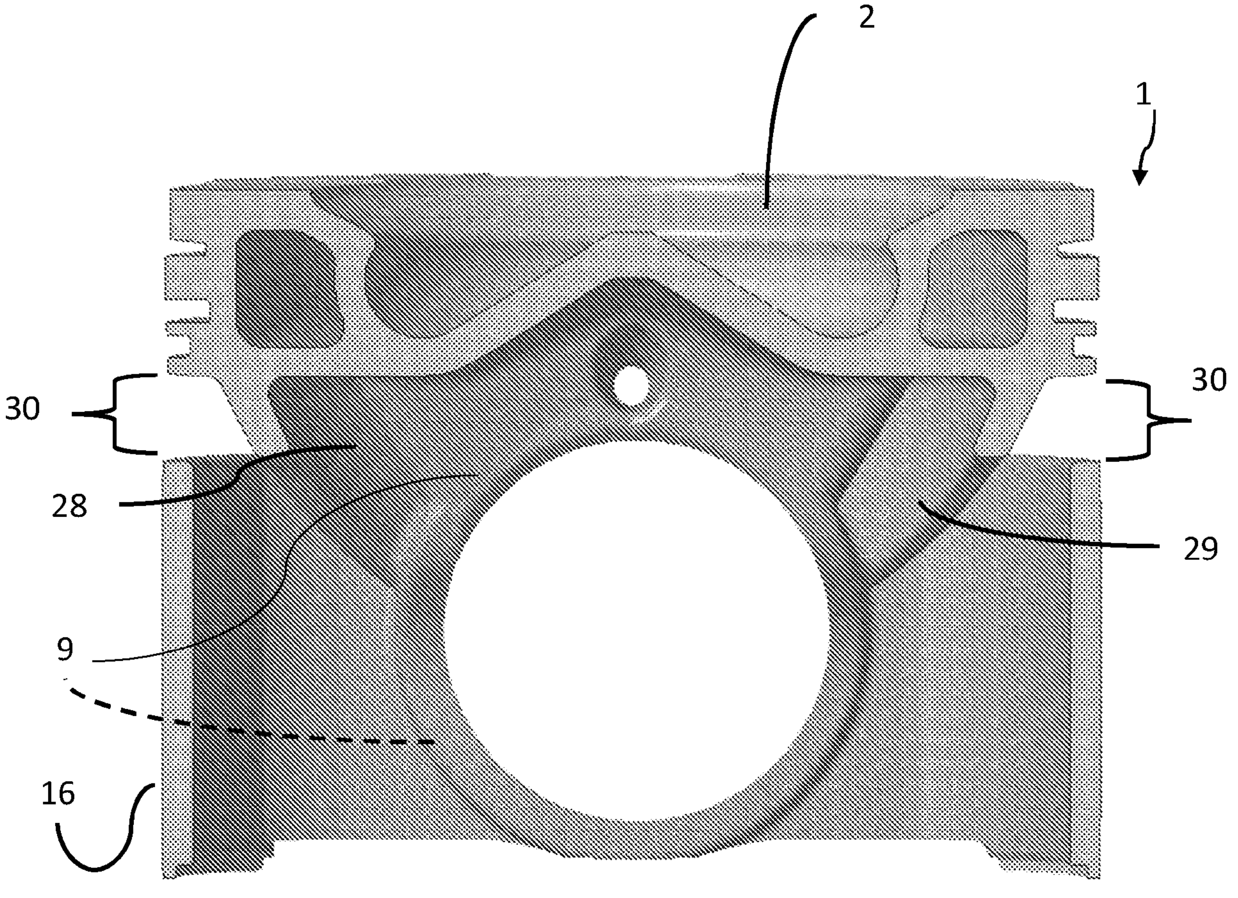


FIG. 12

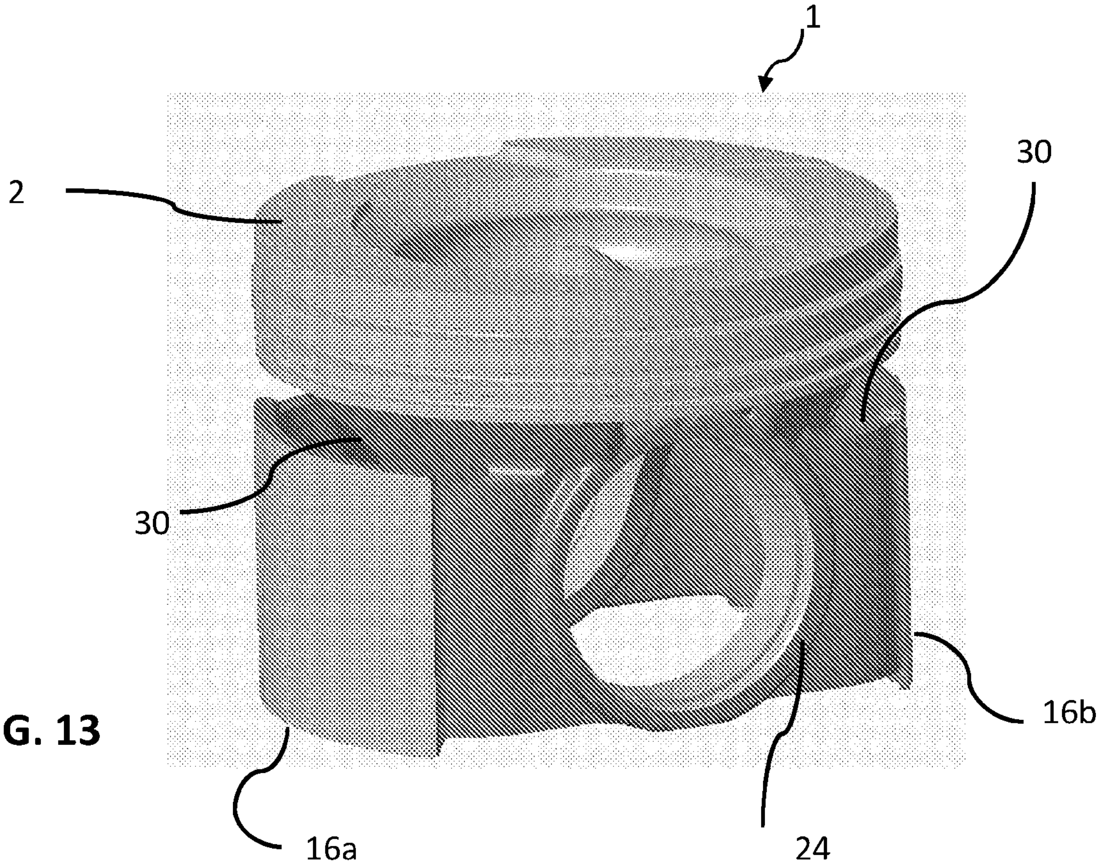


FIG. 13

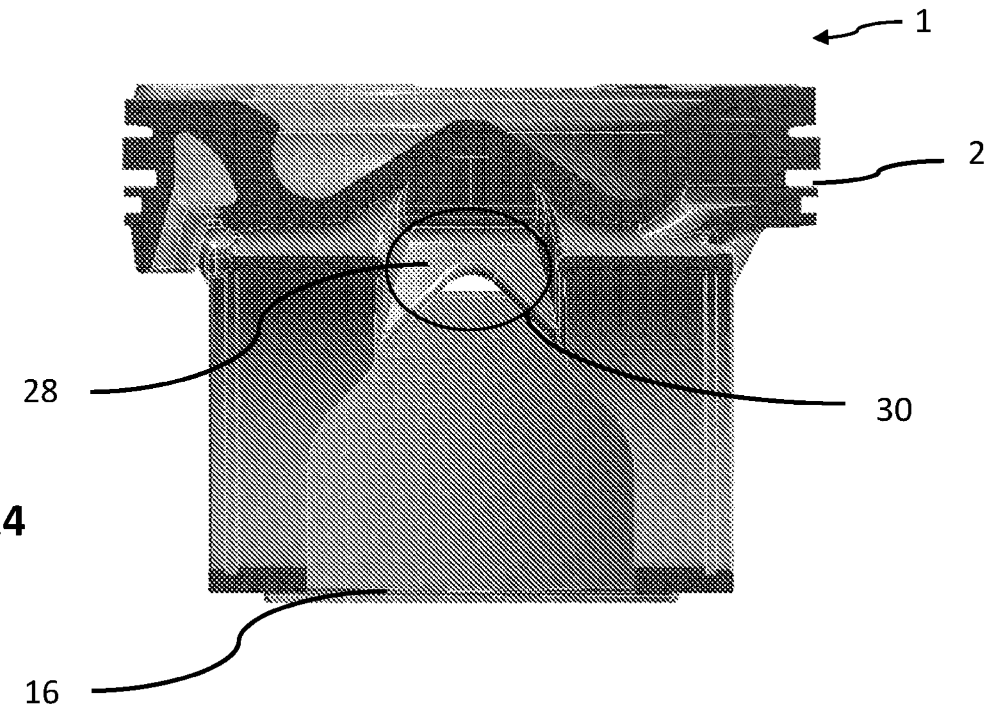


FIG. 14

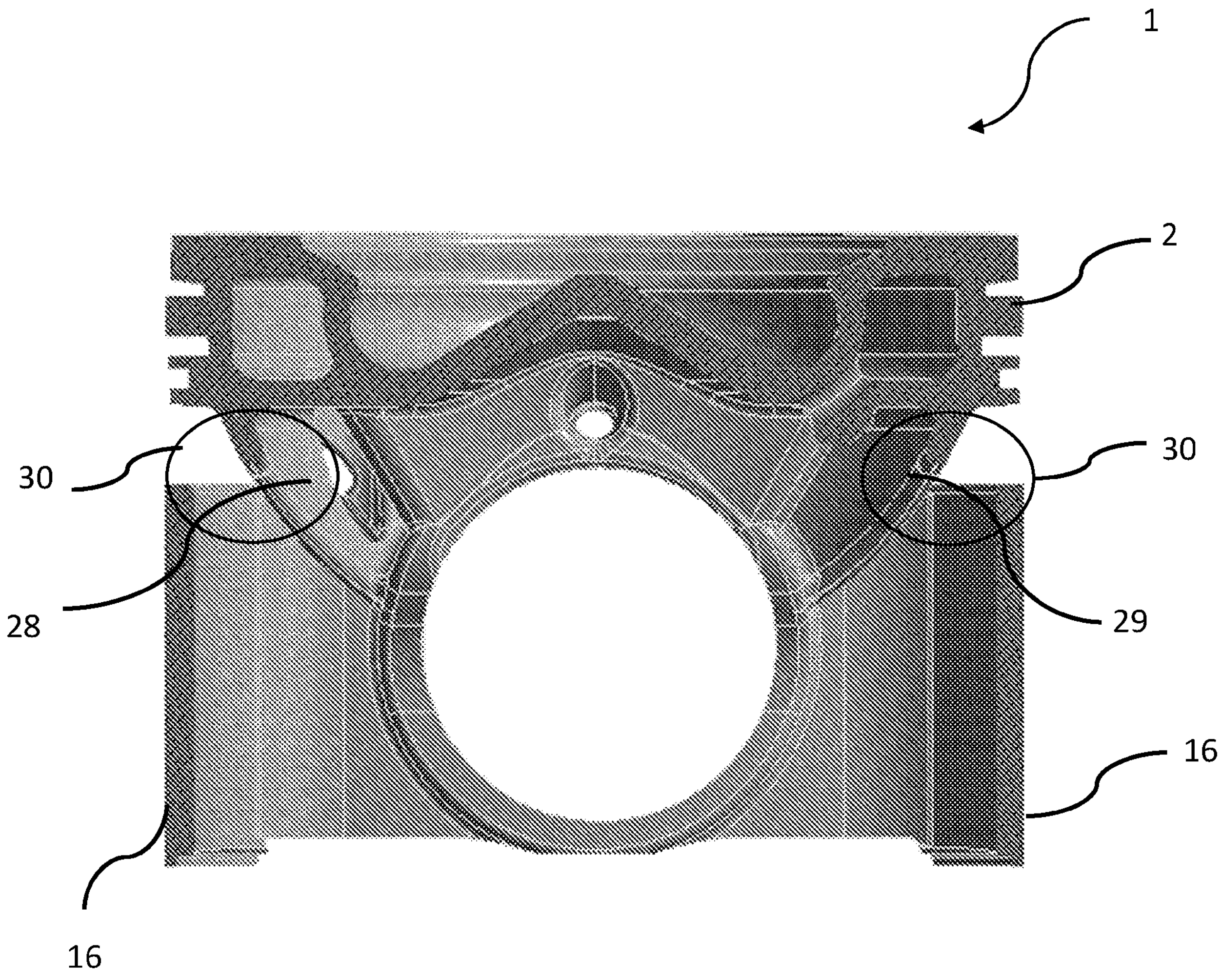


FIG. 15

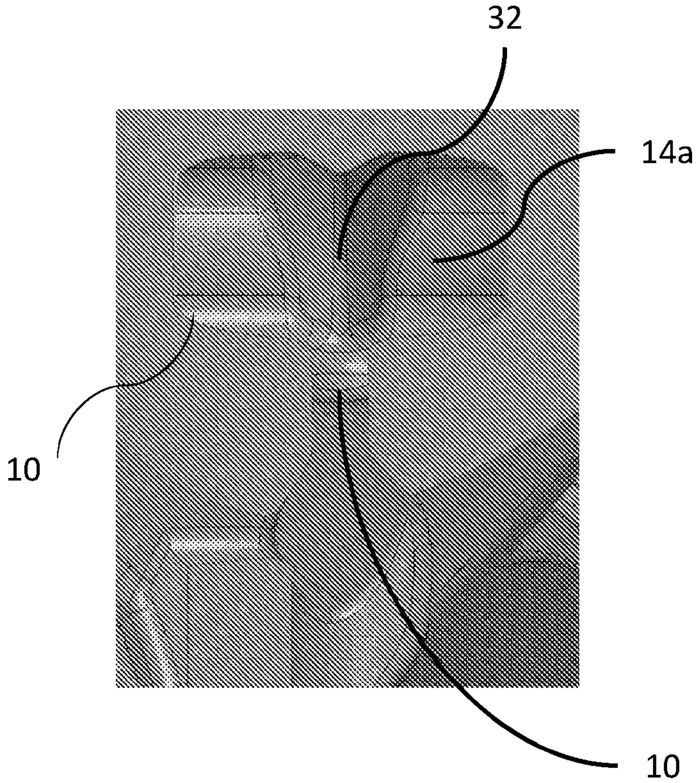


FIG. 16

