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(54) **Title:** INTERNAL COMBUSTION ENGINE HAVING COMBUSTION CHAMBER WITH BLENDED HEMISPHERICAL AND PENT-ROOF PORTIONS

(57) **Abstract:** An internal combustion engine is provided including an engine block, a cylinder head mounted on the engine block including a combustion face forming a portion of a combustion chamber, wherein the combustion face includes a pent-roof portion and a hemispherical shaped portion. A first intake valve port formed in the cylinder head includes a first intake valve port opening formed in the pent-roof portion while a second intake valve port formed in the cylinder head includes a second intake valve port opening formed in the pent-roof portion. An exhaust valve port formed in the cylinder head includes an exhaust valve port opening formed in the hemispherical shaped portion. A transition portion may also be included to blend the combustion face connecting the pent-roof and the hemispherical portions. One or more spark plug bore openings are formed and optimally positioned in the combustion face.

INTERNAL COMBUSTION ENGINE HAVING COMBUSTION CHAMBER WITH BLENDED HEMISPHERICAL AND PENT-ROOF PORTIONS

TECHNICAL FIELD

[0001] This disclosure relates to combustion chambers designed to enhance gas flow and combustion efficiency.

BACKGROUND

[0002] Internal combustion engine designers continue to confront an ever more demanding set of governmental mandated emissions standards and performance standards such as fuel efficiency. The desirability of improved fuel efficiency is especially high in the spark ignition engine market given its size.

SUMMARY

This disclosure provides an internal combustion engine, comprising an engine block, a cylinder head mounted on the engine block, wherein the cylinder head includes a combustion face forming a portion of a combustion chamber, and the combustion face includes a pent-roof portion and a hemispherical shaped portion. A first intake valve port formed in the cylinder head includes a first intake valve port opening formed in the pent-roof portion while a second intake valve port formed in the cylinder head includes a second intake valve port opening formed in the pent-roof portion. An exhaust valve port formed in the cylinder head includes an exhaust valve port opening formed in the hemispherical shaped portion.

The engine may further include a first spark plug mounting bore formed in the cylinder head and including a bore opening positioned on one side of the combustion face adjacent the first intake valve port opening and adjacent the exhaust valve port opening. The first spark plug mounting bore may be positioned at least partially between the first intake valve port opening and the exhaust valve port opening. A second spark plug mounting bore may be formed

in the cylinder head and include a bore opening positioned on an opposite side of the combustion face from the first spark plug mounting bore adjacent the second intake valve port opening and adjacent the exhaust valve port opening. The combustion face may further include a transition portion connecting the pent-roof portion and the hemispherical portion, wherein the transition portion extends across an entire diameter of the combustion face. The transition portion may occupy no more than 20% of the combustion face. The engine may further include two spark plug mounting bores having respective openings formed within at least one of the hemispherical portion and said transition portion. The two spark bore openings may each be positioned in both the hemispherical portion and the transition portion. At least 70% of each of the first intake valve port opening and the second intake valve port opening may be positioned in the pent-roof portion. At least 70% of the exhaust valve port opening may be positioned in the hemispherical portion.

The disclosure also provides an internal combustion engine, comprising an engine block, a cylinder head mounted on the engine block, wherein the cylinder head includes a combustion face forming a portion of a combustion chamber. The combustion face includes a pent-roof portion, a hemispherical shaped portion, and a transition portion connecting the pent-roof portion and the hemispherical portion. A first intake valve port formed in the cylinder head includes a first intake valve port opening formed in the pent-roof portion, while an exhaust valve port formed in the cylinder head includes an exhaust valve port opening formed in the hemispherical shaped portion. A spark plug mounting bore formed in the cylinder head includes a bore opening formed in at least one of the hemispherical shaped portion and the transition portion.

[0003] Advantages and features of the embodiments of this disclosure will become more apparent from the following detailed description of exemplary embodiments when viewed in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0004] FIG. 1 is a bottom view of an exemplary embodiment of the cylinder head including the combustion face of the present disclosure;
- [0005] FIG. 2 is a cross-sectional view of the cylinder head taken along plane 3-3 in FIG. 1;
- [0006] FIG. 3 is a perspective view of the cylinder head including the combustion face of FIG. 1 showing the shape of the pent-roof, transition, and hemispherical portions without the intake and exhaust valves;
- [0007] FIG. 4 is a perspective view of the cylinder head including the combustion face of FIG. 1 showing the shape of the pent-roof, transition, and hemispherical portions with the intake and exhaust valves; and
- [0008] FIG. 5 is a cross-sectional view of the cylinder head including the combustion face taken along plane 5-5 in FIG. 1.

