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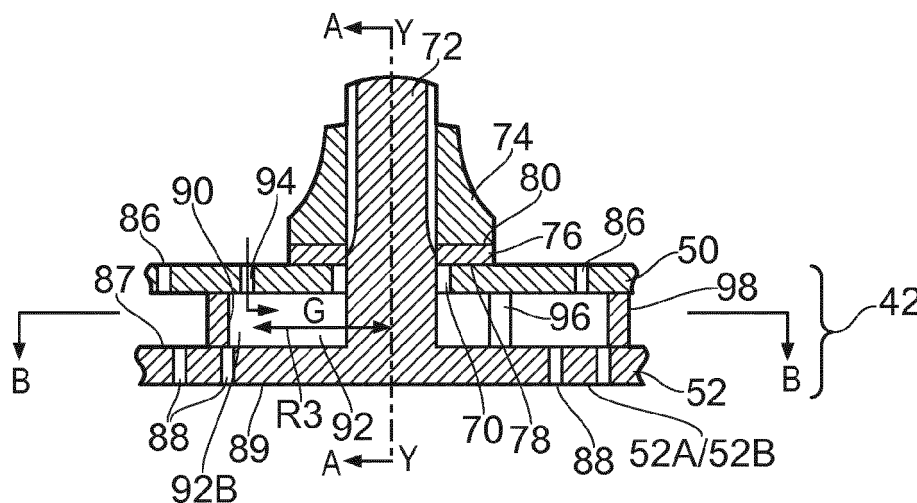
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(54) A combustion chamber

(57) A combustion chamber (15) comprises an outer wall (50) and an inner wall (52). The outer wall (50) has mounting apertures (70) extending there-through and the inner wall (52) has threaded studs (72) extending therefrom. The threaded studs (72) extend through the mounting apertures (70) in the outer wall (50). Cooperating nuts (74) locate on the studs (72). Walls (90) are positioned between the outer wall (50) and the inner wall (52). Each wall (90) is spaced from and extends around a respective fastener (72) to form a chamber (92) around the respec-

tive fastener (72). Apertures (94) extend through the outer wall (50). Each aperture (94) is spaced from a respective mounting aperture (70). Each aperture (94) allows a flow of coolant (G) into the associated chamber (92) and around the associated fastener (72) to cool the fastener (72). Each wall (90) has an opening (96) at a position diametrically opposite to associated aperture (94) to allow the flow of coolant (G) out of the chamber (90) to a space between the outer wall (50) and the inner wall (52).

**FIG. 3****EP 2 770 259 A2**

Description

[0001] The present invention relates to a combustion chamber and in particular to a gas turbine engine combustion chamber.

[0002] Gas turbine engine combustion chambers experience extremely high temperatures in operation and the walls of the combustion chambers are generally cooled using a coolant.

[0003] It is known to provide combustion chambers comprising an inner wall and an outer wall or combustion chambers comprising segments, or tiles, and in particular the inner wall comprises a plurality of segments, or tiles, supported on the outer wall. The tiles consist of high temperature resistant material, e.g. a nickel base superalloy. The tiles are spaced from the inner surface of the outer wall to provide a passage for coolant. The outer wall of the combustion chamber may have apertures extending there-through to provide impingement cooling of the outer surfaces of the tiles. The tiles may have pedestals projecting from their outer surfaces to provide convection cooling of the tiles. The tiles may have apertures extending there-through to provide film cooling, or effusion cooling, of the inner surfaces of the tiles.

[0004] Each tile is generally mounted on the outer wall using studs which are integral with the tile and which extend through mounting apertures in the outer wall. The studs are generally threaded and washers and nuts are fastened onto the studs.

[0005] Our US patent US5435139 discloses an outer wall of a combustion chamber with apertures extending there-through to provide impingement cooling of the outer surfaces of the tiles and apertures extending through the tiles to provide film cooling, or effusion cooling, of the inner surfaces of the tiles. US5435139 uses threaded studs and nuts to mount the tiles on the outer wall.

[0006] Our US patent US6857275 discloses an outer wall of a combustion chamber with apertures extending there-through to provide impingement cooling of the outer surfaces of the tiles, pedestals projecting from the outer surfaces of the tiles to provide convection cooling of the tiles and apertures extending through the tiles to provide film cooling, or effusion cooling, of the inner surfaces of the tiles. US6857275 uses threaded studs and nuts to mount the tiles on the outer wall.

[0007] US6857275 discloses the use of apertures extending through or near the base region of the threaded studs on the tiles. These apertures are intended to produce film cooling of the inner surface of the tiles in the vicinity of the base region of the studs to reduce the amount of heat transferred to the tiles by convection and the apertures are also intended to remove heat by convection from the vicinity of the base region of the studs. These apertures are located in highly stressed areas around the base fillet of the studs where the studs blend into the remainder of the tiles. In order to reduce these stresses either smaller diameter effusion apertures or larger studs are required to provide mechanical integrity.

However, both of these options reduce the cooling of the base regions of the studs.

[0008] US2011/0011095A1 discloses an outer wall of a combustion chamber with apertures extending there-through to provide impingement cooling of the outer surfaces of the tiles, pedestals projecting from the outer surfaces of the tiles to provide convection cooling of the tiles and apertures extending through the tiles to provide film cooling, or effusion cooling, of the inner surfaces of the tiles. US2011/0011095A1 uses threaded studs and nuts to mount the tiles on the outer wall.

[0009] US2011/0011095A1 discloses the use of washers located on the studs and between the nuts and the outer wall of the combustion chamber. The washers are provided with apertures which extend between the surfaces which abut the outer surfaces of the combustion chamber and the surfaces of the nuts. The apertures direct a cooling flow to the base region of the studs to increase convection cooling of the outer surface of the tiles. These apertures only cool a circumferential portion of each stud directly aligned with the apertures and thus the apertures do not provide uniform cooling around the circumference of the studs, which may lead to high local thermal and/or stress gradients at the base regions of the studs. Furthermore, the apertures must be positioned beyond the rims of the nuts and this limits the ability of the apertures to direct a cooling flow onto the base regions of the studs. Additionally, the cooling flow through the apertures may be compromised by the location of the studs and nuts relative to the apertures particularly if the studs and nuts are directly upstream of the apertures.

[0010] In order to maximise the operating life of the tiles the studs must be adequately cooled by a cooling film on the inner surface of the tiles and by cooling flow on the outer surface of the tiles.

[0011] The present invention seeks to provide a novel combustion chamber which reduces, preferably overcomes, the abovementioned problem.

[0012] Accordingly the present invention provides a combustion chamber comprising an outer wall and an inner wall spaced from the outer wall, the outer wall having at least one mounting aperture extending there-through, the inner wall having at least one fastener extending there-from, the at least one fastener on the inner wall extending through a corresponding mounting aperture in the outer wall, a cooperating fastener locating on the at least one fastener extending through the corresponding mounting aperture, at least one wall being positioned between the outer wall and the inner wall, a corresponding wall being spaced from and extending around the at least one fastener to form a chamber around the at least one fastener, at least one inlet opening to allow a flow of coolant into the chamber and at least one outlet opening to allow a flow of coolant from the chamber, wherein the at least one inlet opening and the at least one outlet opening being circumferentially spaced apart with respect to an axis of the at least one fastener and/or the corresponding mounting aperture to allow a flow of

coolant circumferentially around the at least one fastener.

[0013] The outlet opening may supply the coolant from the chamber into the space between the inner wall and the outer wall. The outlet opening may supply the coolant from the chamber into the combustion chamber. The inlet opening may supply coolant from the space between the inner wall and the outer wall into the chamber. The inlet opening may supply coolant from outside the combustion chamber into the chamber.

[0014] The outer wall may have a plurality of mounting apertures, the inner wall may have a plurality of fasteners extending there-from, a plurality of walls, each fastener extending through a respective one of the mounting apertures, each wall being positioned between the outer wall and the inner wall, each wall being spaced from and extending around a respective fastener to form a chamber around the respective fastener.

[0015] The at least one wall may extend from the inner wall or the at least one wall may extend from the outer wall.

[0016] The at least one inlet opening may extend through the outer wall and the at least one outlet opening may extend through the at least one wall or the at least one outlet opening may be defined by the at least one wall.

[0017] The at least one inlet opening may extend through the at least one wall or the at least one inlet opening may be defined by the at least one wall and the at least one outlet opening may extend through the inner wall.

[0018] The at least one wall may comprise at least one arcuate wall portion, a plurality of linear wall portions or at least one arcuate wall portion and at least one linear wall portion.

[0019] The inlet opening and the outlet opening may be arranged 180° apart with respect to an axis of the at least one fastener and/or the at least one mounting aperture.

[0020] The wall may have a first portion, a second portion and a third portion, the first portion and the third portion being arcuate and being arranged coaxially with the axis of the at least one fastener and/or the at least one mounting aperture at a first radius, the second portion being arranged to interconnect a second end of the first portion and a first end of the third portion, the second portion being arcuate and extends to a second radius greater than the first radius, the inlet opening extending through the outer wall, the inlet opening being arranged at a radius intermediate the first radius and the second radius, the outlet opening being defined between a first end of the first portion and a second end of the third portion to allow the flow of coolant from the chamber to a space between the outer wall and the inner wall.