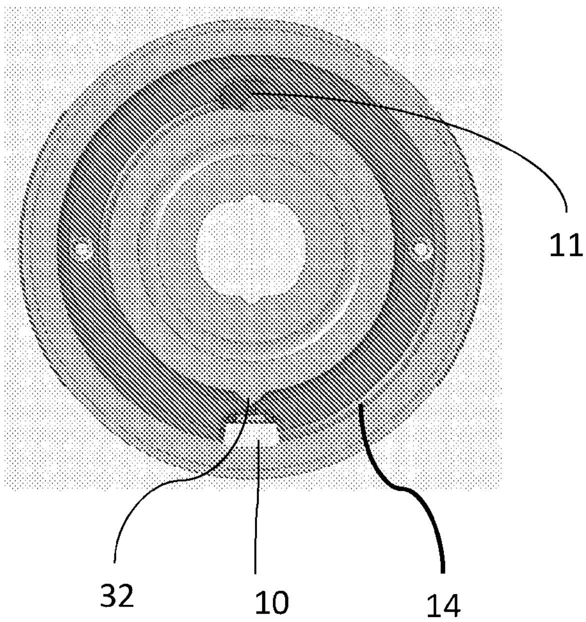


FIG. 17

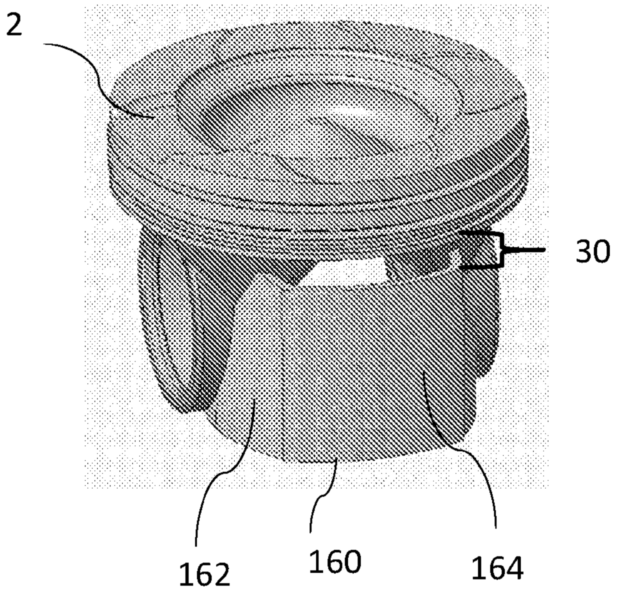


FIG. 18

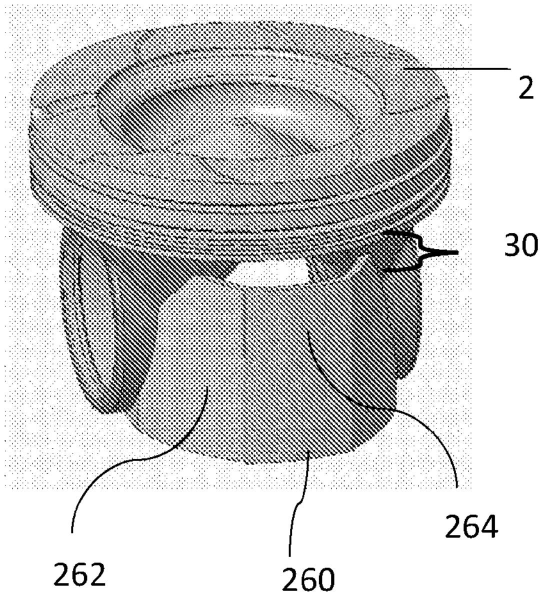


FIG. 19

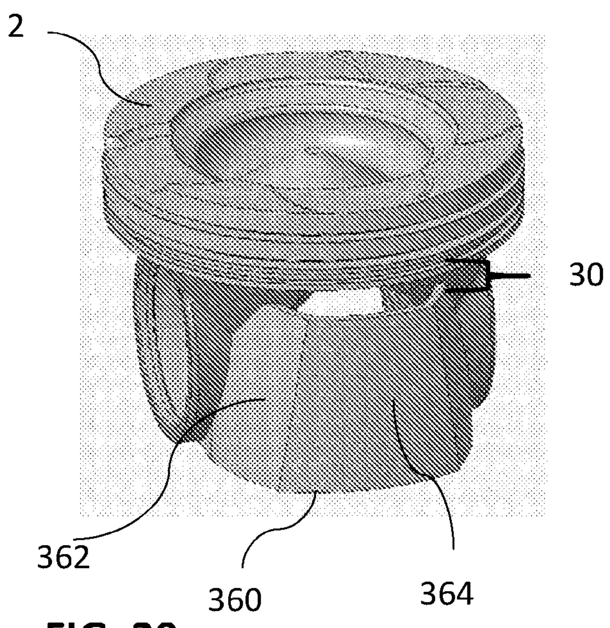


FIG. 20

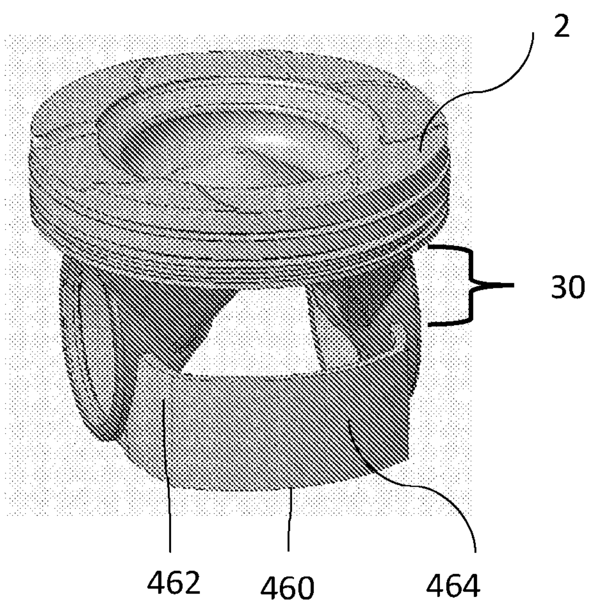
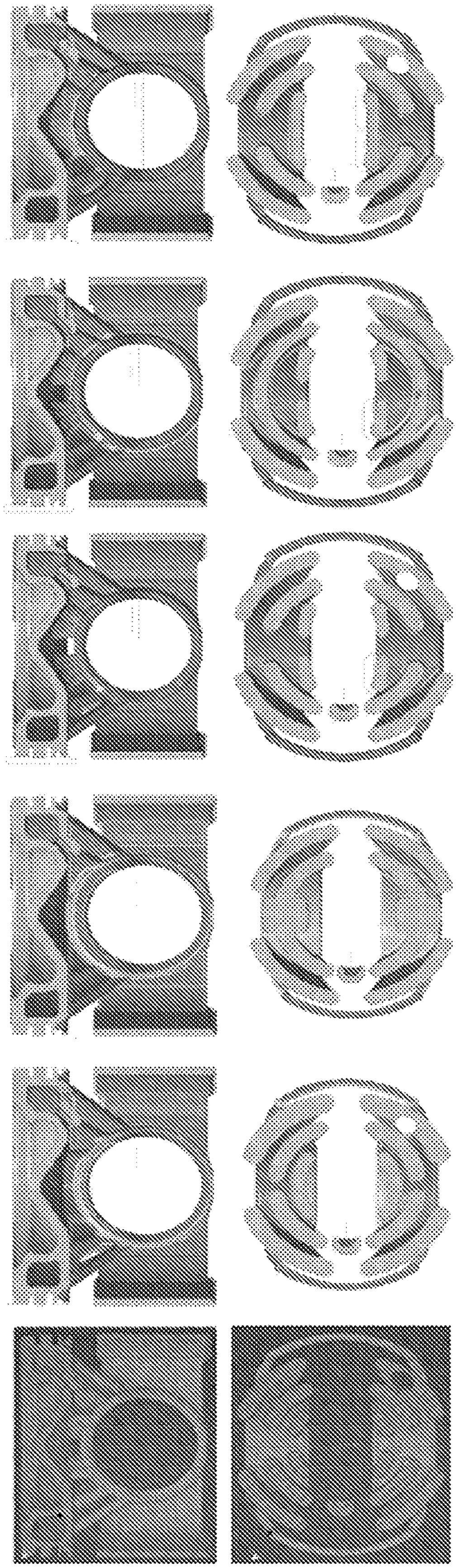