DETAILED DESCRIPTION

[0009] Embodiments of the present disclosure significantly improve the fuel efficiency of spark ignition engines by providing improved porting and enhanced spark ignition. Referring to the FIGS. 1 and 2, an exemplary embodiment of an engine 10 of the present disclosure includes a cylinder or engine block, only a small portion of which is illustrated at 2 (FIG. 2), and at least one combustion chamber 3. Of course, the engine may contain a plurality of combustion chambers, typically four to eight, which may be arranged in a line or in a "V" configuration. Each combustion chamber 3 is formed at one end of a cylinder cavity 4 which may be formed directly in engine block 2. The cylinder cavity 4 may be arranged to receive a removable cylinder liner 19 which is only partially shown in FIG. 2.

[0010] One end of each cylinder cavity 4 is closed by an engine cylinder head 12 having a combustion face 13 of the present disclosure associated with each cavity 4 as discussed more fully hereinbelow. Engine 10 further includes a

respective piston 21 mounted in a corresponding liner 19 associated with each combustion chamber. Although only a top portion of piston 21 is shown in FIG. 2, piston 21 may be any type of piston. For example, piston 21 may be an articulated piston or a single piece piston design. The upper surface or top face of piston 21 cooperates with head 12 and the portion of cylinder liner 19 extending between head 12 and piston 21 to define combustion chamber 3. Although not specifically illustrated, piston 21 is connected through a connecting rod to a crankshaft of the internal combustion engine which causes the piston to reciprocate along a rectilinear path within cylinder liner 19 as the engine crankshaft rotates. FIG. 2 illustrates the position of piston 21 in a top dead center (TDC) position achieved when the crankshaft is positioned to move the piston to the furthest most position away from the rotational axis of the crankshaft. In the conventional manner, the piston moves from the top dead center position to a bottom dead center (BDC) position when advancing through intake and power strokes.

[0011] Engine 10 is a four-cycle spark ignition engine employing premixed fuel and air. A pair of intake ports or passages 25, 27 having respective intake port openings 29, 31 formed in combustion face 13 selectively direct intake air and fuel into combustion chamber 3 by means of a pair of intake valves 18, 20. Similarly, an exhaust port or passage 30 having an exhaust port opening 32 formed in combustion face 13 selectively directs exhaust gas from combustion chamber 3 by means of an exhaust valve 34. The opening and closing of valves 25, 27 and 34 may be achieved by a mechanical cam or hydraulic actuation system or other motive system in carefully controlled time sequence with the reciprocal movement of piston 21. The amount of charge air that is caused to enter the combustion chambers may be increased by providing a pressure boost in the engine's intake manifold. This pressure boost may be provided, for example, by a turbocharger, not illustrated, driven by a turbine powered by the engine's exhaust, or maybe driven by the engine's crankshaft.

[0012] Each combustion face 13 of cylinder head 12 is formed with a particular combination of shaped surfaces or portions, and intake and exhaust

port openings sized and positioned on those portions of combustion face 13 in a particular location, resulting in improved flow and enhanced combustion efficiency. The combustion face 13 preferably also includes one or more spark plugs positioned in a predetermined location to optimize combustion. Specifically, combustion face 13 includes a pent-roof section or portion 14 and a hemispherical, i.e. semispherical, shaped section or portion 16 to optimize the function of the valves and the spark plug(s). In addition, in the exemplary embodiment, combustion face 13 further includes a blended or transition section or portion 17 connecting pent-roof portion 14 and hemispherical portion 16. Transition portion 17 is designed to occupy as little space/area, i.e. no more than 20%, of combustion face 13 as possible to smoothly blend the two geometries (pent-roof and hemispherical), while pent-roof portion 14 and hemispherical portion 16 may occupy approximately equal amounts of the remainder of the combustion face or hemispherical portion 16 may occupy slightly more combustion face area than pent-roof portion 14. A pressure transducer may be inserted into a central passage 23.