[0021] The wall may have a first portion, a second portion and a third portion, the first portion and the third portion being arcuate and being arranged coaxially with the axis of the at least one fastener and/or the at least one mounting aperture at a first radius, the second portion

being arranged to interconnect a second end of the first portion and a first end of the third portion, the second portion being arcuate and extends to a second radius greater than the first radius, the outlet opening extending through inner wall, the outlet opening being arranged at a radius intermediate the first radius and the second radius, the inlet opening being defined between a first end of the first portion and a second end of the third portion to allow the flow of coolant from a space between the outer wall and the inner wall into the chamber.

[0022] The wall may have a first portion, a second portion, a third portion and a fourth portion, the first portion and the third portion being arcuate and being arranged coaxially with the axis of the at least one fastener and/or the at least one mounting aperture at a first radius, the second portion being arranged to interconnect a second end of the first portion and a first end of the third portion, the second portion being arcuate and extends to a second radius greater than the first radius, the fourth portion being arcuate and extends to a second radius greater than the first radius, the inlet opening extending through the outer wall, the inlet opening being arranged at a radius intermediate the first radius and the second radius, the outlet opening extending through inner wall, the outlet opening being arranged at a radius intermediate the first radius and the second radius.

[0023] The inner wall may comprise a plurality of segments, the wall having a first portion, a second portion and a third portion, the first portion being defined by a circumferentially extending wall at an axially upstream end or an axially downstream end of the segment, the second portion being defined by an axially extending wall at a circumferential edge of the segment and a third portion extending from and interconnecting the first portion and the second portion, the inlet opening extending through the outer wall or the inlet opening extending through the third portion of the wall, the outlet opening extending through the first portion of the wall or the second portion of the wall to allow the flow of coolant from the chamber into the combustion chamber.

[0024] The inner wall may comprise a plurality of segments, the wall having a first portion and a second portion, the first portion being defined by a circumferentially extending wall at an axially upstream end or an axially downstream end of the segment, the second portion extending from and returning to the first portion, the inlet opening extending through the outer wall or the second portion of the wall, the outlet opening extending through the first portion of the wall to allow the flow of coolant from the chamber into the combustion chamber.

[0025] The inlet opening and the outlet opening may be arranged 90° apart with respect to an axis of the at least one fastener and/or the at least one mounting aperture.

[0026] There may be a first inlet opening, a second inlet opening, a first outlet opening and a second outlet opening.

[0027] The first inlet opening and the second inlet

opening may be arranged 180° apart with respect to the axis of the at least one fastener and/or the at least one mounting aperture and the first outlet opening and the second outlet opening being arranged 180° apart with respect to the axis of the at least one fastener and/or the at least one mounting aperture.

[0028] The at least one wall may comprise a first portion and a second portion spaced from the first portion, the first portion and the second portion defining two outlet openings at diametrically opposite positions of the chamber with respect to the axis of the fastener, two inlet openings extending through the outer wall at diametrically opposite positions of the chamber with respect to the axis of the fastener.

[0029] The at least one wall may comprise a first portion and a second portion spaced from the first portion, the first portion and the second portion defining two inlet openings at diametrically opposite positions of the chamber with respect to the axis of the fastener, two outlet openings extending through the inner wall at diametrically opposite positions of the chamber with respect to the axis of the fastener.

[0030] The at least one cooperating fastener may have a periphery arranged substantially at a fourth radius from the axis of the at least one fastener, the first portion and the third portion of the at least one wall being arranged such that the first radius is equal to or less than the fourth radius such that clamping loads are passed from the periphery of the cooperating fastener through the outer wall and the at least one wall to the inner wall.

[0031] The inner wall may comprise a plurality of segments.

[0032] The at least one fastener may be arranged at a corner of the segment. The at least one wall extending around the at least one fastener may be partially defined by a circumferentially extending wall at an axial end of the segment and by an axially extending wall at the circumferential edge of the segment and the outlet opening being arranged in the circumferentially extending wall at the axial end of the segment or in the axially extending wall at the circumferential edge of the segment.

[0033] The at least one fastener may be arranged adjacent an end of the segment. The at least one wall extending around the at least one fastener may be partially defined by a circumferentially extending wall at an axial end of the segment and the outlet opening being arranged in the circumferentially extending wall at the axial end of the segment.

[0034] The outer wall may have a plurality of impingement apertures extending there-through and the inner wall having a plurality of effusion apertures extending there-through.

[0035] The inner wall may be a radially inner wall and the outer wall being a radially outer wall of an outer wall of an annular combustion chamber. The inner wall may be a radially outer wall and the outer wall being a radially inner wall of an inner wall of an annular combustion chamber. The inner wall may be a radially inner wall and the

outer wall being a radially outer wall of a tubular combustion chamber. The inner wall may be a downstream wall and the outer wall is an upstream wall of an upstream end wall of an annular combustion chamber or a tubular combustion chamber.

[0036] The present invention also provides a combustion chamber inner wall, the inner wall having at least one fastener extending there-from, at least one wall being spaced from and extending around the at least one fastener to form a chamber around the at least one fastener, at least one inlet opening to allow a flow of coolant into the chamber and at least one outlet opening to allow a flow of coolant from the chamber, wherein the at least one inlet opening extending through the at least one wall or the at least one inlet opening being defined by the at least one wall and the at least one outlet opening extending through the at least one wall or the at least one outlet opening being defined by the at least one wall or the at least one outlet opening extending through the inner wall.

[0037] The outlet opening may supply the coolant from the chamber into a space around the at least one wall and partially defined by the at least one wall and the inner wall. The outlet opening may supply the coolant from the chamber into the combustion chamber. The inlet opening may supply the coolant from a space around the at least one wall and partially defined by the at least one wall and the inner wall into the chamber.

[0038] The present invention will be more fully described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is partially cut away view of a turbofan gas turbine engine having a combustion chamber according to the present invention.

Figure 2 is an enlarged cross-sectional view of a combustion chamber according to the present invention.

Figure 3 is a further enlarged cross-sectional view of a portion of a combustion chamber according to the present invention.

Figure 4 is a cross-sectional view in the direction of arrows A-A in Figure 3.

Figure 5 is a cross-sectional view in the direction of arrow B in Figure 3.

Figure 6 is a perspective view of the portion of the combustion chamber shown in figure 3.

Figure 7 is an alternative cross-sectional view in the direction of arrow B in Figure 3.

Figure 8 is another alternative cross-sectional view in the direction of arrow B in Figure 3.

Figure 9 is a further enlarged cross-sectional view of a portion of another combustion chamber according to the present invention.

Figure 10 is a cross-sectional view in the direction of arrows C-C in Figure 9.

Figure 11 is a cross-sectional view in the direction of arrow D in Figure 9.

Figure 12 is a further enlarged cross-sectional view of a portion of a further combustion chamber according to the present invention.

Figure 13 is a cross-sectional view in the direction of arrows E-E in Figure 12.

Figure 14 is a cross-sectional view in the direction of arrow F in Figure 12.

Figure 15 is an alternative cross-sectional view in the direction of arrow F in Figure 12.

Figure 16 is an alternative cross-sectional view in the direction of arrow B in Figure 3.

[0039] A turbofan gas turbine engine 10, as shown in figure 1, comprises in flow series an intake 11, a fan 12, an intermediate pressure compressor 13, a high pressure compressor 14, a combustion chamber 15, a high pressure turbine 16, an intermediate pressure turbine 17, a low pressure turbine 18 and an exhaust 19. The high pressure turbine 16 is arranged to drive the high pressure compressor 14 via a first shaft 26. The intermediate pressure turbine 17 is arranged to drive the intermediate pressure compressor 13 via a second shaft 28 and the low pressure turbine 18 is arranged to drive the fan 12 via a third shaft 30. In operation air flows into the intake 11 and is compressed by the fan 12. A first portion of the air flows through, and is compressed by, the intermediate pressure compressor 13 and the high pressure compressor 14 and is supplied to the combustion chamber 15. Fuel is injected into the combustion chamber 15 and is burnt in the air to produce hot exhaust gases which flow through, and drive, the high pressure turbine 16, the intermediate pressure turbine 17 and the low pressure turbine 18. The hot exhaust gases leaving the low pressure turbine 18 flow through the exhaust 19 to provide propulsive thrust. A second portion of the air bypasses the main engine to provide propulsive thrust.

[0040] The combustion chamber 15, as shown more clearly in figure 2, is an annular combustion chamber and comprises a radially inner annular wall structure 40, a radially outer annular wall structure 42 and an upstream end wall structure 44. The radially inner annular wall structure 40 comprises a first annular wall 46 and a second annular wall 48. The radially outer annular wall structure 42 comprises a third annular wall 50 and a fourth

annular wall 52. The second annular wall 48 is spaced radially from and is arranged radially around the first annular wall 46 and the first annular wall 46 supports the second annular wall 48. The fourth annular wall 52 is spaced radially from and is arranged radially within the third annular wall 50 and the third annular wall 50 supports the fourth annular wall 52. The upstream end of the first annular wall 46 is secured to the upstream end wall structure 44 and the upstream end of the third annular wall 50 is secured to the upstream end wall structure 44. The upstream end wall structure 44 has a plurality of circumferentially spaced apertures 54 and each aperture 54 has a respective one of a plurality of fuel injectors 56 located therein. The fuel injectors 56 are arranged to supply fuel into the annular combustion chamber 15 during operation of the gas turbine engine 10.