FIG. 21

FIG. 22



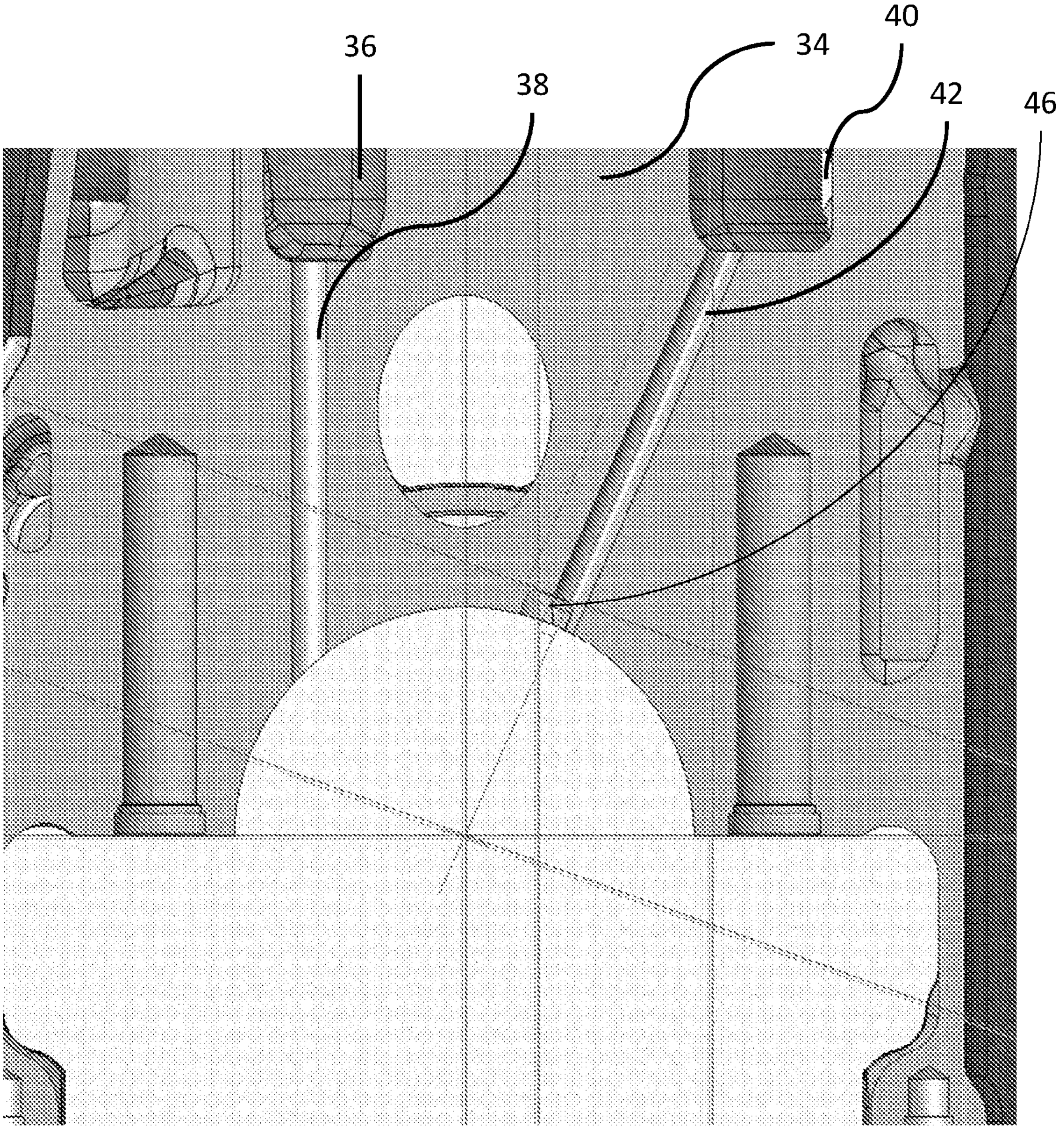


FIG. 23

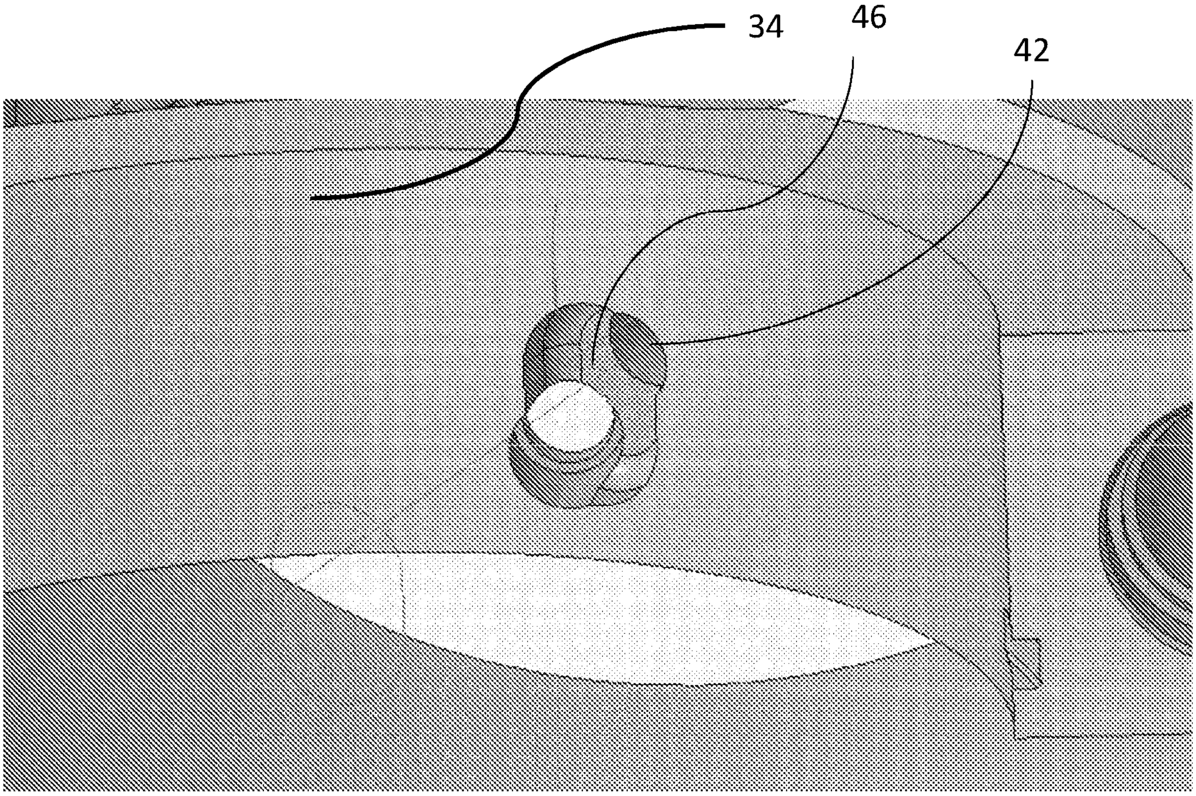


FIG. 24

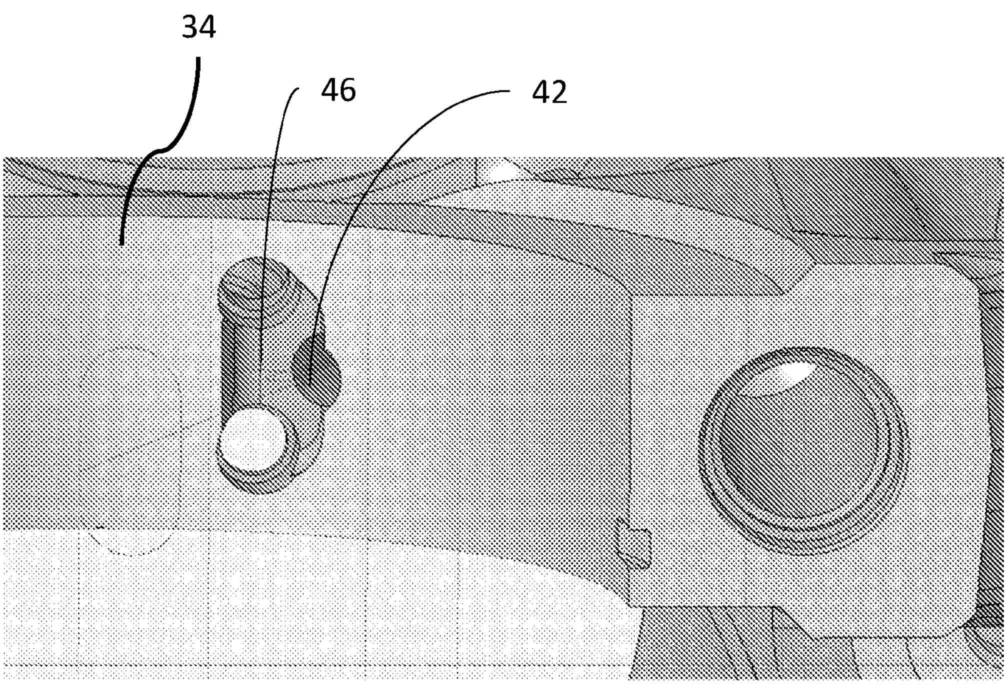