[0013] In the exemplary embodiment, the two intake port openings 29, 31 are located on the pent-roof portion 14 and thus are positioned at an acute angle relative to the lower planar surface of cylinder head 12 (i.e. angled relative to the upper surface of the engine block 2/liner 19 (FIG. 2)). Specifically, a substantial portion, i.e., at least 70%, of each intake valve port opening 29, 31 is located in the pent-roof portion while a smaller remaining portion, i.e., less than 30%, is located in transition portion 17. The exhaust valve port opening 32, also positioned at an angle, is located on the hemispherical shaped side or portion 16. Specifically, a substantial portion, i.e., at least 70%, of exhaust valve port opening 32 is located in the hemispherical portion 16 while a smaller remaining portion, i.e., less than 30%, is located in transition portion 17. The intake valves, and the exhaust valve, are each positioned in the respective ports and openings. A first spark plug mounting bore and opening 26, for receiving a spark plug 36, is positioned in the open/available surface area of combustion face 13 on one side of face 13 and exhaust valve opening 32 adjacent intake valve port opening

29. A second spark plug mounting bore and opening 28, for receiving a spark plug 38, is positioned adjacent intake valve port opening 31 on an opposite side of both the combustion face 13 and exhaust valve port opening 32 from bore opening 26. In the exemplary embodiment, the plug bore openings 26, 28 are partially positioned in both the transition and hemispherical portions in the space between a respective intake valve port opening and the exhaust valve port opening. The spark plug bores are located to maintain a minimum design distance between valve openings to achieve a sufficient wall thickness providing the strength necessary to prevent a structural failure while optimizing combustion ignition and efficiency.

[0014] A goal of this cylinder head is to maximize the efficiency of the intake and exhaust ports. By angling the port openings and respective valves relative to the combustion face 13 (FIG. 1), it is possible to increase the size of the intake ports, openings and valves while at the same time provide more room for the spark plug boss or bosses. Applicant has determined that a three valve design with dual spark plugs produces a very efficient package with the two intake valves/ports/openings positioned in the pent-roof shaped face or portion 14 and the single exhaust valve/port/opening positioned in hemispherical shaped face or portion 16. This combustion chamber arrangement allows for maximum valve area (maximizing the size of the valve port openings) with minimal flow interference (also known as masking) from the head surface that surrounds the openings and valves. The improved flow afforded by this new configuration lowers the pumping work required and improves the fuel consumption of the engine. Another advantage of this design is that it allows for the placement of two spark plugs in the open/available surface area on opposite sides of the combustion chamber and strategically positioned on opposite sides of the exhaust valve opening, with each plug bore opening being positioned adjacent a respective one intake valve. Each spark plug bore opening may be positioned at least partially between the exhaust valve and a respective intake valve opening. This placement of multiple plugs has been shown to promote rapid and efficient

combustion thereby reducing the combustion duration, also improving fuel economy.

[0015] The number, position, and arrangement of the valves, in combination with the shape of the combustion chamber portions, allows for efficient placement/positioning of one or more spark plugs in the remaining open space/area of the cylinder head forming the combustion chamber. In this manner, the system of the present disclosure packages the intakes valves, spark plug(s), and exhaust valves to optimize the area of the cylinder face 13 forming the combustion chamber.

[0016] Thus, embodiments described herein include the use of a blended pent-roof and hemispherical combustion chamber shape with two intake valves, a single exhaust valve located on the respective sides along with at least one, but preferably two, spark plugs. This combination yields significant improvement in flow and combustion efficiency relative to the industry standard flat face combustion deck.

[0017] While various embodiments of the disclosure have been shown and described, it is understood that these embodiments are not limited thereto. The embodiments may be changed, modified and further applied by those skilled in the art. Therefore, these embodiments are not limited to the detail shown and described previously, but also include all such changes and modifications.

We Claim:

1. An internal combustion engine, comprising:
 - an engine block;
 - a cylinder head mounted on said engine block, said cylinder head including a combustion face forming a portion of a combustion chamber, said combustion face including a pent-roof portion and a hemispherical shaped portion;
 - a first intake valve port formed in said cylinder head, said first intake valve port including a first intake valve port opening formed in said pent-roof portion;
 - a second intake valve port formed in said cylinder head, said second intake valve port including a second intake valve port opening formed in said pent-roof portion; and
 - an exhaust valve port formed in said cylinder head, said exhaust valve port including an exhaust valve port opening formed in said hemispherical shaped portion.

2. The engine of claim 1, further including a first spark plug mounting bore formed in said cylinder head and including a bore opening positioned on one side of the combustion face adjacent the first intake valve port opening and adjacent the exhaust valve port opening.

3. The engine of claim 2, wherein said first spark plug mounting bore is positioned at least partially between said first intake valve port opening and said exhaust valve port opening.

4. The engine of claim 2, further including a second spark plug mounting bore formed in said cylinder head and including a bore opening positioned on an opposite side of said combustion face from said first spark plug mounting bore adjacent said second intake valve port opening and adjacent said exhaust valve port opening.

