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Application Number	Filed herewith
Filing Date	Herewith
First Named Inventor	William A. Pratesi, et al.
Title	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS
Art Unit	Unassigned
Examiner Name	Unassigned
Attorney Docket Number	HISEN.046A

SIGNATURE of Applicant or Patent Practitioner

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ABSTRACT

A sprinkler assembly with a nutating distribution plate that tilts and/or rotates upon water impinging the distribution plate. A deflector assembly includes the distribution plate and a base. A body of the sprinkler assembly includes a base retainer surface and a flanged bolt which combine to create a portion of a confinement structure. A portion of the deflector assembly is located within the confinement structure to limit a range of movement of the distribution plate. A nozzle subassembly includes a nozzle and retainer supporting a seal. The nozzle alone or in combination with the retainer can be removed from the sprinkler assembly. The sprinkler assembly can be disassembled and reassembled with minimal tools and effort for servicing. The distribution plate and the base can have mass properties optimized to improve sprinkler performance by reducing vibration, improving uniform water distribution, and reducing fine water droplet generation upon water stream impingement on the distribution plate.

WHAT IS CLAIMED IS:

1. A sprinkler assembly comprising:
 - an inlet configured to receive water;
 - a body supported by the inlet and having a confinement structure;
 - a nozzle supported by the body and disposed downstream of the inlet, the nozzle being in fluid communication with the inlet and configured to direct the water out of the nozzle along an axis; and
 - a deflector assembly having a base and a distribution plate, a portion of the base being disposed in the confinement structure to allow the deflector assembly to move with respect to the axis in one or both of a rotational and a tilting direction, the distribution plate comprising a plurality of channels on a side of the distribution plate facing the nozzle, at least one channel of the plurality of channels has an asymmetrical cross-sectional shape.
2. The sprinkler assembly of Claim 1, wherein the cross-sectional shape is asymmetric across a vertical line passing through a vertex or bottom of the at least one channel.
3. The sprinkler assembly of Claim 1, wherein the cross-sectional shape is asymmetric across a vertical line passing through a midpoint of a width of the at least one channel as measured at a top of the at least one channel.
4. The sprinkler assembly of Claim 1, wherein the cross-sectional shape comprises a first side and an opposite second side, wherein a degree of curvature of at least a portion of the first side is different than a degree of curvature of at least a portion of the opposite second side.
5. The sprinkler assembly of Claim 4, wherein the at least one channel comprises a leading edge disposed between the first side and the opposite second side and extending along a length of the at least one channel to an exit of the at least one channel, a first distance measured between the leading edge and one of the first side or the opposite second side at a first location along the at least one channel being different than a second distance measured between the leading edge and the one of the first side or the opposite second side at a second

location along the at least one channel, the first location being different than the second location.

6. The sprinkler assembly of Claim 1, wherein the plurality of channels is curved.

7. The sprinkler assembly of Claim 1, wherein the distribution plate further comprises a first region and a second region, a thickness of the first region being different than a thickness of the second region.

8. The sprinkler assembly of Claim 1, wherein the distribution plate further comprises a web located between adjacent channels of the plurality of channels, the web having a wall thickness that is greater than a wall thickness of the adjacent channels.

9. The sprinkler assembly of Claim 1, further comprising a retainer configured to be inserted in the body and between the nozzle and the inlet, the nozzle being removable from the body independent from removing the retainer from the body, the retainer being configured to support a seal at least when disposed in the body.

10. The sprinkler assembly of Claim 9, wherein the retainer is further configured to engage with the nozzle so that the nozzle and the retainer can be removed from the body as a subassembly.

11. A sprinkler assembly comprising:

an inlet configured to receive water;

a body supported by the inlet and having a base retaining surface;

a nozzle supported by the body and disposed downstream of the inlet, the nozzle being in fluid communication with the inlet and configured to direct the water out of the nozzle along an axis;

a deflector assembly having a base and a distribution plate, the base comprising a first side and an opposite second side, the first side of the base being supported by the base retaining surface, the distribution plate comprising a plurality of channels on a side of the distribution plate facing the nozzle, at least one channel of the plurality of channels has an asymmetrical cross-sectional shape; and

a flanged bolt configured to be supported by the body and disposed between the nozzle and the side of the distribution plate facing the nozzle, the flanged bolt supporting the second side of the base so that the deflector assembly can move with respect to the axis in one or both of a rotational and a tilting direction.