[0041] The first annular wall 46 has a plurality of mounting apertures 58 extending there-through and the second annular wall 48 has at plurality of fasteners 60 extending radially there-from. Each fastener 60 on the second annular wall 48 extends radially through a corresponding mounting aperture 58 in the first annular wall 46. A cooperating fastener 62 locates on each of the fasteners 60 extending through the mounting apertures 58 in the first annular wall 46. A washer 64 is positioned between each fastener 60 on the second annular wall 48 and the cooperating fastener 62. Each washer 64 has a first surface 66 abutting an outer surface of the first annular wall 46 and a second surface 68 abutting a surface of the cooperating fastener 62. The second annular wall 48 comprises a plurality of segments, or tiles, 48A and 48B and the segments, or tiles, 48A and 48B are arranged circumferentially and axially around the first annular wall 46. The axially extending edges of adjacent segments, or tiles, 48A and/or 48B may abut each other or may overlap each other and the circumferentially extending ends of adjacent segments, or tiles, 48A and 48B may abut each other or may overlap each other.

[0042] Similarly, the third annular wall 50 has a plurality of mounting apertures 70 extending there-through and the fourth annular wall 52 has at plurality of fasteners 72 extending radially there-from. Each fastener 72 on the fourth annular wall 52 extends radially through a corresponding mounting aperture 70 in the third annular wall 50. A cooperating fastener 74 locates on each of the fasteners 72 extending through the mounting apertures 70 in the third annular wall 50. A washer 76 is positioned between each fastener 72 on the fourth annular wall 52 and the cooperating fastener 74. Each washer 76 has a first surface 78 abutting an outer surface of the third annular wall 50 and a second surface 80 abutting a surface of the cooperating fastener 74. The fourth annular wall 52 comprises a plurality of segments, or tiles, 52A and 52B and the segments, or tiles, 52A and 52B are arranged circumferentially and axially adjacent to each other to define the fourth annular wall 52. The axially extending edges of adjacent segments, or tiles, 52A and/or 52B may abut each other or may overlap each other and

the circumferentially extending ends of adjacent segments, or tiles, 52A and 52B may abut each other or may overlap each other.

[0043] The fasteners 60 and 72 on the second and fourth annular walls 48 and 52 are threaded studs which are cast integrally with the segments, or tiles, 48A, 48B, 52A and 52B or may be secured to the segments, or tiles, 48A, 48B, 52A and 52B by welding, brazing etc. The cooperating fasteners 62 and 74 are nuts.

[0044] Figure 3 is an enlarged cross-sectional view through a portion of the radially outer wall structure 42 of the combustion chamber 15 in the vicinity of an arrangement to mount a segment, or tile, 52A, 52B of the fourth annular wall 52 onto the third annular wall 50 of the radially outer annular wall structure 42. The third annular wall 50 is provided with a plurality of apertures 86 extending there-through to provide a flow of coolant through the third annular wall 50 to impinge upon and cool the radially outer surface 87 of the fourth annular wall 52. The axes of the apertures 86 are generally arranged at 90° to the radially inner and outer surfaces of the third annular wall 50. The segments, or tiles, 52A and 52B of the fourth annular wall 52 are provided with a plurality of apertures 88 extending there-through to provide a flow of coolant through the fourth annular wall 52 to provide effusion cooling and/or film cooling of the radially inner surface 89 of the fourth annular wall 52. The axes of the apertures 88 are generally arranged at an angle of 90° to the radially inner and outer surfaces of the fourth annular wall 52, however the axes of the apertures 88 may be arranged such that they are angled to the radially inner surface 89 of the fourth annular wall 52. The segments, or tiles, 52A and 52B have walls 90 extending radially outwardly there-from to space the fourth annular wall 52 from the third annular wall 50. Each wall 90 is located immediately around a respective one of the mounting apertures 70 in the third annular wall 50 and is also located around a respective one of the associated fasteners 72.

[0045] Each wall 90, as shown more clearly in figures 3 to 6, is positioned between the tiles 52A and 52B of the fourth annular wall 52 and the third annular wall 50. Each wall 90 is spaced from and extends around a respective one of the fasteners 72 to form a chamber 92 around the corresponding fastener 72. The third annular wall 50 has a plurality of apertures 94 extending there-through and each aperture 94 is spaced from a respective one of the mounting apertures 70 and the wall 90 has an outlet opening 96. The radially outer extremity of each wall 90 is arranged to abut the radially inner surface of the third annular wall 50.

[0046] Each aperture 94 and the associated outlet opening 96 are arranged at diametrically opposite positions with respect to an axis Y of the associated fastener 72 and/or the associated mounting aperture 70, however other suitable angles may be used. Each aperture 94 and its associated outlet opening 96 are thus circumferentially, or angularly, spaced apart with respect to the axis Y

of the associated fastener 72 and/or the associated mounting aperture 70.

[0047] Each wall 90 has a first portion 90A, a second portion 90B and a third portion 90C. The first portion 90A and the third portion 90C of each wall 90 are arcuate and are arranged substantially coaxially with the axis Y of the associated fastener 72 and/or the associated mounting aperture 70 and the first portion 90A and the third portion 90C are arranged at a first radius R1 from the axis Y of the fastener 72. The second portion 90B of each wall 90 is arranged to interconnect a second end 90A2 of the first portion 90A and a first end 90C1 of the third portion 90C. The second portion 90B of each wall 90 is arcuate and extends to a second radius R2 greater than the first radius R1, such that the second portion 90B of each wall 90 forms a sub-chamber 92B of the chamber 92. The associated aperture 94 is arranged at a third radius R3 intermediate the first radius R1 and the second radius R2. The outlet opening 96 is defined between a first end 90A1 of the first portion 90A and a second end 90C2 of the third portion 90C. The wall 90 forms a generally key-hole shaped chamber 92 around the fastener 72.

[0048] Each cooperating fastener 74 has a periphery arranged substantially at a fourth radius R4 from the axis Y of the associated fastener 72. The first portion 90A and the third portion 90C of each wall 90 is arranged such that the first radius R1 is equal to or less than the fourth radius R4 such clamping loads are passed from the periphery of the cooperating fastener 74 through the third annular wall 50 and the wall 90 to the fourth annular wall 52.

[0049] There are also projections, or pedestals, 98 extending radially outwardly from the tiles 52A, 52B to space the fourth annular wall 52 from the third annular wall 50. The projections, or pedestals, 98 also provide convection cooling of the fourth annular wall 52. However, the tiles 52A, 52B do not need to have projections, or pedestals.

[0050] In operation the apertures 94 provide a flow of coolant G from the outside of the third annular wall 50 through the apertures 94 in the third annular wall 50 into the space between the third annular wall 50 and the fourth annular wall 52. In particular the coolant G flows radially through each aperture 94 into the sub-chamber 92B of the respective chamber 92 so that the coolant G flows around the respective one of the fasteners 72. The flow of coolant G then turns to flow axially with respect to the axis of the annular combustion chamber 15 from the sub-chamber 92B and into the main portion of the chamber 92 defined by the respective wall 90. The flow of coolant G is initially directed axially towards the respective fastener 90 from the sub-chamber 92B and then the flow of coolant G splits to form two flows of coolant G1 and G2 which flow circumferentially around both sides of the respective fastener 72. The two flows of coolant G1 and G2 merge together at the diametrically opposite side of the respective fastener 72 to form a single flow of coolant G3 which flows out of the outlet opening 96. The flow of

coolant G, G1 and G2 completely surrounds the full circumference of the respective fastener 72. The flow of coolant G, G1 and G2 cools the base of the respective fastener 72 and the outer surface 87 of the segment, or tile, 52A or 52B where the fastener 72 blends into the segment, or tile, 52A or 52B and then flows through the outlet opening 96 to provide heat removal.

[0051] Each wall 90, respective outlet opening 96 and respective aperture 94 is arranged such that the openings 96 direct the flow of coolant in a downstream direction with respect to the axis of the combustion chamber 15. It is equally possible to arrange each wall 90, respective outlet opening 96 and respective aperture 94 such that the openings 96 direct the flow of coolant in an upstream direction with respect to the axis of the combustion chamber 15. It is also possible to arrange each wall 90, respective outlet opening 96 and respective aperture 94 such that the openings 96 direct the flow of coolant in a circumferential direction with respect to the axis of the combustion chamber 15. Additionally it is possible to arrange some of the walls 90, respective openings 96 and respective apertures 94 such that the openings 96 direct the flow of coolant in a downstream direction and some of the walls 90, respective openings 96 and respective apertures 94 such that the openings 96 direct the flow of coolant in a circumferential direction with respect to the axis of the combustion chamber 15.

[0052] Although figures 3 to 6 have shown a generally arcuate wall 90, the wall 90 doesn't need to be arcuate. The wall 90 may comprise a plurality of straight wall portions arranged on, or to define, the majority of the sides of a polygon, e.g. a square, a rectangle, a hexagon etc, and the straight wall portions on the majority of the sides of the polygon have regions at a first distance R1 from the axis of the fastener 70. One or more wall portions of the wall 90 are arranged with regions at a second distance R2 greater than the first distance R1 so that the aperture 94 is at a third distance R3 intermediate the first distance R1 and the second distance R2.