5. The engine of claim 1, wherein said combustion face further includes a transition portion connecting said pent-roof portion and said hemispherical portion, said transition portion extending across an entire diameter of said combustion face.

6. The engine of claim 5, wherein said transition portion occupies no more than 20% of said combustion face.

7. The engine of claim 1, further including two spark plug mounting bores having respective openings formed within at least one of said hemispherical portion and said transition portion.

8. The engine of claim 7, wherein said two spark bore openings are each positioned in both said hemispherical portion and said transition portion.

9. The engine of claim 1, wherein at least 70% of each of said first intake valve port opening and said second intake valve port opening is positioned in said pent-roof portion.

10. The engine of claim 9, wherein at least 70% of said exhaust valve port opening is positioned in said hemispherical portion.

11. An internal combustion engine, comprising:
an engine block;
a cylinder head mounted on said engine block, said cylinder head including a combustion face forming a portion of a combustion chamber, said combustion face including a pent-roof portion, a hemispherical shaped portion, and a transition portion connecting said pent-roof portion and said hemispherical portion;

a first intake valve port formed in said cylinder head, said first intake valve port including a first intake valve port opening formed in said pent-roof portion;

an exhaust valve port formed in said cylinder head, said exhaust valve port including an exhaust valve port opening formed in said hemispherical shaped portion; and

a spark plug mounting bore formed in the cylinder head and including a bore opening formed in at least one of said hemispherical shaped portion and said transition portion.

12. The engine of claim 11, wherein said first spark plug mounting bore opening is positioned on one side of the combustion face adjacent the first intake valve port opening and adjacent the exhaust valve port opening.

13. The engine of claim 11, wherein said first spark plug mounting bore is positioned at least partially between said first intake valve port opening and said exhaust valve port opening.

14. The engine of claim 12, further including a second spark plug mounting bore formed in said cylinder head and including a bore opening positioned on an opposite side of said combustion face from said first spark plug mounting bore adjacent said second intake valve port opening and adjacent said exhaust valve opening.

15. The engine of claim 11, wherein said transition portion extends across an entire diameter of said combustion face.

16. The engine of claim 11, wherein said transition portion occupies no more than 20% of said combustion face.

17. The engine of claim 11, further including a second spark plug mounting bore having a bore opening, said first and said second spark plug bore openings formed entirely within at least one of said hemispherical portion and said transition portion.

18. The engine of claim 17, wherein said first and said second spark plug bore openings are each positioned in both said hemispherical portion and said transition portion.

19. The engine of claim 11, further including a second intake valve port formed in said cylinder head, said second intake valve port including a second intake valve port opening formed in said pent-roof portion, wherein at least 70% of each of said first intake valve port opening and said second intake valve port opening is positioned in said pent-roof portion.

20. The engine of claim 11, wherein at least 70% of said exhaust valve port opening is positioned in said hemispherical portion.