FIG. 25

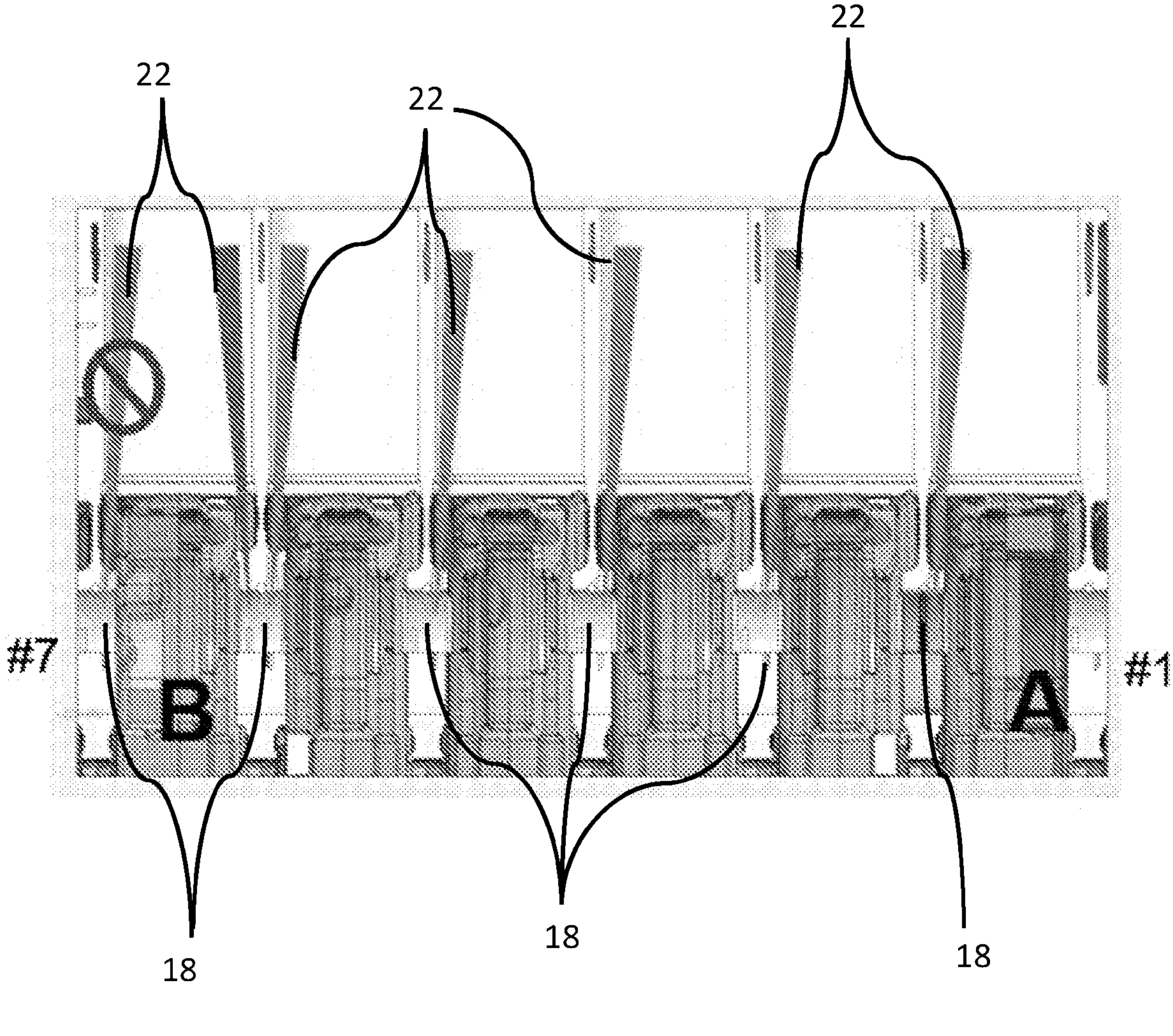


FIG. 26

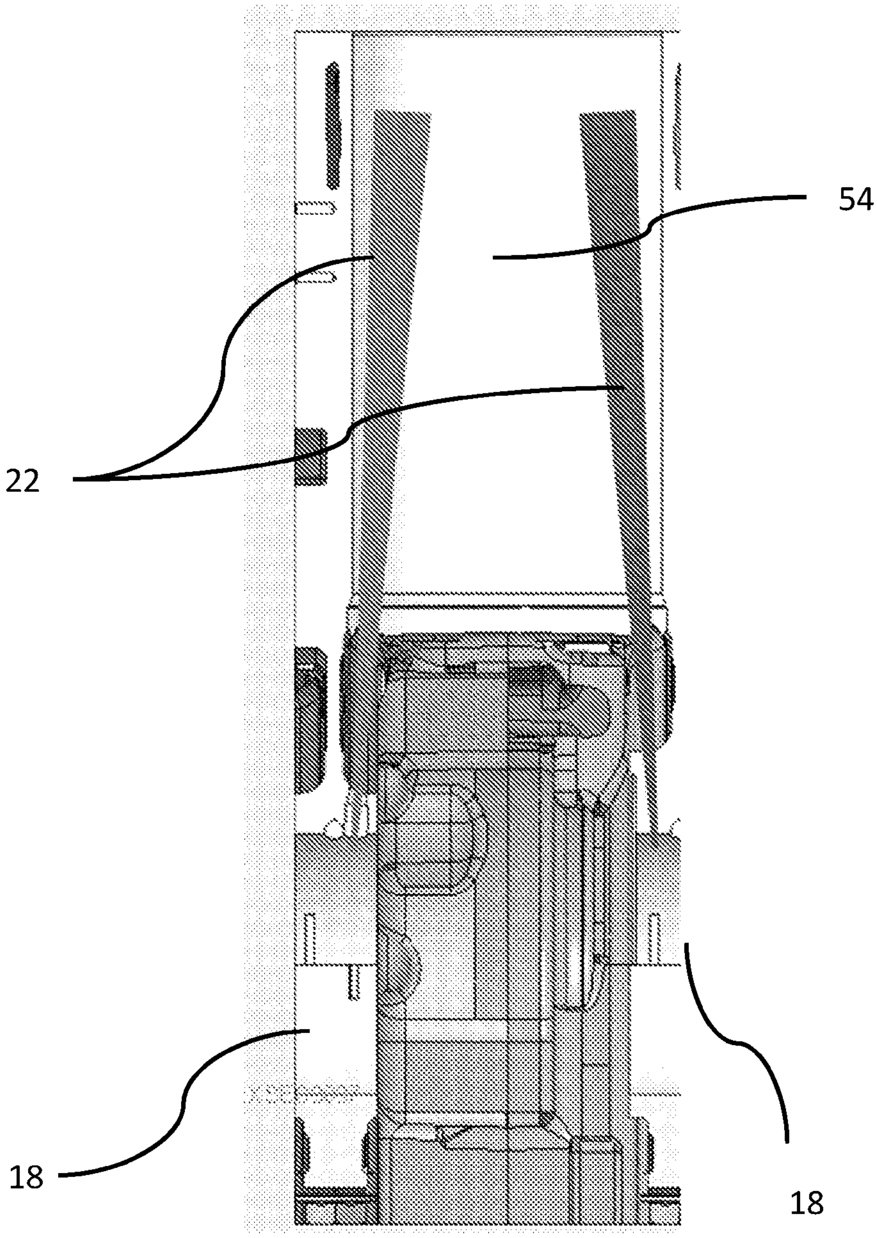


FIG. 27

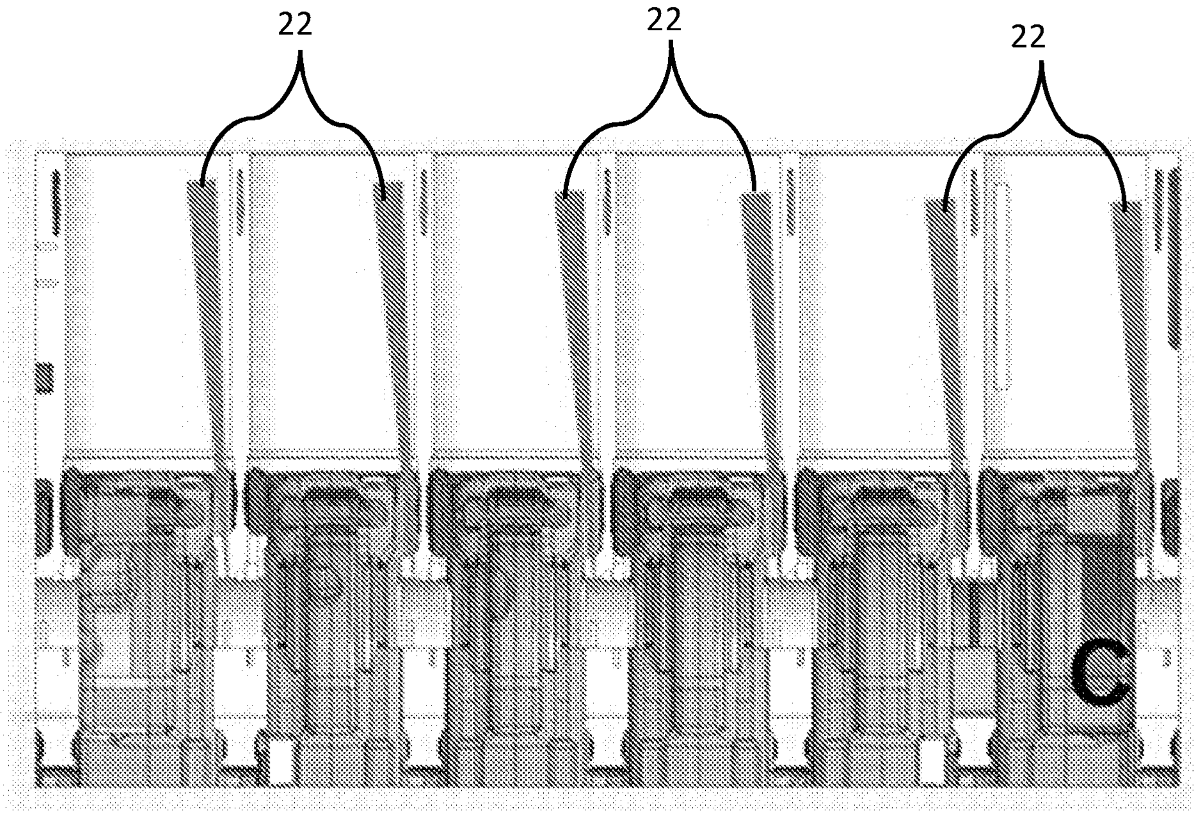