[0053] Figure 7 shows another arrangement of the present invention, in which a fastener 72 is located at or adjacent, a corner of the tile, or segment, 52A/52B of the fourth annular wall 52. In this example a wall 190 is spaced from and extends around the fastener 72 to form a chamber 192 around the respective fastener 72. This chamber 192 also has a sub-chamber 192B. The wall 190 has a first portion defined by a circumferentially extending wall 197 at an axially upstream end or axially downstream end of the tile 52A/52B, a second portion defined by an axially extending wall 198 at circumferential edge of the tile 52A/52B and a third portion 200 which extends from, and interconnects, the circumferentially extending wall 197 to the axially extending wall 198. The third portion 200 of the wall 190 is generally L-shaped and in particular comprises two interconnected Z-shaped portions. An outlet opening 196 is provided in the circumferentially extending wall 197 of the tile 52A/52B and it may be an axially upstream wall or and axially downstream

wall. In this example the coolant G flows through the outlet opening 196 and out of the space between the third and fourth annular walls 50 and 52 and is able to flow over the radially inner surface 89 of the tile 52A/52B to cool the radially inner surface of the tile 52A/52B. The wall 190 forms a generally key-hole shaped chamber 192 around the fastener 72. The radially outer extremity of the circumferentially extending wall 197 and the axially extending wall 198 are also arranged to abut the radially inner surface of the third annular wall 50. An inlet opening is provided in the third annular wall 50 to supply coolant into the sub-chamber 192B of the chamber 192.

[0054] Each aperture 194 and the associated outlet opening 196 are arranged at diametrically opposite positions with respect to an axis of the associated fastener 72 and/or the associated mounting aperture 70, however other suitable angles may be used. Each aperture 194 and its associated outlet opening 196 are thus circumferentially, angularly, spaced apart with respect to the axis of the associated fastener 72 and/or the associated mounting aperture 70.

[0055] Each cooperating fastener 74 has a periphery arranged substantially at a fourth distance R4 from the axis Y of the associated fastener 72. The portion 197, the portion 198 and the portion 200 of each wall 190 are arranged such that the first distance R1 is equal to or less than the fourth distance R4 such clamping loads are passed from the periphery of the cooperating fastener 74 through the third annular wall 50 and the wall 190 to the fourth annular wall 52.

[0056] Figure 8 shows a further arrangement of the present invention, in which a fastener 72 is located at, or adjacent, an end of the tile 52A/52B. In this example a wall 290 is spaced from and extends around the fastener 72 to form a chamber 292 around the respective fastener 72. The wall 290 has a first portion defined by a circumferentially extending wall 297 at an axially upstream end or axially downstream end of the tile 52A/52B and a second portion 298 which extends from the first portion 297 around the fastener 72 and back to the first portion 297. The second portion 298 is generally U-shaped and in particular comprises two L-shaped portions. An outlet opening 296 is provided in the circumferentially extending wall 297 of the tile 52A/52B and it may be an axially upstream wall or and axially downstream wall. In this example the coolant G flows through the outlet opening 296 and out of the space between the third and fourth annular walls 50 and 52 and is able to flow over the radially inner surface 89 of the tile 52A/52B to cool the radially inner surface of the tile 52A/52B. The wall 290 forms a generally key-hole shaped chamber 292 around the fastener 72. The extremity of the circumferentially extending wall 294 is also arranged to abut the radially inner surface of the third annular wall 50. An inlet opening 294 is provided in the second portion 298 of the wall 290 to supply coolant into the chamber 292. The inlet opening 294 is provided between the two L-shaped portions of the second portion 298 of the wall 290.

[0057] Each aperture 294 and the associated outlet opening 296 are arranged at diametrically opposite positions with respect to an axis of the associated fastener 72 and/or the associated mounting aperture 70, however other suitable angles may be used. Each aperture 124 and its associated outlet opening 296 are thus circumferentially, angularly, spaced apart with respect to the axis of the associated fastener 72 and/or the associated mounting aperture 70.

[0058] Each cooperating fastener 74 has a periphery arranged substantially at a fourth distance R4 from the axis Y of the associated fastener 72. The portion 294 and the portion 298 of each wall 290 are arranged such that the first distance R1 is equal to or less than the fourth distance R4 such clamping loads are passed from the periphery of the cooperating fastener 74 through the third annular wall 50 and the wall 290 to the fourth annular wall 52.

[0059] It is equally possible to provide an inlet opening 194 in the third portion 200 of the wall 190 of figure 7 instead of a sub-chamber and an inlet opening in the third annular wall. Similarly it is equally possible to provide a sub-chamber and an inlet opening in the third annular wall instead of an inlet opening in the second portion of the wall. It is equally possible to provide an arcuate second portion of the wall in figure 8, as shown in figure 16 and to provide an arcuate third portion of the wall in figure 7. Figure 16 is substantially the same as figure 8 and the same features have the same reference numbers but with B as a suffix.

[0060] Figures 9 to 11 show another arrangement of the present invention. This is similar to the arrangement shown in figures 3 to 6 and like parts are denoted by like numerals.

[0061] This arrangement differs in that the, or each, wall 390 located immediately around a respective one of the mounting apertures 70 in the third annular wall 50 has an inlet opening 394 to allow the flow of coolant G from the space between the third annular wall 50 and the fourth annular wall 52 into the chamber 392. The flow of coolant splits into two flows G1 and G2 as previously to flow circumferentially around the fastener 72. The flows of coolant G1 and G2 merge together to form a single flow G3 which flows into a sub-chamber 392B of the chamber 392 and through an aperture 396 in the fourth annular wall 52 into the combustion chamber 15. In this arrangement there is no aperture in the third annular wall 50 supplying coolant directly into the chamber 392.

[0062] Each aperture 394 and the associated outlet opening 396 are arranged at diametrically opposite positions with respect to an axis of the associated fastener 72 and/or the associated mounting aperture 70, however other suitable angles may be used. Each aperture 394 and its associated outlet opening 396 are thus circumferentially, angularly, spaced apart with respect to the axis of the associated fastener 72 and/or the associated mounting aperture 70.

[0063] Each wall 390 has a first portion 390A, a second

portion 390B and a third portion 390C. The first portion 390A and the third portion 390C of each wall 390 are arcuate and are arranged substantially coaxially with the axis Y of the associated fastener 72 and/or the associated mounting aperture 70 and the first portion 390A and the third portion 390C are arranged at a first radius R1 from the axis Y of the fastener 72. The second portion 390B of each wall 390 is arranged to interconnect a second end 390A2 of the first portion 390A and a first end 390C1 of the third portion 390C. The second portion 390B of each wall 390 is arcuate and extends to a second radius R2 greater than the first radius R1 such that the second portion 390B of each wall 390 forms the sub-chamber 392B of the chamber 392. The associated aperture 396 is arranged at a third radius R3 intermediate the first radius R1 and the second radius R2, the inlet opening 394 is defined between a first end 390A1 of the first portion 390A and a second end 390C2 of the third portion 390C. The wall 390 forms a generally key-hole shaped chamber 392 around the fastener 72.

[0064] The embodiment in figures 9 to 11 may be modified such that the flow of coolant G3 discharges through an outlet opening 396 in the circumferentially extending wall of the tile as in figures 7 or 8 rather than into a sub-chamber and then through an aperture through the fourth annular wall.

[0065] Figures 12 to 14 show another arrangement of the present invention. This is similar to the arrangement shown in figures 3 to 6 and like parts are denoted by like numerals. This arrangement is similar in that the, or each, wall 490 located immediately around a respective one of the mounting apertures 70 in the third annular wall 50 has an inlet opening 494 in the third annular wall to allow the flow of coolant G directly into the sub-chamber 492B of the chamber 492. The flow of coolant splits into two flows G1 and G2 as previously to flow circumferentially around the fastener 72. This arrangement differs in that the flows of coolant G1 and G2 merge together to form a single flow G3 which flows into a sub-chamber 492D of the chamber 490 and then flows through an aperture 496 in the fourth annular wall 52 into the combustion chamber 15. In this arrangement the, or each, wall 490 extends completely around the respective mounting aperture 70 and associated fastener 72, whereas in figures 3 to 6 the wall 90 had an outlet opening to discharge the flow of coolant into the space between the third and fourth annular walls 50 and 52 and in figures 9 to 11 the wall 390 had an inlet opening to allow a flow of coolant from the space between the third and fourth annular walls 50 and 52 into the chamber 392. In this arrangement each of the flows G1 and G2 flows circumferentially through about a half of the circumference of the fastener 72 and then combine as flow G3 which flows out of the outlet opening 496. The inlet apertures 494 and the outlet openings 496 are preferentially arranged substantially 180° apart with respect to the axis of the respective fastener 72, however other suitable angles may be used.

[0066] Each aperture 494 and the associated outlet

opening 496 are arranged at diametrically opposite positions with respect to an axis of the associated fastener 72 and/or the associated mounting aperture 70. Each aperture 494 and its associated outlet opening 496 are thus circumferentially, angularly, spaced apart with respect to the axis of the associated fastener 72 and/or the associated mounting aperture 70.

[0067] Each wall 490 has a first portion 490A, a second portion 490B, a third portion 490C and a fourth portion 490D. The first portion 490A and the third portion 490C of each wall 490 are arcuate and are arranged substantially coaxially with the axis Y of the associated fastener 72 and/or the associated mounting aperture 70 and the first portion 490A and the third portion 90D are arranged at a first radius R1 from the axis Y of the fastener 72. The second portion 490B of each wall 490 is arranged to interconnect a second end of the first portion 490A and a first end of the third portion 490C. The fourth portion 490D of each wall 490 is arranged to interconnect a first end of the first portion 490A and a second end of the third portion 490C. The second and the fourth portions 490B and 490D of each wall 490 are arcuate and extend to a second radius R2 greater than the first radius R1 such that the second portion 490B of each wall 490 forms a sub-chamber 492B of the chamber 492 and the fourth portion 490D of each wall 490 forms a sub-chamber 492D. The associated aperture 494 and 496 are arranged at radii intermediate the first radius R1 and the second radius R2. The wall 90 forms a generally key-hole shaped chamber 92 around the fastener 72.