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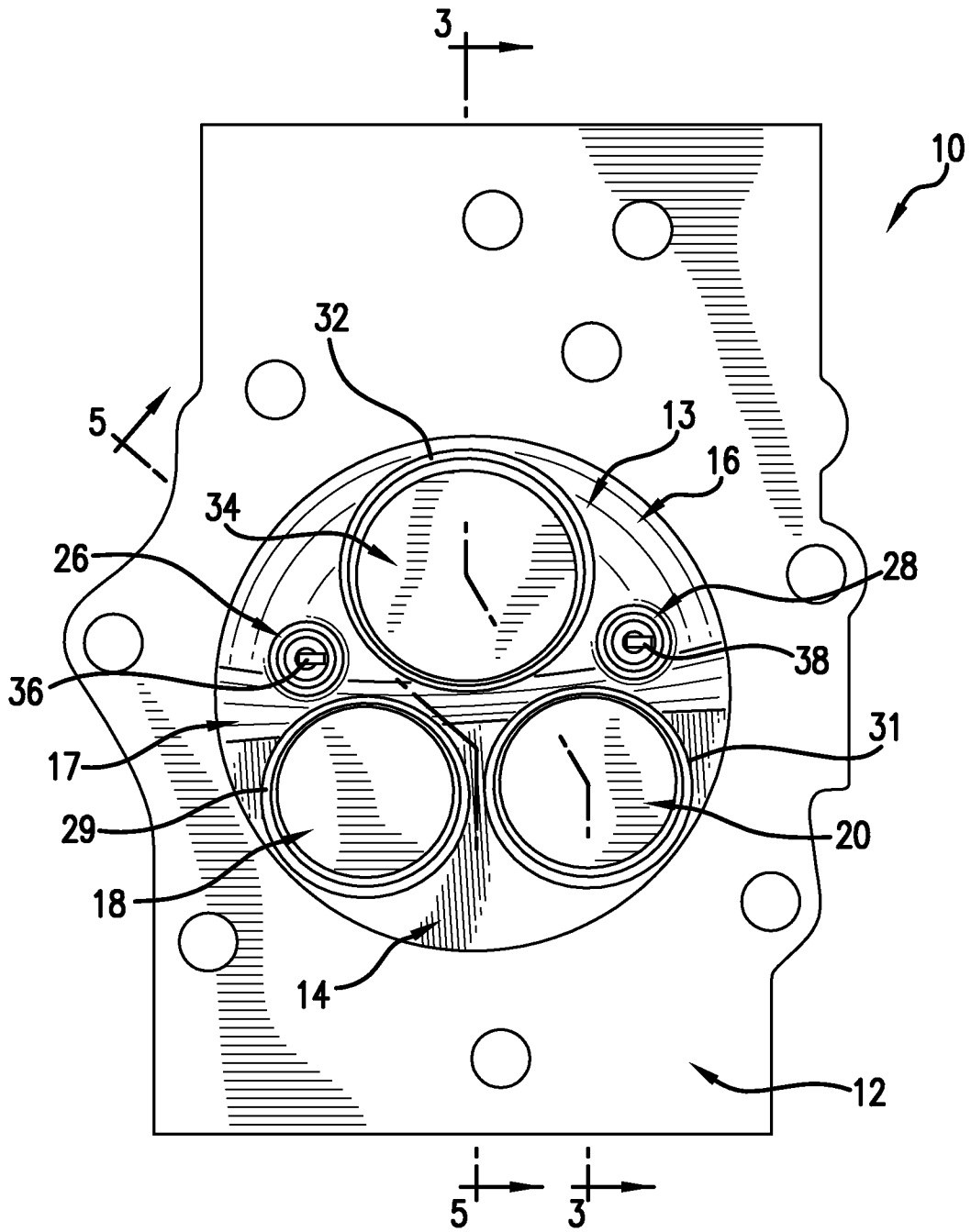