FIG. 28

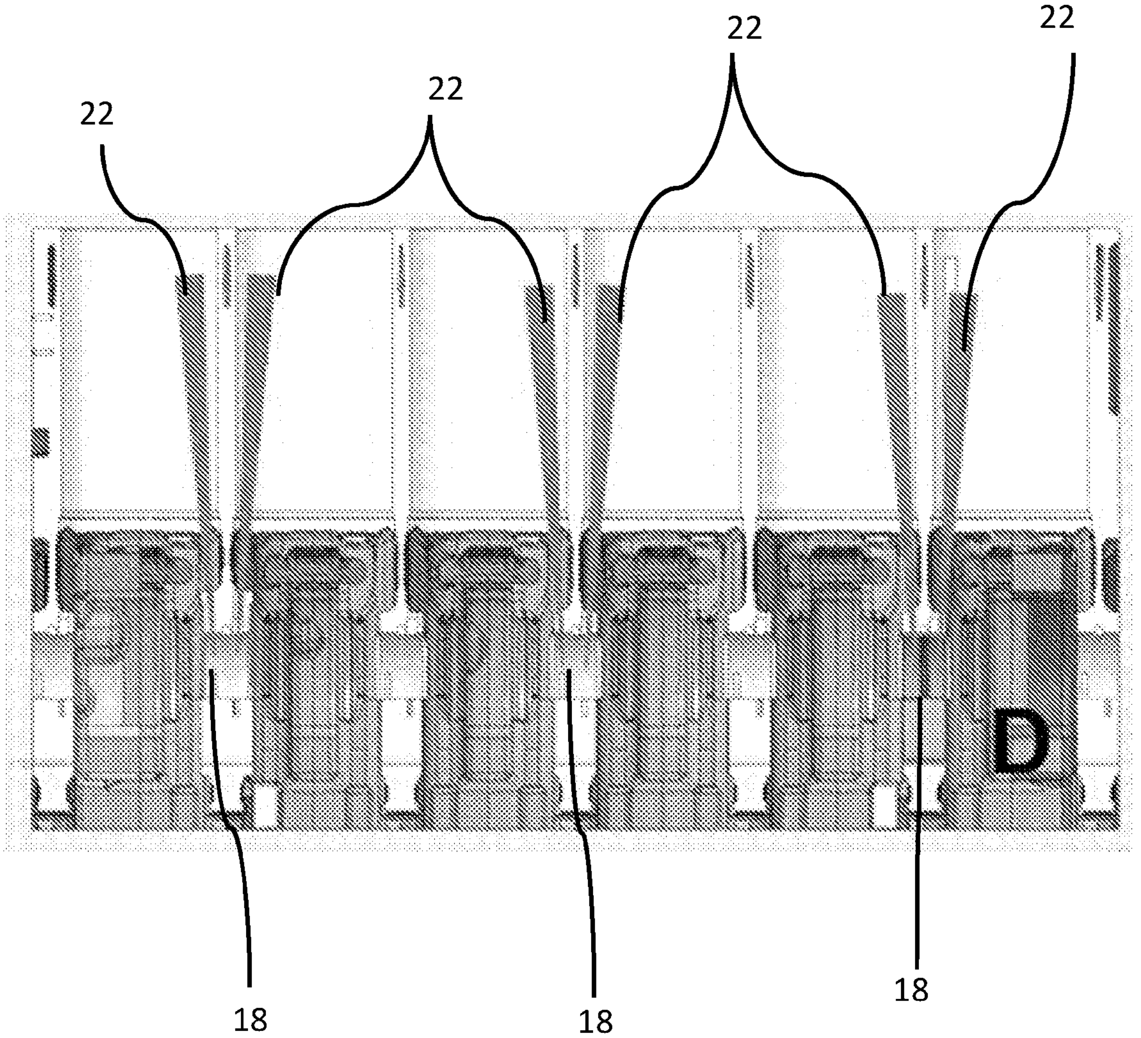


FIG. 29

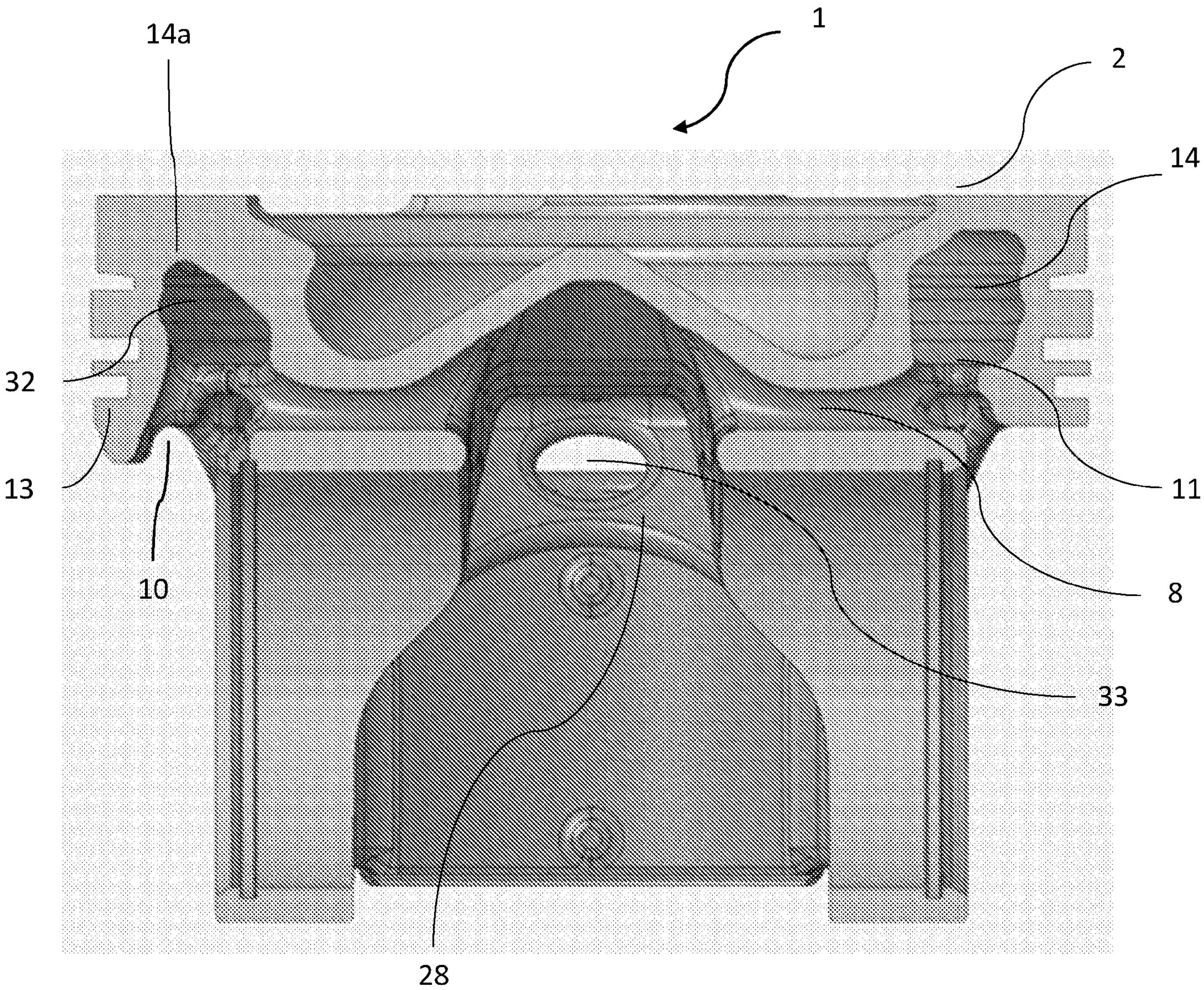


FIG. 30

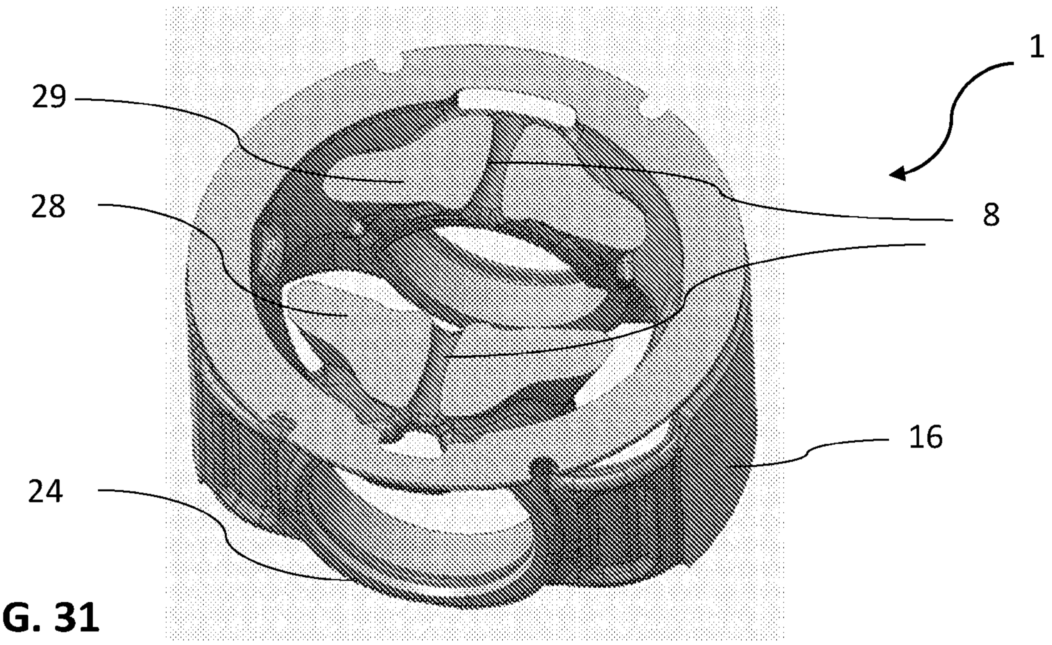