12. The sprinkler assembly of Claim 11, wherein the cross-sectional shape comprises a first side, an opposite second side, and a radiused section, the radiused section blending the first side and the opposite second side together in an off center arrangement relative to the cross-sectional shape of the at least one channel.

13. The sprinkler assembly of Claim 12, wherein the at least one channel comprises a leading edge that moves closer to the first side than the opposite second side along a length of the at least one channel.

14. The sprinkler assembly of Claim 11, wherein the distribution plate further comprises a web located between adjacent channels of the plurality of channels, the web having a wall thickness that is different than a wall thickness of the adjacent channels.

15. The sprinkler assembly of Claim 11, further comprising a retainer configured to be inserted in the body and between the nozzle and the inlet, the retainer being configured to support a seal at least when disposed in the body, at least a portion of the nozzle engaging with the seal, the nozzle being tiltable to disengage from the seal when the nozzle and the retainer are both disposed in the body allowing the nozzle to be removed from the body independent from removing the retainer,.

16. The sprinkler assembly of Claim 15, wherein when the nozzle is engaged with the seal, the nozzle and the retainer can be removed from the body as a subassembly.

17. A sprinkler assembly comprising:

an inlet configured to receive water;

a body supported by the inlet;

a nozzle supported by the body and disposed downstream of the inlet, the nozzle being in fluid communication with the inlet and configured to direct the water out of the nozzle along an axis; and

a distribution plate being coupled to the body to move with respect to the axis in one or both of a rotational and a tilting direction, the distribution plate having a plurality of channels on a side of the distribution plate facing the nozzle, at least one channel of the plurality of channels having sides and a bottom surface connecting the sides, the bottom surface defining a leading edge that extends along a length of the at least one channel, the leading edge being closer to one of the sides.

18. The sprinkler assembly of Claim 17, wherein the distribution plate further comprises a web located between adjacent channels of the plurality of channels, the web having a wall thickness that is different than a wall thickness of the adjacent channels.

19. The sprinkler assembly of Claim 17, further comprising a retainer configured to be inserted in the body and between the nozzle and the inlet, the retainer being configured to support a seal at least when disposed in the body, at least a portion of the nozzle engaging with the seal, the nozzle being tiltable relative to the retainer to disengage from the seal when the nozzle and the retainer are both disposed in the body allowing the nozzle to be removed from the body independent from removing the retainer.

20. The sprinkler assembly of Claim 19, wherein when the nozzle is engaged with the seal, the nozzle and the retainer can be removed from the body as a subassembly.

SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS

TECHNICAL FIELD

[0001] The present disclosure relates to apparatuses for irrigating turf, agriculture, and/or landscaping.

BACKGROUND

[0002] In many parts of the world, rainfall can be insufficient and/or too irregular to keep turf and landscaping green and/or to sufficiently water crops and other agricultural products. Therefore, irrigation systems are often installed to provide adequate irrigation to landscaping and/or agricultural products.

SUMMARY

[0003] In certain irrigation applications, it can be advantageous to utilize sprinklers with a nutating distribution plate. For example, sprinklers with a nutating distribution plate can utilize fewer parts than a gear driven sprinkler. Sprinklers with a nutating distribution plate can also be capable of operating using relatively large unobstructed water flow paths for overhead irrigation of large fields and crops. Utilizing larger water flow paths can reduce the need to finely filter or otherwise purify water used for irrigation. In some such cases, water from rivers, streams, lakes, ponds, wells, and/or other water sources can be used with less purification infrastructure than may be necessary for gear driven sprinklers.

[0004] However, it can be important to provide such sprinklers with interchangeable nozzles for varying conditions. In some applications, it may be important for the sprinkler to operate with a flow of 0.80 gallons of water per minute or less. In some applications, it may be important for the sprinkler to operate with a flow of 18 gallons of water per minute or more. A wide variety of nozzles can allow for many different flows. When the distribution plate rocks and rotates while the water is applied, asymmetrical water channels in

the distribution plate can help to optimize the speed of rotation with various water flows from the different nozzles.