FIG. 1

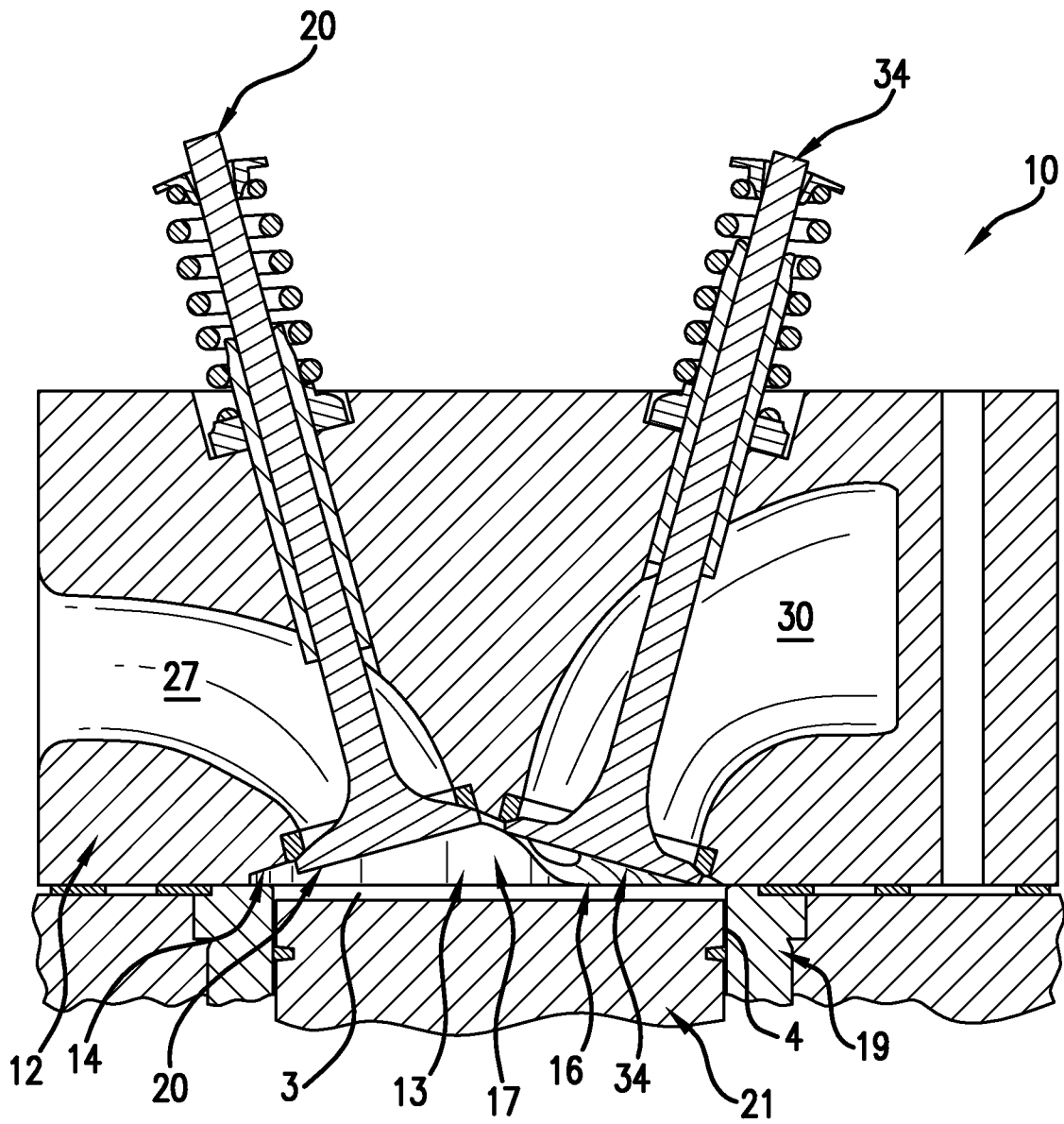


FIG.2