FIG. 31

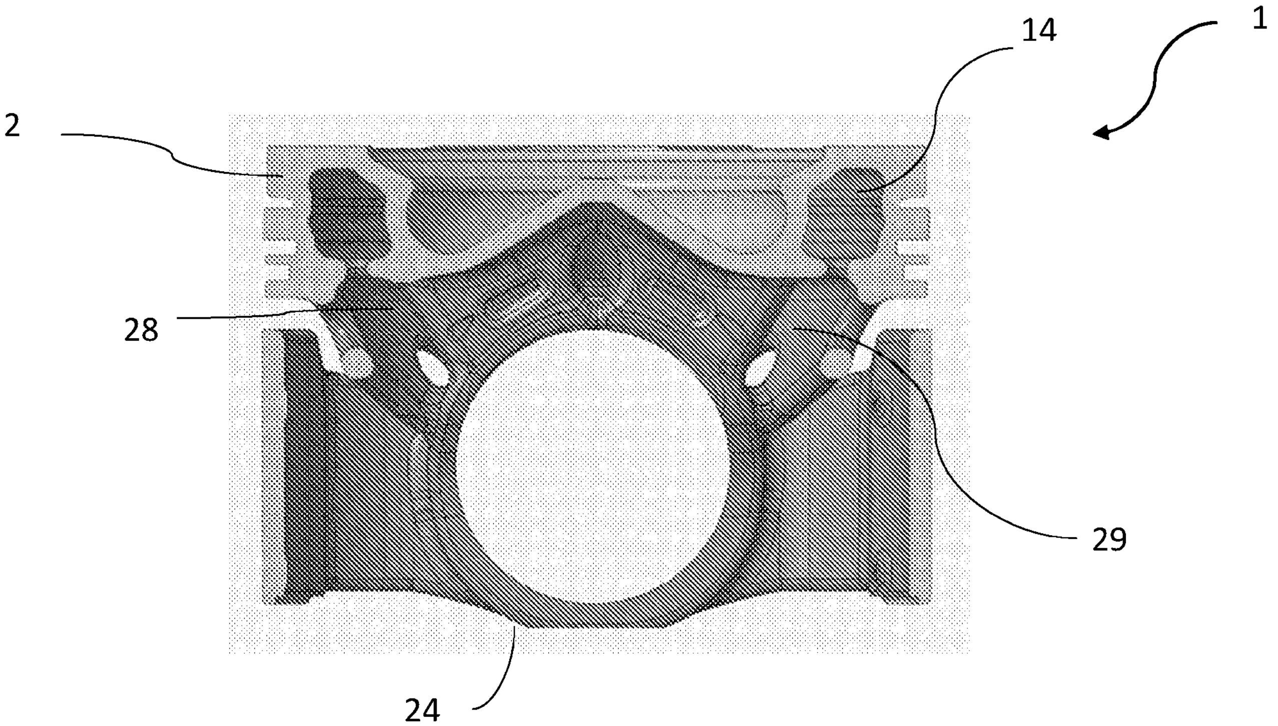


FIG. 32

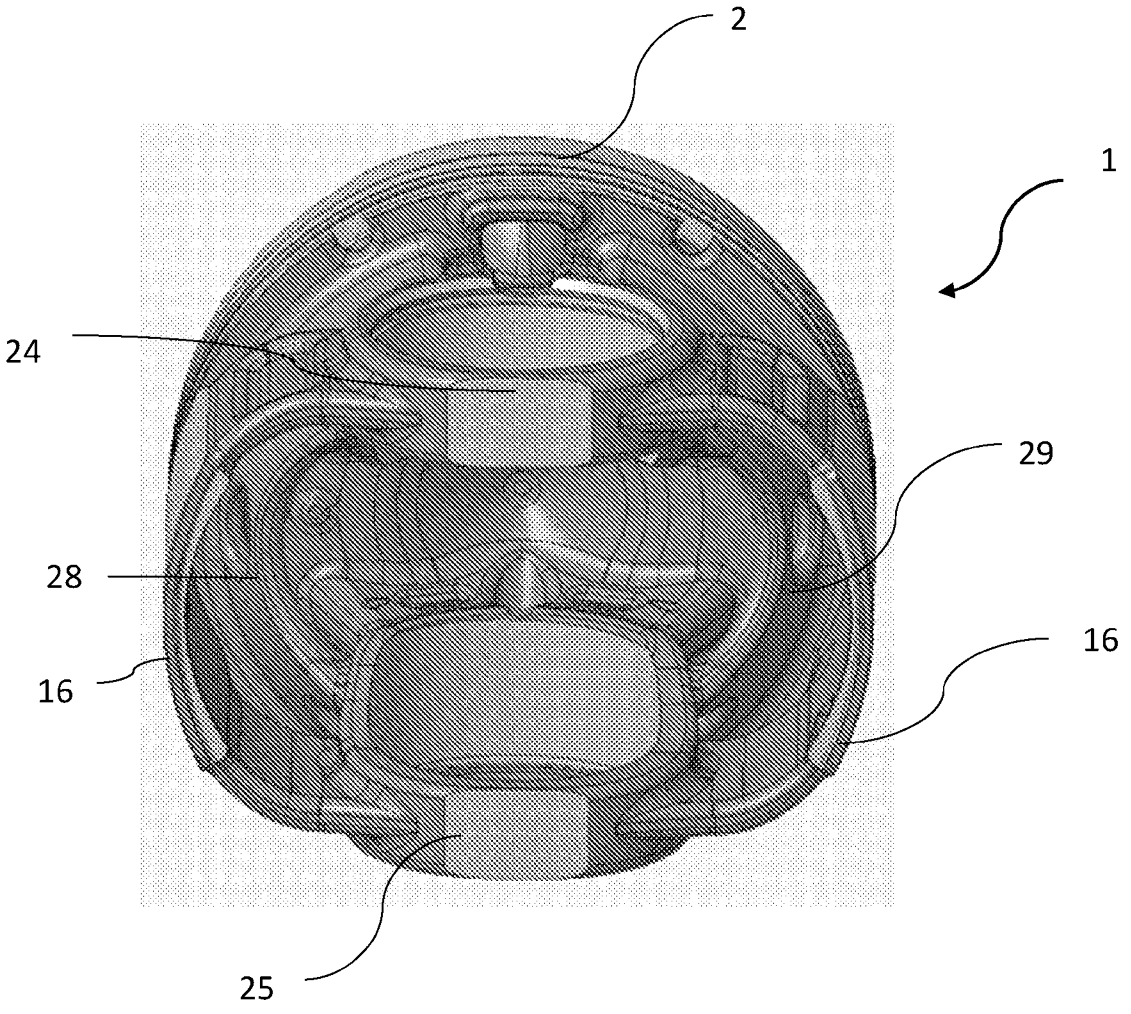


FIG. 33

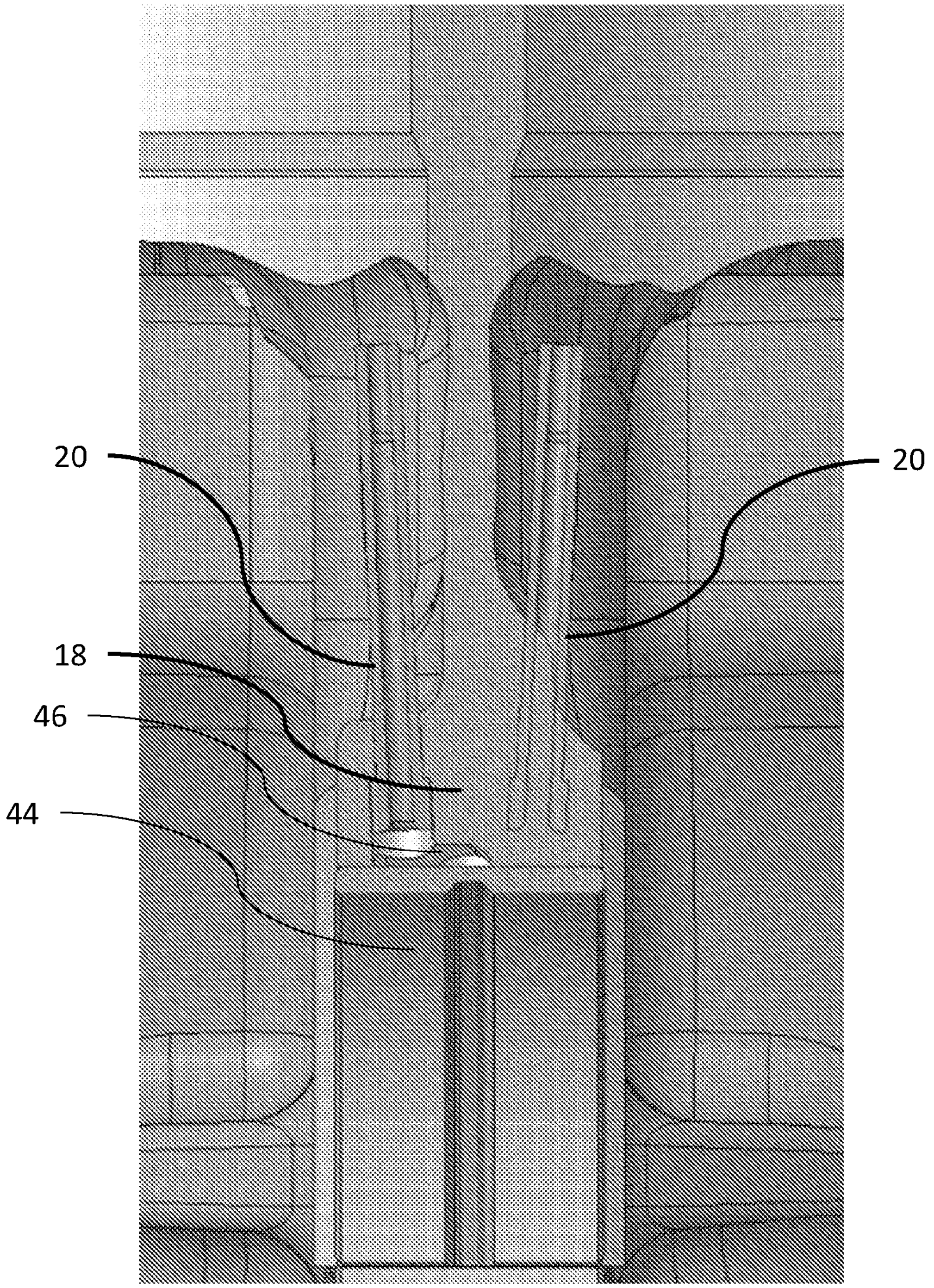