[0005] In some embodiments, a sprinkler assembly comprises an inlet configured to receive water, a body supported by the inlet and having a confinement structure, and a nozzle supported by the body and disposed downstream of the inlet. The nozzle is in fluid communication with the inlet and configured to direct the water out of the nozzle along an axis. The sprinkler assembly further comprises a deflector assembly having a base and a distribution plate. A portion of the base is disposed in the confinement structure to allow the deflector assembly to move with respect to the axis in one or both of a rotational and a tilting direction. The distribution plate comprises a plurality of channels on a side of the distribution plate facing the nozzle. At least one channel of the plurality of channels has an asymmetrical cross-sectional shape.

[0006] In some embodiments, a sprinkler assembly comprises an inlet configured to receive water, a body supported by the inlet and having a base retaining surface, and a nozzle supported by the body and disposed downstream of the inlet. The nozzle is in fluid communication with the inlet and configured to direct the water out of the nozzle along an axis. The sprinkler assembly further comprises a deflector assembly having a base and a distribution plate. The base comprises a first side and an opposite second side. The first side of the base is supported by the base retaining surface. The distribution plate comprises a plurality of channels on a side of the distribution plate facing the nozzle. At least one channel of the plurality of channels has an asymmetrical cross-sectional shape. The sprinkler assembly further comprises a flanged bolt configured to be supported by the body and disposed between the nozzle and the side of the distribution plate facing the nozzle. The flanged bolt supports the second side of the base so that the deflector assembly can move with respect to the axis in one or both of a rotational and a tilting direction.

[0007] In some embodiments, a sprinkler assembly comprises an inlet configured to receive water, a body supported by the inlet, and a nozzle supported by the body and disposed downstream of the inlet. The nozzle is in fluid communication with the inlet and configured to direct the water out of the nozzle along an axis. The sprinkler assembly further comprises a distribution plate coupled to the body to move with respect to the axis in one or both of a rotational and a tilting direction. The distribution plate has a plurality of channels on

a side of the distribution plate facing the nozzle. At least one channel of the plurality of channels has sides and a bottom surface connecting the sides. The bottom surface defines a leading edge that extends along a length of the at least one channel. The leading edge is closer to one of the sides.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Various embodiments are depicted in the accompanying drawings for illustrative purposes and should in no way be interpreted as limiting the scope of the embodiments. In addition, various features of different disclosed embodiments can be combined to form additional embodiments, which are part of this disclosure.

[0009] Figure 1 is a front plan view of an embodiment of a sprinkler with a distribution plate which nutates during operation of the sprinkler showing the distribution plate located downstream of a nozzle coupled to an inlet.

[0010] Figure 2 is a back plan view of the sprinkler of Figure 1.

[0011] Figure 3 is a top perspective view of the sprinkler of Figure 1 showing one or more water channels and a through hole through a flanged bolt for water to flow from the nozzle to the distribution plate.

[0012] Figure 4 is another top perspective view of the sprinkler of Figure 1 showing a skirt sculptured to allow for easy access to the nozzle from a side of the sprinkler of Figure 1.

[0013] Figure 5 is a side elevation view of the sprinkler of Figure 1.

[0014] Figure 6 is a top view of the sprinkler of Figure 5 showing an outer surface of the distribution plate.

[0015] Figure 7 is a cross-sectional view of the sprinkler of Figure 5, as viewed along the cut-plane 7-7 of Figure 6, showing the distribution plate of a deflector assembly located downstream of the nozzle and temporarily positioned so that a central axis of the deflector assembly is off axis from a longitudinal axis of the nozzle.

[0016] Figure 7A is an enlarged view of a portion of the nozzle including the flanged bolt from Figure 7.

[0017] Figure 8 is a perspective exploded view of the sprinkler of Figure 5 including a body configured to receive a nozzle subassembly.

[0018] Figure 9 is a perspective view of a retainer of the nozzle subassembly from Figure 8.

[0019] Figure 10 is a perspective view of the body and the nozzle subassembly from Figure 8 showing the seal and the retainer assembled to the nozzle prior to insertion of the nozzle subassembly into the body according to a first assembly process.

[0020] Figure 11 is similar to Figure 10 except the retainer and the seal of the nozzle assembly has been inserted into the body prior to insertion of the nozzle into the body according to a second assembly process.

[0021] Figure 12 is similar to Figure 7 except it shows the nozzle being assembled to the retainer and the seal by tilting the nozzle after the retainer and the seal have already been installed in the body according to the second assembly process.