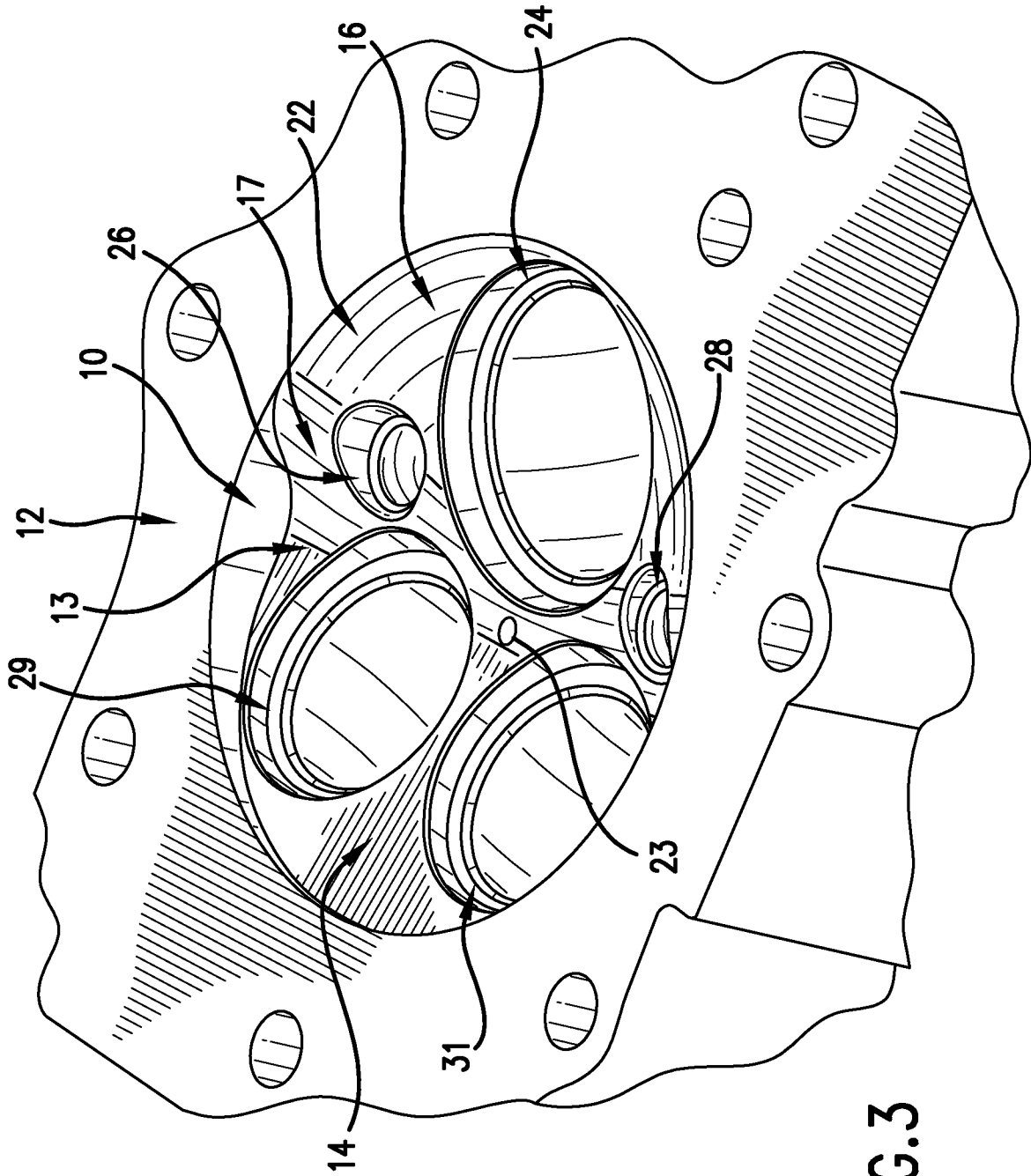


FIG.3

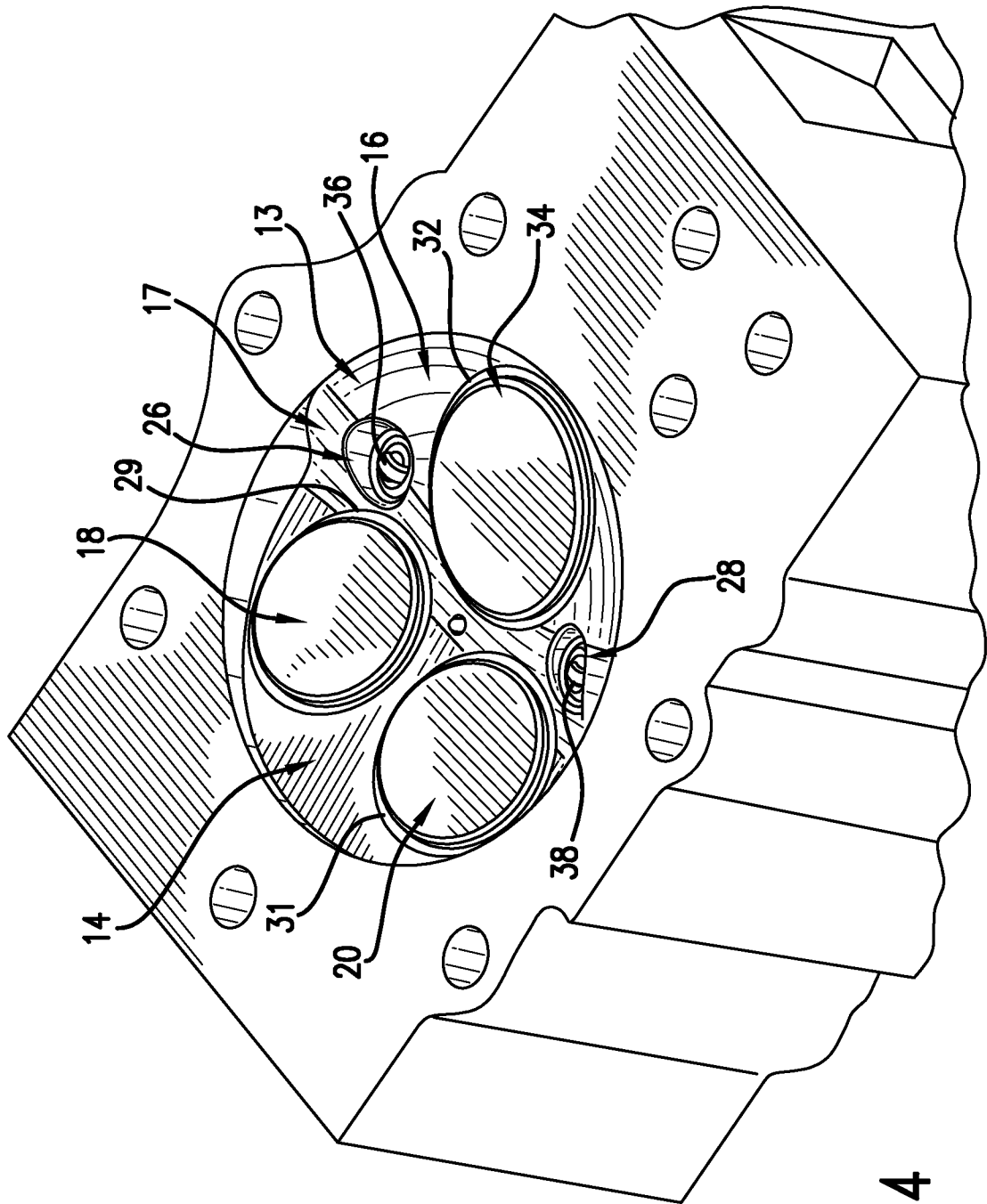