[0068] Figure 15 shows a further embodiment of the present invention. In this arrangement the, or each, wall 590 has two spaced portions 590A and 590B to define two outlet openings 596 at diametrically opposite positions of the chamber 592 with respect to the axis of the fastener 72 to supply coolant G3 in opposite directions from the chamber 592 into the space between the third and fourth annular walls 50 and 52. Two apertures are provided in the third annular wall 50 to supply coolant G into two sub-chambers 592A and 592B of the chamber 592 at diametrically opposite positions of the chamber 592 with respect to the axis of the fastener 72. The coolant G supplied from each of the apertures in the third annular wall 50 into the two sub-chambers 592A and 592B of the chamber 592 splits into coolant flows G1 and G2 each of which flows circumferentially through about a quarter of the circumference of the fastener 72. The coolant flow G1 from sub-chamber 592A combines with coolant flow G2 from sub-chamber 592B and the coolant flow G1 from sub-chamber 592B combines with coolant flow G2 from sub-chamber 592A to form combined flows G3 which flow out of both of the outlet openings 596. The inlet apertures and outlet openings 596 are preferably arranged substantially 90° apart with respect to the axis of the respective fastener 72, however other suitable angles may be used. The inlet apertures and the associated outlet openings 596 are thus circumferentially, angularly, spaced apart with respect to the axis of the associated fastener

72 and/or the associated mounting aperture 70. It may be possible to reverse the arrangement such that there are two inlet openings 596 at diametrically opposite positions of the chamber 592 to supply coolant G in opposite directions from the space between the third and fourth annular walls 50 and 52 into the chamber 592. Two apertures are provided in the fourth annular wall 52 to supply coolant out of the sub-chambers 592A and 592B of the chamber 592 at diametrically opposite positions of the chamber 592. The coolant G supplied from each of the inlet openings 596 into the chamber 592 splits into coolant flows G1 and G2 which flow circumferentially through about a quarter of the circumference of the fastener 72 and produce a combined coolant flow G3 into the sub-chambers 592A and 592B of the chamber 592. The coolant G3 then flows from the sub-chambers 592A and 592B of the chamber 592 out of both of the apertures in the fourth annular wall 52. The outlet apertures and inlet openings 596 are preferably arranged substantially 90° apart with respect to the axis of the respective fastener 72, however other suitable angles may be used. The inlet apertures 596 and the associated outlet openings are thus circumferentially, angularly, spaced apart with respect to the axis of the associated fastener 72 and/or the associated mounting aperture 70.

[0069] The inlet opening in the wall or the outlet opening in the wall in each of the embodiments described preferably extends the full radial distance from fourth annular wall 52 to the third annular wall 50. However, the inlet opening in the wall or the outlet opening in the wall may extend only a portion of the radial distance from the third annular wall 52 to the fourth annular wall 52 or only a portion of the radial distance from the fourth annular wall 50 to the third annular wall 50. The inlet opening in the wall or the outlet opening in the wall may be an aperture, or slot, in the wall spaced from the third annular wall 50 and the fourth annular wall 52.

[0070] Although the present invention has been described with reference to mounting a segment, or tile, 52A, 52B of the fourth annular wall 52 onto the third annular wall 50 of the radially outer annular wall structure 42, it is equally applicable to mounting a segment, or tile, 48A, 48B of the second annular wall 48 onto the first annular wall 46. It is also applicable to mounting a segment, a tile, or a heat shield, onto an upstream wall as part of an upstream end wall structure 44.

[0071] The present invention provides a wall around each fastener and associated mounting aperture to form a chamber around the fastener. The chamber is supplied with coolant through one or more inlet openings, or apertures, through the outer wall of the combustion chamber or by one or more inlet openings in the wall. The chamber guides the coolant such that it flows over and around the fastener. The chamber discharges coolant through one or more outlet openings, apertures, through the inner wall or through one or more outlet openings in the wall. However, it is necessary to select an appropriate supply of coolant for the chamber and to select an ap-

appropriate place to discharge the coolant from the chamber such that there is a pressure difference to provide a flow of coolant through the chamber.

[0072] The fastener may be integral with the segment, or the tile. The studs, or pedestals, may be integral with the segment, or the tile. The wall may be integral with the segment, or the tile. The segment, or the tile, may be formed by casting molten metal or may be formed from powder metal by selective laser sintering or using a fused powder bed.

[0073] Although the present invention has been described with reference to the provision of the, or each, wall on the segment, or the tile, it is equally possible to provide the, or each, wall on the outer wall. It may be possible to provide some walls on the tiles and some walls on the outer wall. It may also be possible to provide the, or each, wall on the segment, or the tile, but each wall only extends a portion of the required distance between the inner wall and outer wall and the outer wall has a cooperating wall which extends the remainder of the required distance between the inner wall and the outer wall.

[0074] The inner wall may be a radially inner wall and the outer wall may be a radially outer wall of an outer wall of an annular combustion chamber. The inner wall may be a radially outer wall and the outer wall may be a radially inner wall of an inner wall of an annular combustion chamber. Alternatively the inner wall may be a radially inner wall and the outer wall may be a radially outer wall of a tubular combustion chamber. The inner wall may be a downstream wall and the outer wall may be an upstream wall of an upstream end wall of annular combustion chamber or a tubular combustion chamber.

[0075] The advantage of the present invention is that it provides enhanced cooling of the, or each, fastener extending from a combustion chamber wall segment, or tile. The enhanced cooling of the, or each, fastener extending from the chamber wall segment, or tile, increases the service life of the combustion chamber segment, or tile, by reducing the temperature to which the fastener, or fasteners, is/are exposed and by reducing thermally induced stresses in the fastener or fasteners extending from the segment, or tile. The enhanced cooling is provided by uniform cooling of the, or each, fastener extending from the combustion chamber segment, or tile, at the cooler side of the segment, or tile. In addition because the enhanced cooling of the, or each, fastener is provided by cooling the cooler side of the segment, or tile, there is no requirement to provide cooling apertures through the segments, or tiles, in the region of the fasteners. The walls which define the chambers around the fasteners are used to directly react the clamping loads from the inner to the outer wall and therefore distortions in the segments, or tiles, of the inner wall are reduced.

Claims

1. A combustion chamber (15) comprising an outer wall (50) and an inner wall (52) spaced from the outer wall (50), the outer wall (50) having at least one mounting aperture (70) extending there-through, the inner wall (52) having at least one fastener (72) extending there-from, the at least one fastener (72) on the inner wall (52) extending through a corresponding mounting aperture (70) in the outer wall (50), a cooperating fastener (74) locating on the at least one fastener (72) extending through the corresponding mounting aperture (70), at least one wall (90) being positioned between the outer wall (50) and the inner wall (52), a corresponding wall (90) being spaced from and extending around the at least one fastener (72) to form a chamber (92) around the at least one fastener (72), at least one inlet opening (94) to allow a flow of coolant (G) into the chamber (92) and at least one outlet opening (96) to allow a flow of coolant (G) from the chamber (92), wherein the at least one inlet opening (94) and the at least one outlet opening (96) being circumferentially spaced apart with respect to an axis (Y) of the at least one fastener (72) and/or the corresponding mounting aperture (70) to allow a flow of coolant (G) circumferentially around the at least one fastener (72).
2. A combustion chamber as claimed in claim 1 wherein the outer wall (50) having a plurality of mounting apertures (70), the inner wall (52) having a plurality of fasteners (72) extending there-from, a plurality of walls (90), each fastener (72) extending through a respective one of the mounting apertures (70), each wall (90) being positioned between the outer wall (50) and the inner wall (52), each wall (90) being spaced from and extending around a respective fastener (72) to form a chamber (92) around the respective fastener (72).
3. A combustion chamber as claimed in claim 1 or claim 2 wherein the at least one wall (90) extending from the inner wall (52) or the at least one wall (90) extending from the outer wall (50).
4. A combustion chamber as claimed in claim 1, claim 2 or claim 3 wherein the at least one inlet opening (94) extending through the outer wall (50) and the at least one outlet opening (96) extending through the at least one wall (90) or the at least one outlet opening (96) being defined by the at least one wall (90).
5. A combustion chamber as claimed in claim 1, claim 2 or claim 3 wherein the at least one inlet opening (394) extending through the at least one wall (390) or the at least one inlet opening (394) being defined by the at least one wall (390) and the at least one outlet opening (396) extending through the inner wall