FIG. 34

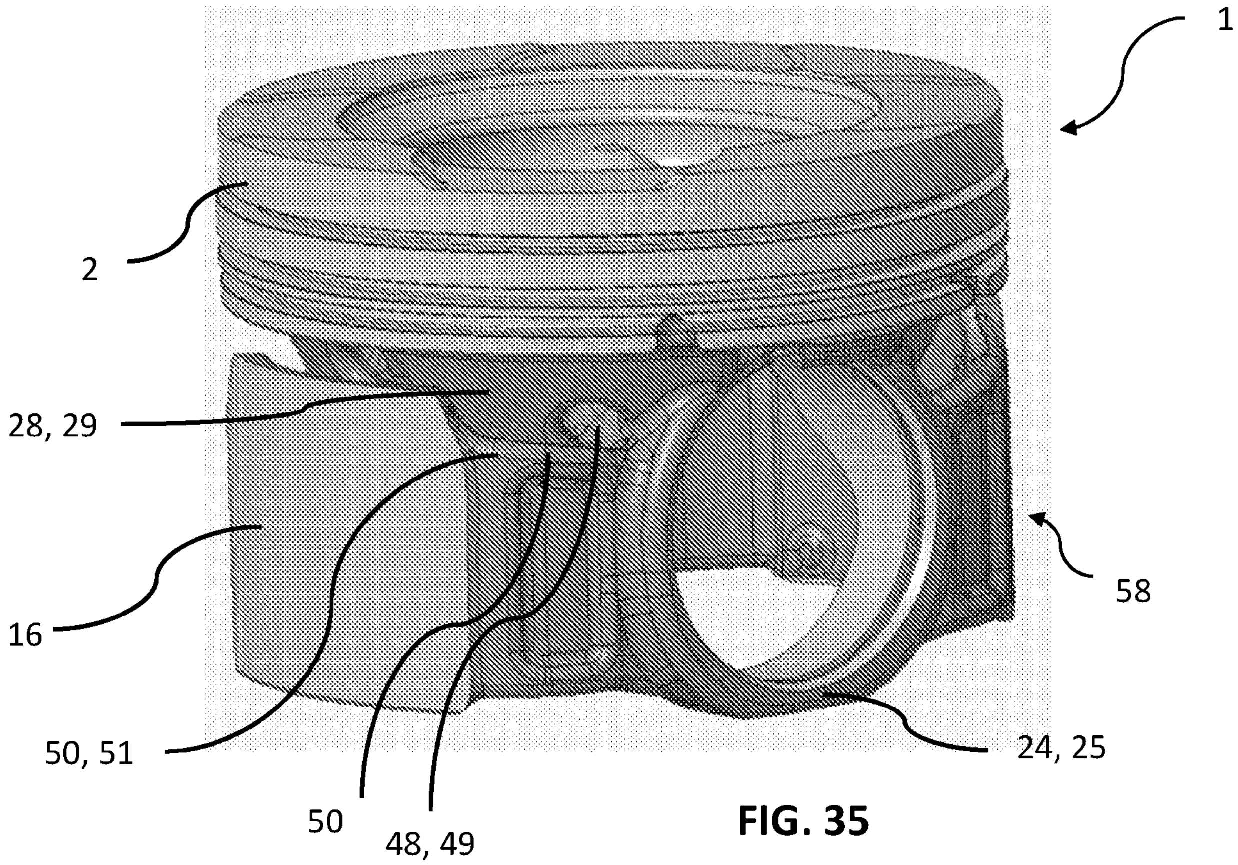


FIG. 35

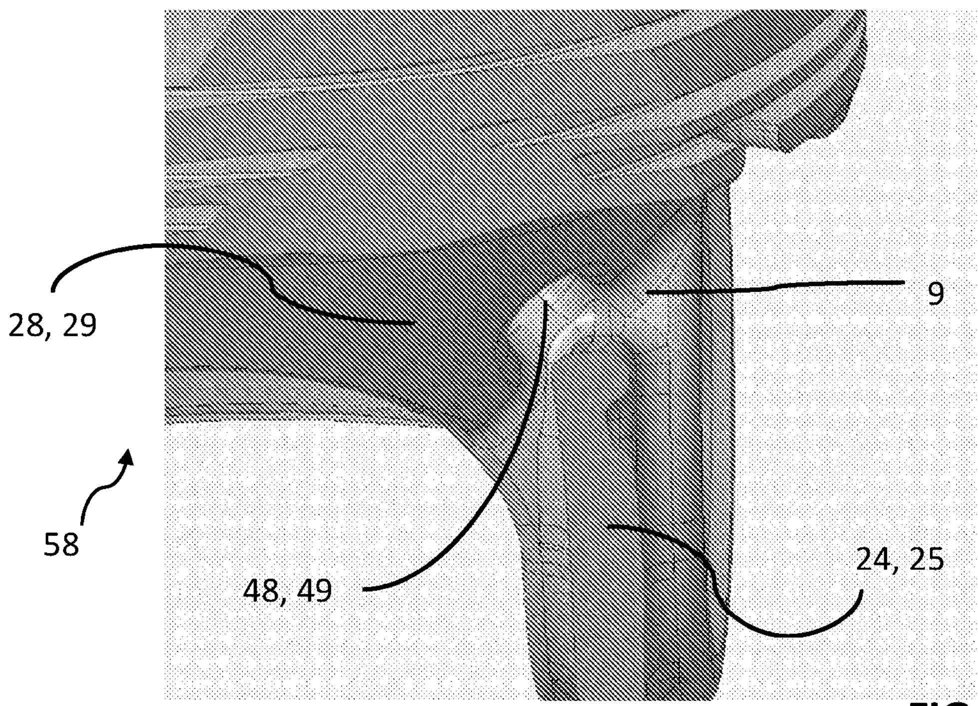


FIG. 36

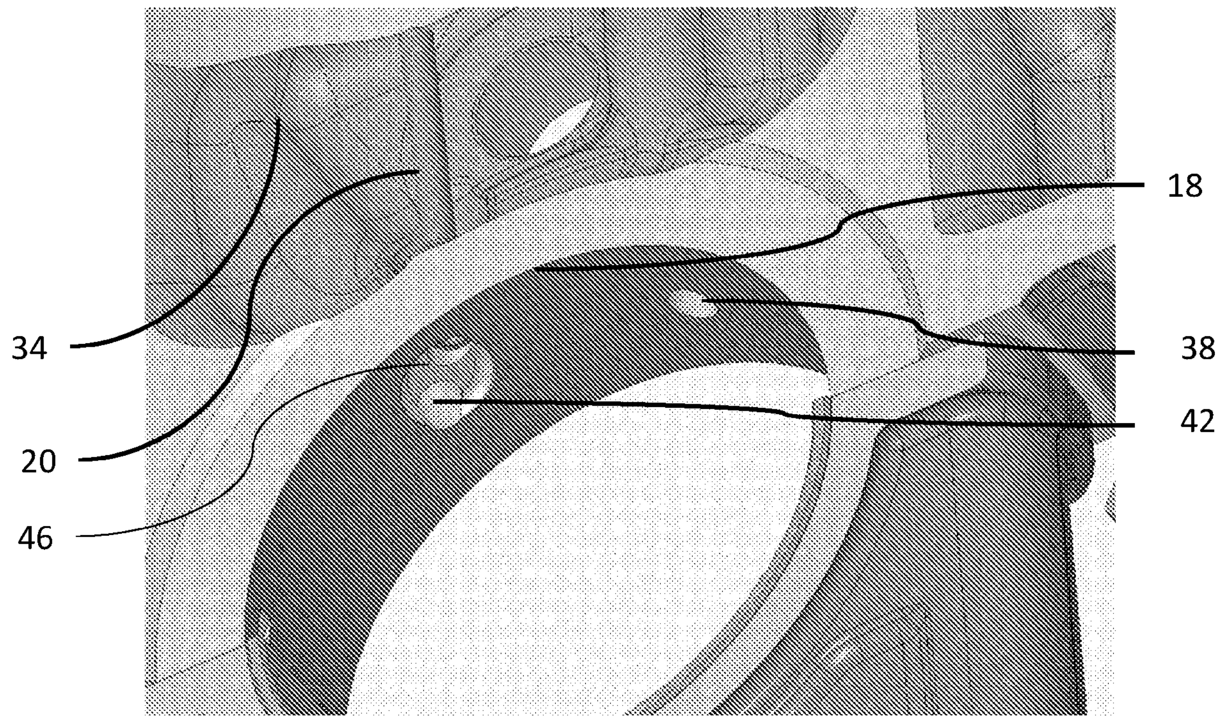