FIG. 4

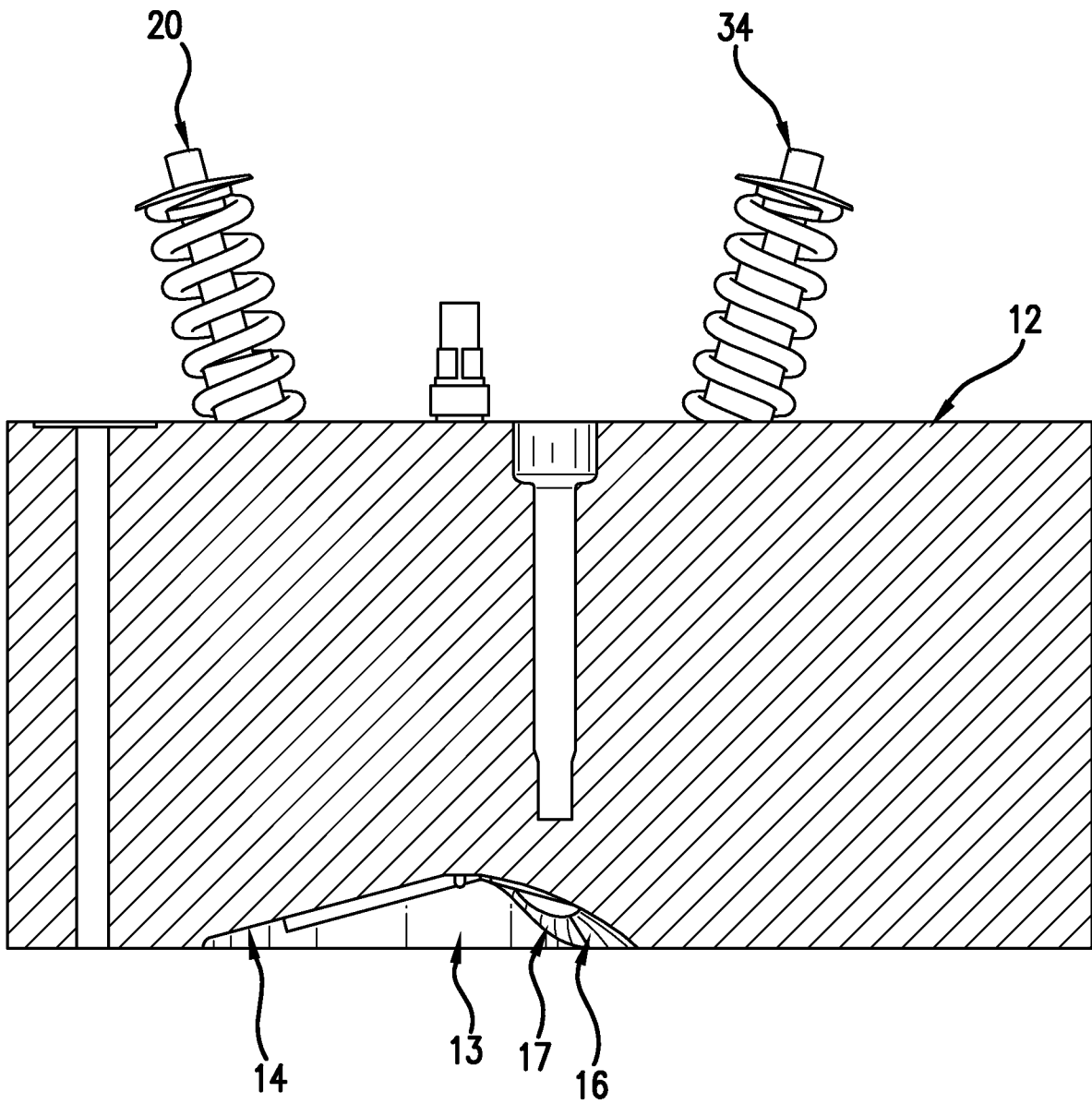


FIG.5