- (52).
6. A combustion chamber as claimed in any of claims 1 to 5 wherein the inlet opening (94) and the outlet opening (96) being arranged 180° apart with respect to an axis (Y) of the at least one fastener (72) and/or the at least one mounting aperture (70). 5
 7. A combustion chamber as claimed in claim 6 wherein the inner wall (52) comprising a plurality of segments (52A, 52B), the at least one wall (290) having a first portion (297) and a second portion (298), the first portion (297) being defined by a circumferentially extending wall at an axially upstream end or an axially downstream end of the segment (52A, 52B), the second portion (298) extending from and returning to the first portion (297), the inlet opening (294) extending through the outer wall (50) or the second portion (298) of the wall (290), the outlet opening (296) extending through the first portion (297) of the wall (290) to allow the flow of coolant from the chamber (290) into the combustion chamber (15). 10
 8. A combustion chamber as claimed in any of claims 1 to 5 wherein the inlet opening and the outlet opening (596) being arranged 90° apart with respect to an axis (Y) of the at least one fastener (72) and/or the at least one mounting aperture (70). 15
 9. A combustion chamber as claimed in claim 8 comprising a first inlet opening, a second inlet opening, a first outlet opening (596) and a second outlet opening (596). 20
 10. A combustion chamber as claimed in claim 9 wherein the first inlet opening and the second inlet opening being arranged 180° apart with respect to the axis (Y) of the at least one fastener (72) and/or the at least one mounting aperture (70) and the first outlet opening (596) and the second outlet opening (596) being arranged 180° apart with respect to the axis (Y) of the at least one fastener (72) and/or the at least one mounting aperture (70). 25
 11. A combustion chamber as claimed in any of claims 1 to 6 wherein the inner wall (52) comprising a plurality of segments (52A, 52B), the at least one fastener (72) being arranged at a corner of the segment (52A, 52B), the at least one wall (190) extending around the at least one fastener (72) being partially defined by a circumferentially extending wall (197) at an axial end of the segment (52A, 52B) and by an axially extending wall (198) at the circumferential edge of the segment (52A, 52B) and the outlet opening (196) being arranged in the circumferentially extending wall (197) at the axial end of the segment (52A, 52B) or in the axially extending wall (198) at the circumferential edge of the segment (52A, 52B). 30
 12. A combustion chamber as claimed in any of claims 1 to 11 wherein at least a portion (90A, 90B) of the at least one wall (90) being arranged at a first radius (R1) from the axis (Y) of the at least one fastener (72), the at least one cooperating fastener (74) having a periphery arranged substantially at a second radius (R4) from the axis (Y) of the at least one fastener (72), and the first radius (R1) is equal to or less than the second radius (R4) such clamping loads are passed from the periphery of the cooperating fastener (74) through the outer wall (50) and the at least one wall (90) to the inner wall (52). 35
 13. A combustion chamber as claimed in any of claims 1 to 12 wherein the outer wall (50) having a plurality of impingement apertures (86) extending there-through and the inner wall (52) having a plurality of effusion apertures (88) extending there-through. 40
 14. A combustion chamber as claimed in any of claims 1 to 13 wherein the inner wall (52) being a radially inner wall and the outer wall (50) being a radially outer wall of an outer wall (42) of an annular combustion chamber (15) or the inner wall (48) being a radially outer wall and the outer wall (46) being a radially inner wall of an inner wall (40) of an annular combustion chamber (15). 45
 15. A gas turbine engine (10) comprising a combustion chamber (15) as claimed in any of claims 1 to 14. 50