[0022] Figure 13 is a top perspective view of the distribution plate of the sprinkler of Figure 8 showing one or more water channels that have an asymmetric shape.

[0023] Figure 14 is a bottom perspective view of the distribution plate of Figure 13.

[0024] Figure 15 is a top perspective view of the base of the sprinkler of Figure 13.

[0025] Figure 16 is a front elevation view of a distribution plate similar to Figures 13 and 14 assembled to the base of Figure 15 showing that the distribution plate has a variable thickness.

[0026] Figure 17 is a bottom view of the distribution plate and the base of Figure 16.

[0027] Figure 18 is a cross-sectional view taken along cut-plane 18-18 of Figure 17 and shows a plurality of legs of the distribution plate being inserted through corresponding holes in the base.

[0028] Figure 18A is similar to Figure 18 except that a distal end of one of the plurality of legs has been deformed to inhibit the distribution plate from being disassembled from the base.

[0029] Figure 19 is a front view of the distribution plate from Figure 8 showing a cross-sectional shape of the one or more water channels is asymmetric.

[0030] Figure 20 is a bottom view of the distribution plate of Figure 18 showing a leading edge of a radiused section of the one or more water channels have an asymmetric shape.

[0031] Figure 21 is similar to Figure 20 and shows a water flow path through one of the water channels when the nozzle inserted into the body has a small water flow path.

[0032] Figure 22 is similar to Figure 21 and shows a water flow path through the same water channel when the nozzle inserted into the body has a larger water flow path than the flow path of the nozzle from Figure 21.

[0033] Figure 23 is a top, side perspective view of an embodiment of a sprinkler.

[0034] Figure 24 is a bottom, side perspective view of the sprinkler of Figure 23.

[0035] Figure 25 is a front plan view of the sprinkler of Figure 23.

[0036] Figure 26 is a back plan view of the sprinkler of Figure 23.

[0037] Figure 27 is a left side plan view of the sprinkler of Figure 23.

[0038] Figure 28 is a right side plan view of the sprinkler of Figure 23.

[0039] Figure 29 is a top plan view of the sprinkler of Figure 23.

[0040] Figure 30 is a bottom plan view of the sprinkler of Figure 23.

[0041] Figure 31 is a top, side perspective view of an embodiment of a sprinkler wherein broken lines are used to illustrate features of the sprinkler which may or may not form part of the design, depending on the embodiment.

[0042] Figure 32 is a bottom, side perspective view of the sprinkler of Figure 31.

[0043] Figure 33 is a front plan view of the sprinkler of Figure 31.

[0044] Figure 34 is a back plan view of the sprinkler of Figure 31.

[0045] Figure 35 is a left side plan view of the sprinkler of Figure 31.

[0046] Figure 36 is a right side plan view of the sprinkler of Figure 31.

[0047] Figure 37 is a top plan view of the sprinkler of Figure 31.

[0048] Figure 38 is a bottom plan view of the sprinkler of Figure 31.

DETAILED DESCRIPTION

[0049] **Figure 1** is a front plan view of an embodiment of a sprinkler 10 with a distribution plate 12 configured to nutate in a clockwise direction (see Figure 6) during operation of the sprinkler 10. A radial angle of one or more water channels 42 in the distribution plate 12 causes the distribution plate 12 to rotate in the clockwise direction. In some embodiments, the water channels 42 can be formed to cause the distribution plate 12 to rotate in a counter-clockwise direction.

[0050] In some embodiments, a cross-sectional shape of the one or more water channels 42 in the distribution plate 12 is selected to cause the distribution plate 12 to rotate at different rates depending on, for example, a volumetric flow rate of water through the sprinkler 10. In some embodiments, a cross-sectional shape of the one or more water channels 42 in the distribution plate 12 is selected to cause the distribution plate 12 to rotate at the same or similar rates despite, for example, different volumetric flow rates of water through the sprinkler 10. In certain embodiments, the cross-sectional shape of the one or more water channels 42 can be asymmetric. In certain embodiments, the cross-sectional shape of the one or more water channels 42 is asymmetric relative to a vertex or bottom of the cross-sectional shape. In certain embodiments, the one or more water channels 42 can have an exit geometry that has a first side that has a degree of curvature different from a degree of curvature of a second side. For example, the first side can be nearly straight while the second side can be radiused. In certain embodiments, one or more arcs forming the first side of the exit geometry have a degree of curvature different from one or more arcs forming the second side of the exit geometry.