FIG. 37

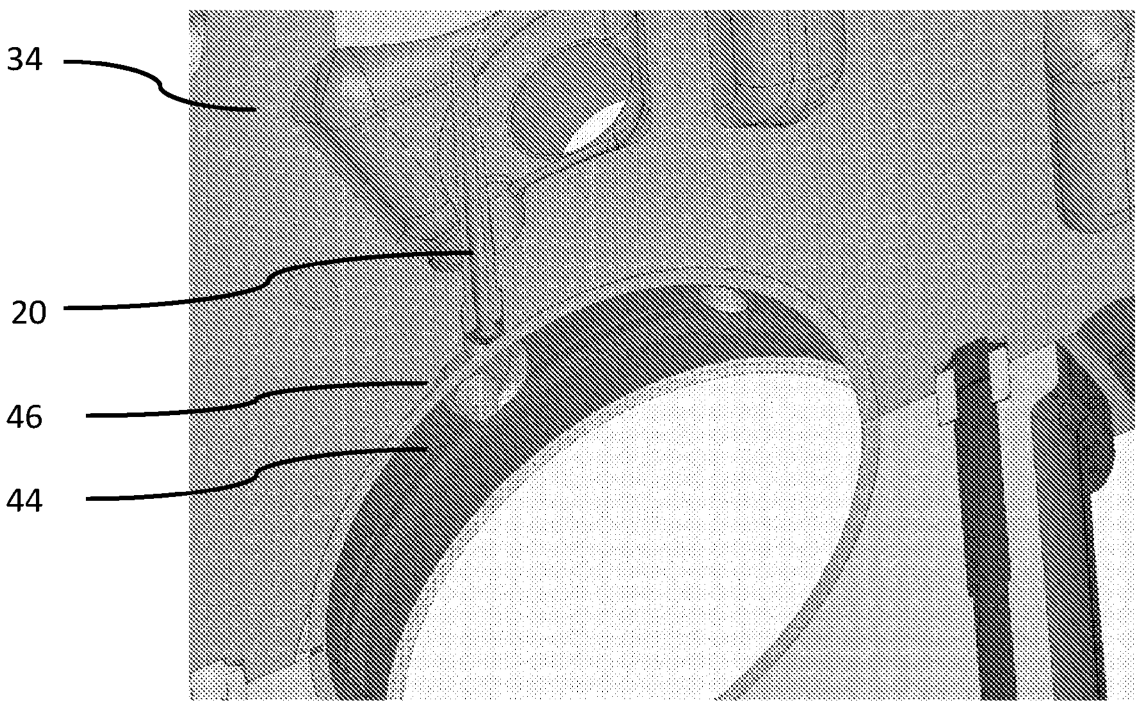


FIG. 38

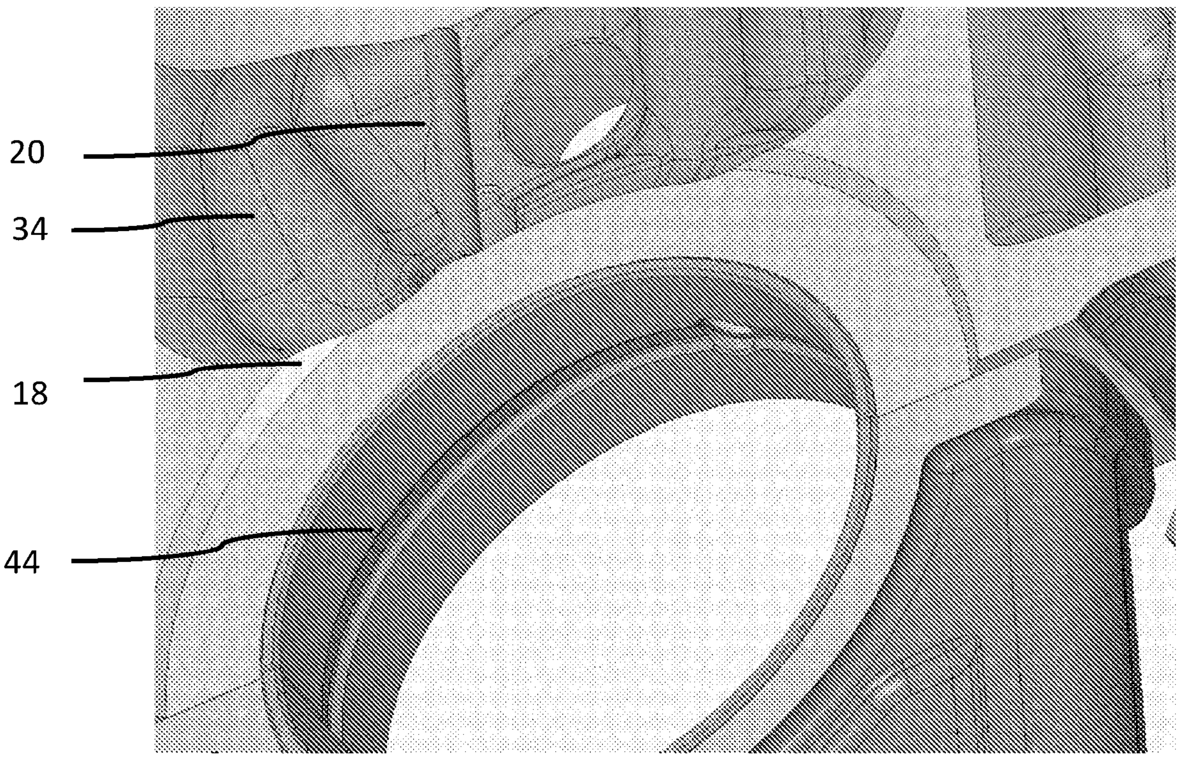


FIG. 39

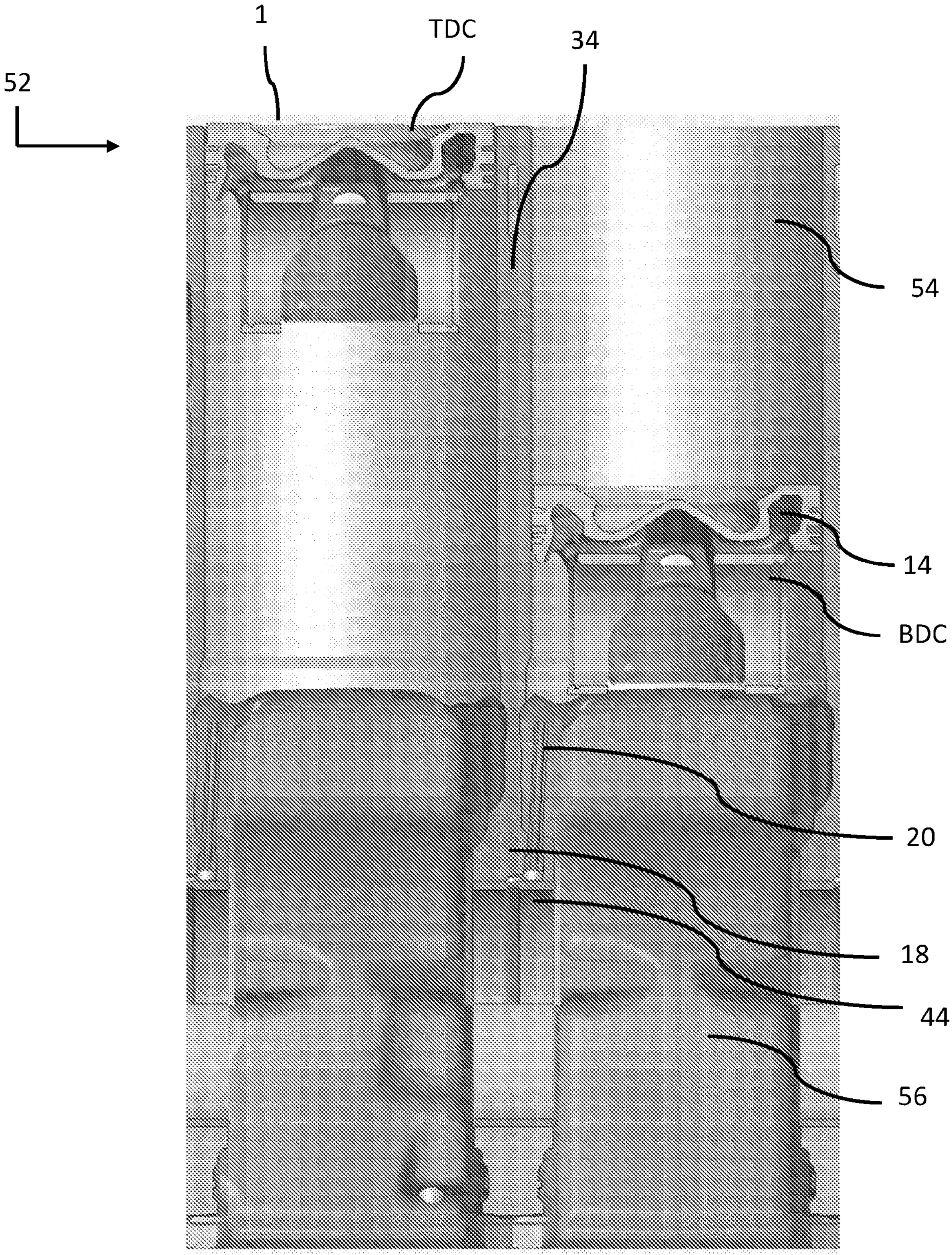


FIG. 40