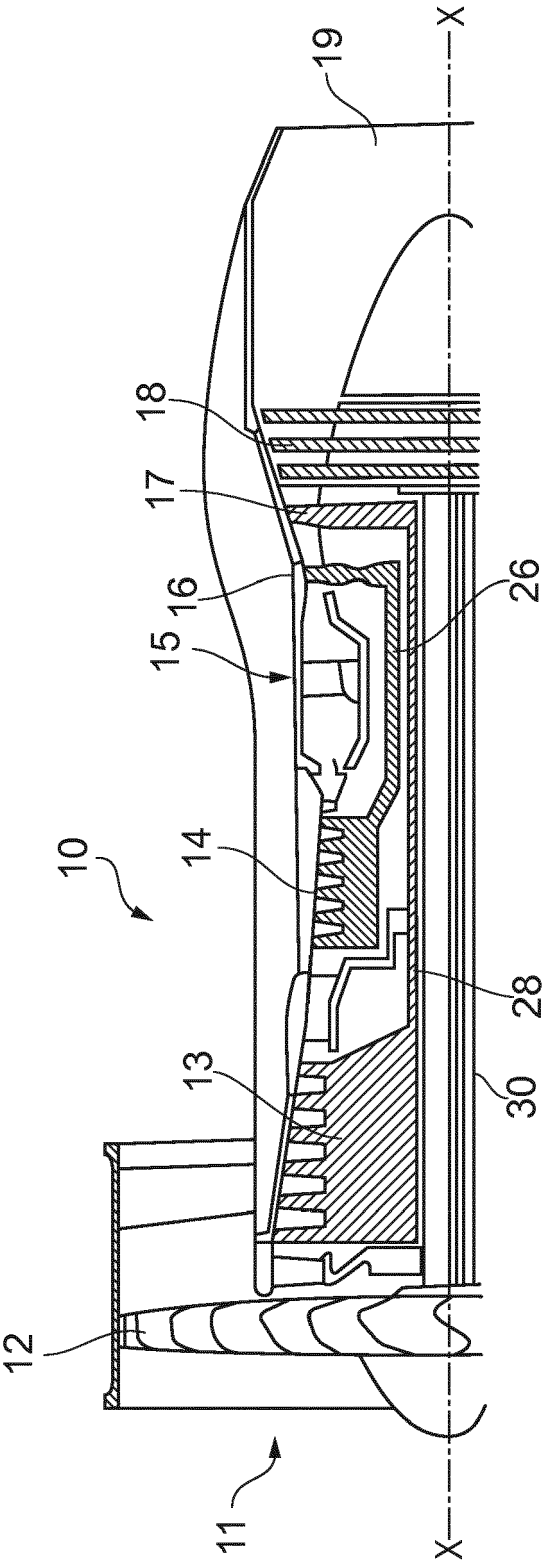


FIG. 1

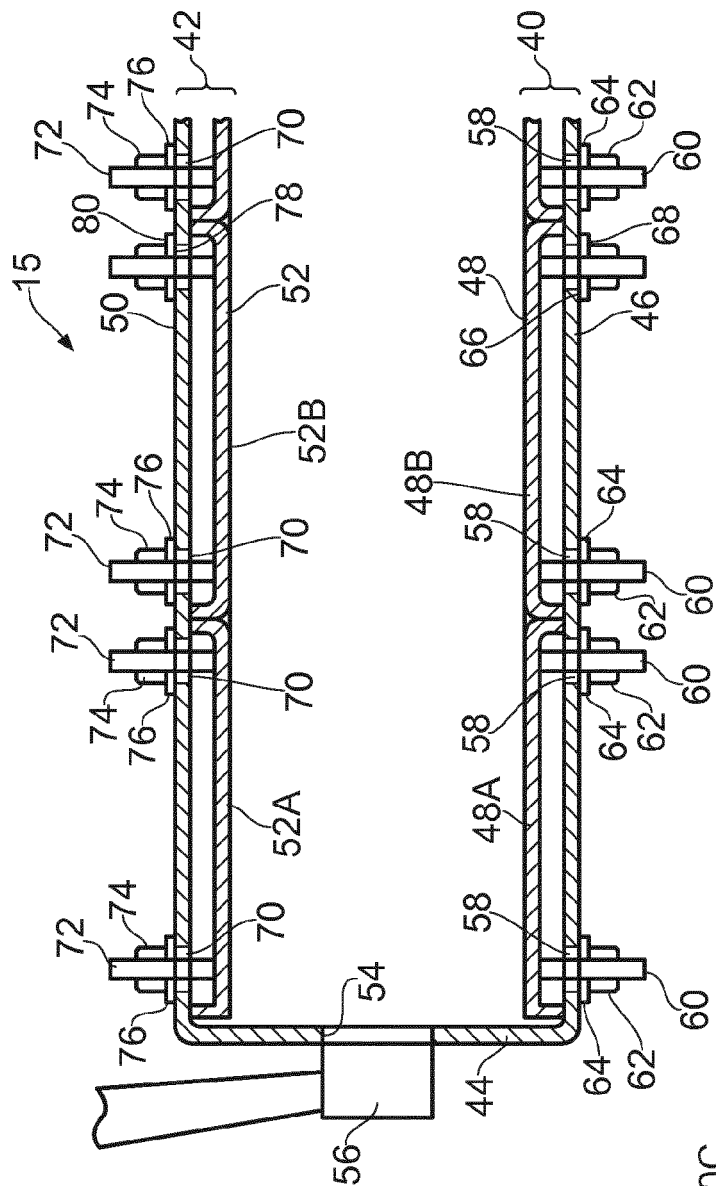


FIG. 2

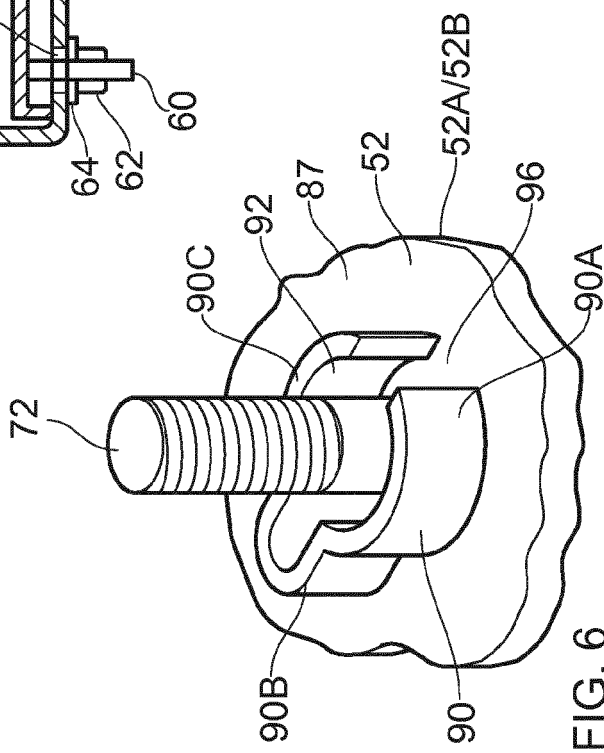


FIG. 6

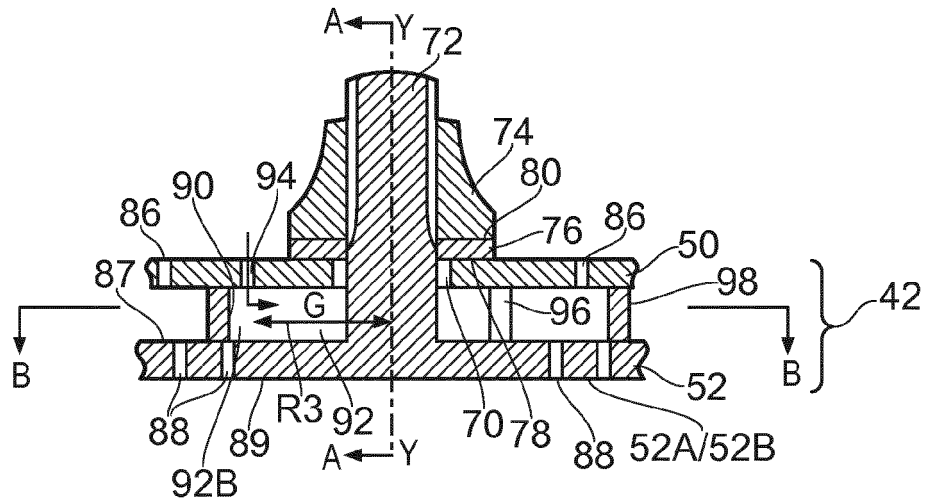


FIG. 3

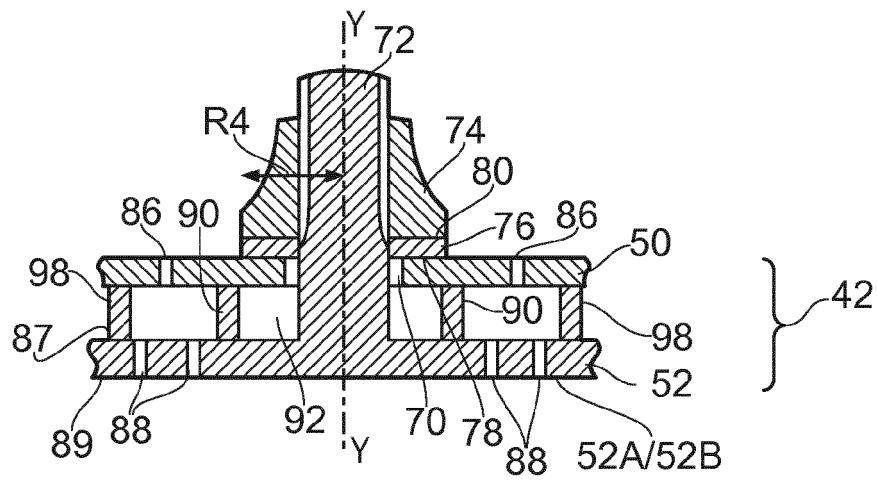


FIG. 4

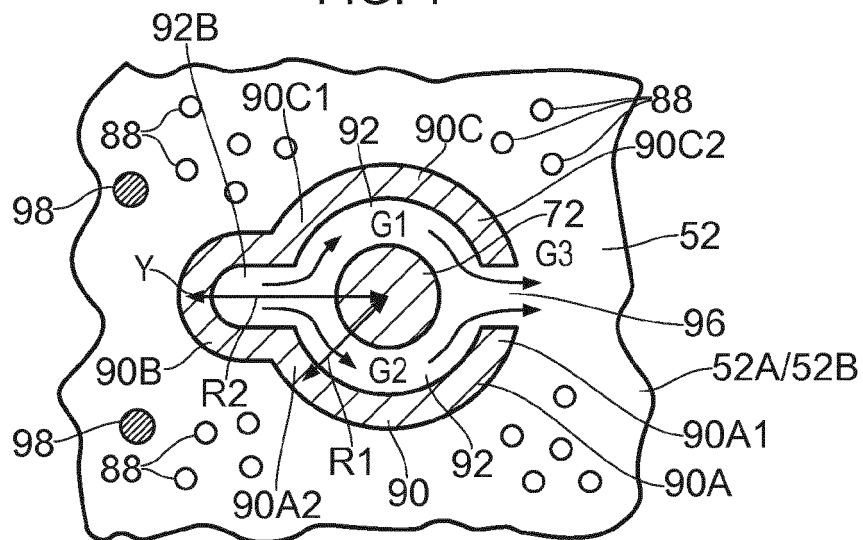


FIG. 5

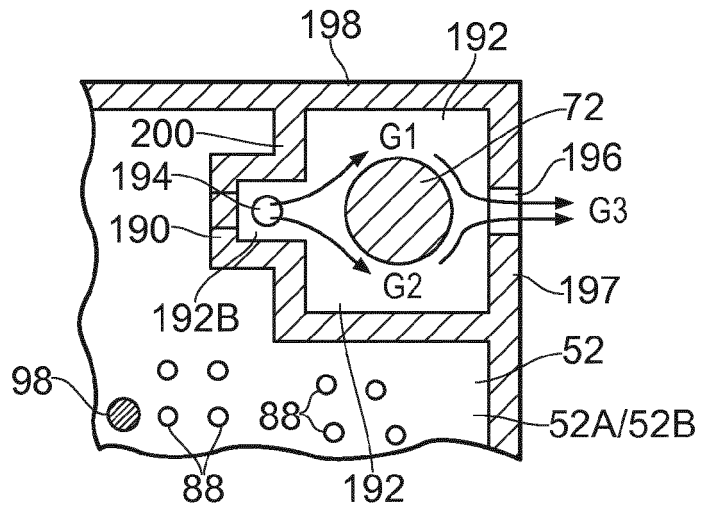


FIG. 7

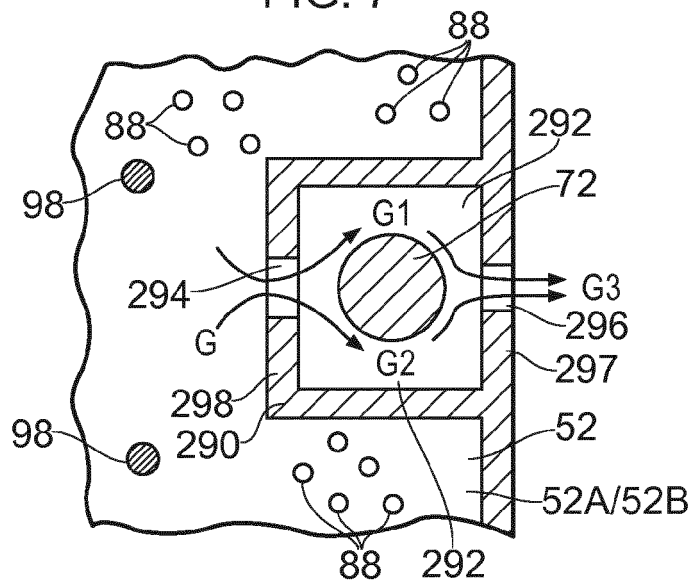


FIG. 8

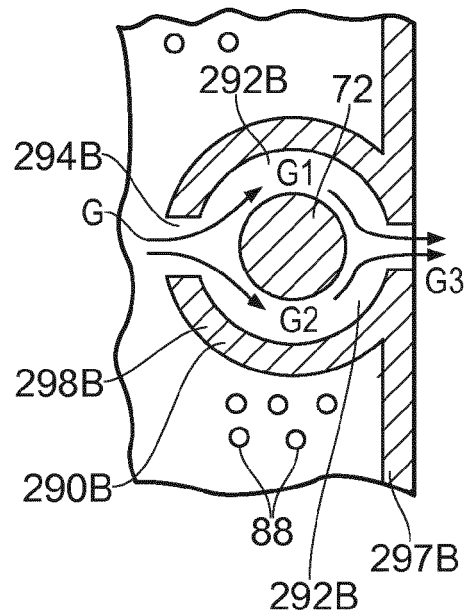


FIG. 16

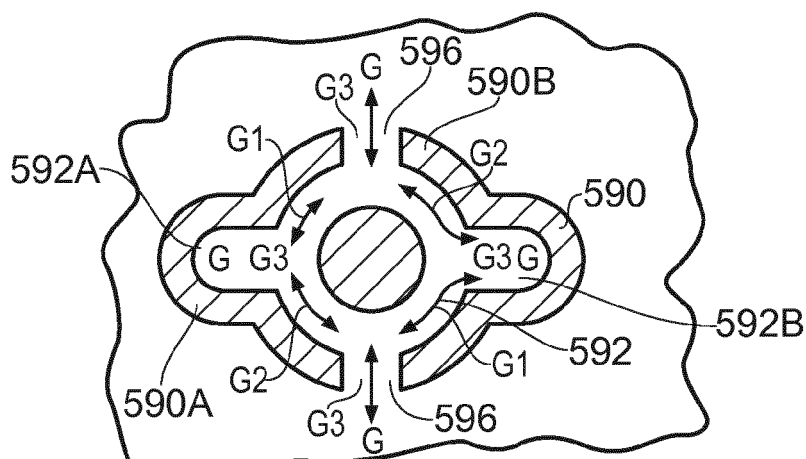


FIG. 15

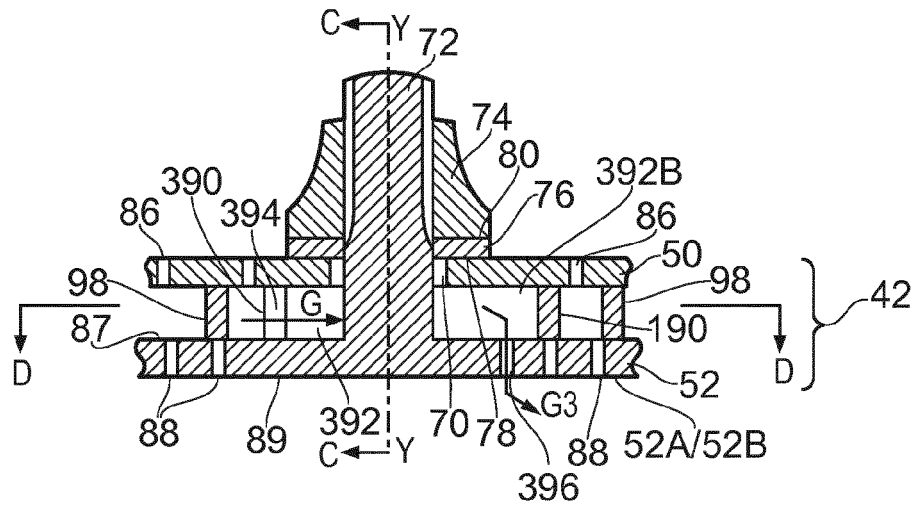


FIG. 9

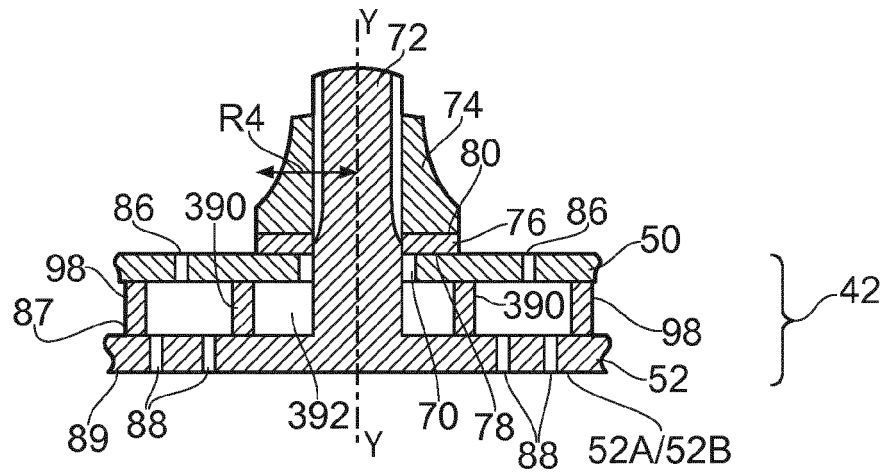


FIG. 10

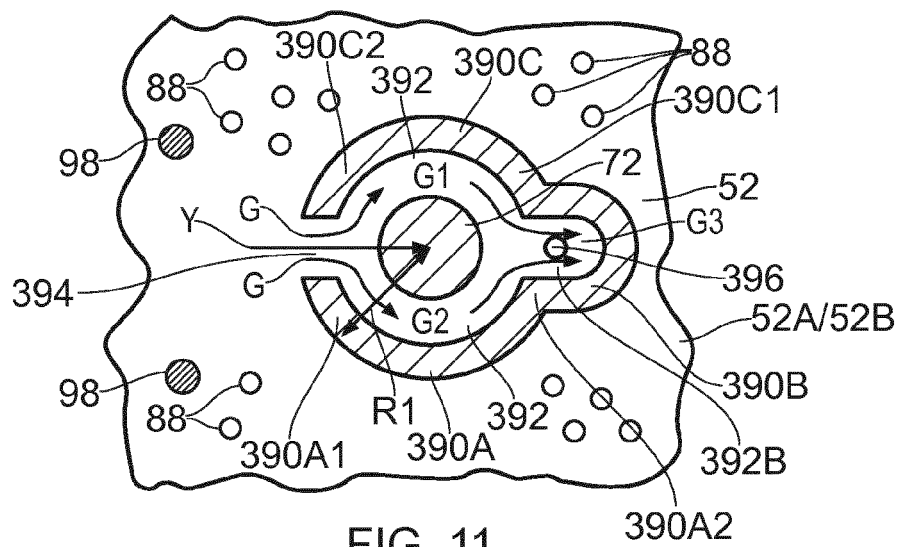


FIG. 11

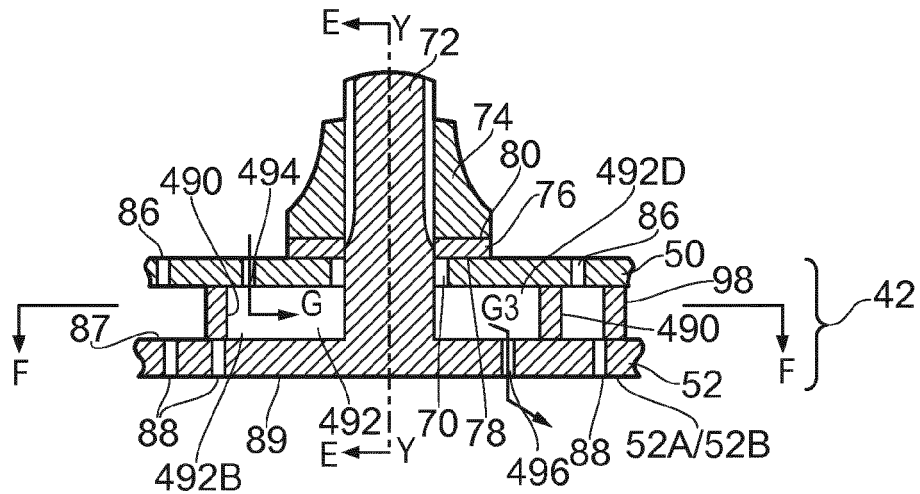


FIG. 12

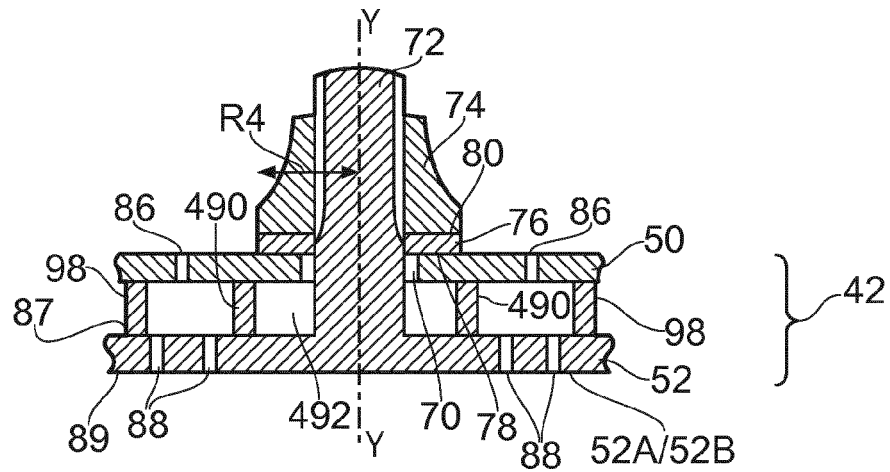


FIG. 13

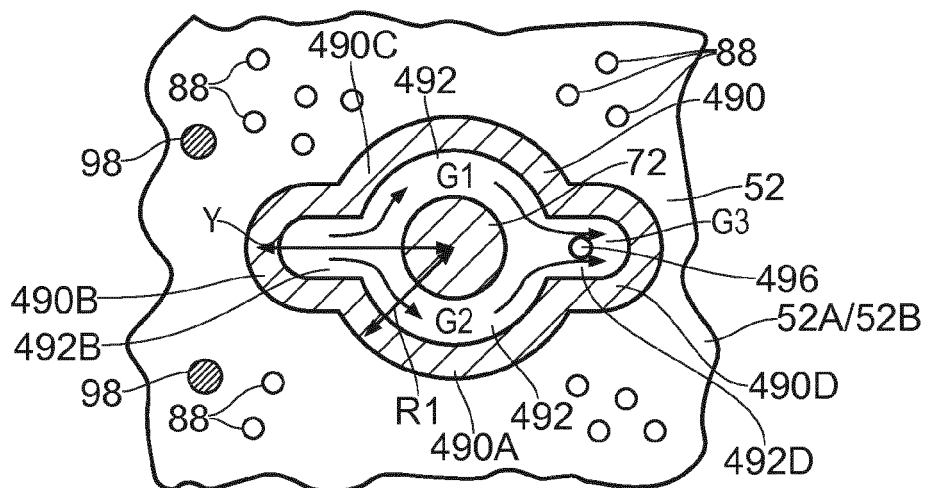


FIG. 14

REFERENCES CITED IN THE DESCRIPTION

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