[0051] As explained below, the distribution plate 12 is coupled to the sprinkler 10 to exhibit a desired nutating or swaying motion about an axis of rotation and a desired rate(s) of rotation during operation of the sprinkler 10.

[0052] The sprinkler 10 can include an inlet 14. The inlet 14 defines an upstream end of the sprinkler 10. The inlet 14 can be configured to connect to a water source (e.g., an arm of an irrigation system, a water line, a hose, or some other source of water). In certain embodiments, the inlet 14 supports a body 16. In some embodiments, the inlet 14 can be formed as a part of the body 16. In some embodiments, the inlet 14 can be a separate piece that is removably or permanently attached to the body 16.

[0053] In certain embodiments, the inlet 14 comprise one or more vanes 56 disposed in at least a portion of a flow path through the inlet 14. In certain embodiments, the one or more vanes 56 are inserted into the inlet 14 after manufacture of the inlet 14. In certain embodiments, the one or more vanes 56 are molded in the flow path during manufacture of the inlet 14. The one or more vanes 56 are configured to align or straighten the water passing through the inlet 14.

[0054] In some embodiments, the inlet 14 is configured to be secured to a water supply line on an irrigation system. In some embodiments, the inlet 14 is at least partially

surrounded by threads 18. The threads 18 can be screwed into the water supply line on the irrigation system. In some instances, a pressure regulator can be positioned between the water supply line and the sprinkler 10. The inlet 14 can also be screwed into an outlet of the pressure regulator. Other attachment methods, including, but not limited to, glued connections, bayonet mounts, snap rings, keys, or collars can be used to secure the sprinkler 10 to either a water supply line or a pressure regulator.

[0055] The sprinkler 10 can include a nozzle 20. The nozzle 20 can be in fluid communication with the inlet 14. The nozzle 20 can extend at least partially beyond a downstream end of the inlet 14. The nozzle 20 can be configured to output water that enters the nozzle 20 from the inlet 14. In some embodiments, the nozzle 20 can output water in a pressurized manner. For example, the nozzle 20 can direct pressurized water received from the inlet 14.

[0056] In some embodiments, the nozzle 20 can output water in a predetermined direction. For example, the nozzle 20 can output water along a longitudinal axis 46 of the nozzle 20 (see Figure 7). In some embodiments, the nozzle 20 can direct water towards a predetermined location within the sprinkler 10. In some embodiments, the nozzle 20 can direct water in a direction towards a component of the sprinkler 10. In certain embodiments, the position of the component may be fixed, user adjustable, or movable with respect to the nozzle 20. For example, the nozzle 20 can direct water in a direction towards the distribution plate 12.

[0057] In the illustrated embodiments, the body 16 is manufactured as an integral component with the inlet 14. In alternate embodiments, the body 16 is manufactured as a separate component from the inlet 14 and subsequently coupled to the inlet 14 during assembly.

[0058] The body 16 is configured to generally support the distribution plate 12 relative to the inlet 14 and/or the nozzle 20 while allowing the distribution plate 12 to nutate during operation of the sprinkler 10. In the illustrated embodiment, the body 16 is sized and shaped to accept a flanged bolt 40 to allow the distribution plate 12 to nutate during operation of the sprinkler 10 while preventing the distribution plate 12 from separating from the sprinkler 10. In this way, the body 16 and the flanged bolt 40 prevent the distribution plate 12 from breaking free from the inlet 14 due to the force created by the pressurized water exiting the nozzle 20 impinging on the distribution plate 12.

[0059] **Figure 2** is a back plan view of the sprinkler 10 of Figure 1. The body 16 can directly or indirectly couple to the distribution plate 12. In the illustrated embodiment, the body 16 couples the inlet 14 to the distribution plate 12 via the flanged bolt 40. In some embodiments, the flanged bolt 40 can incorporate a through hole 32 (Figure 3). In certain embodiments, the through hole 32 provides an unobstructed passageway for the water leaving the nozzle 20 to contact the distribution plate 12. In other embodiments, the body 16 directly couples to the distribution plate 12 while allowing the distribution plate 12 to nutate during operation of the sprinkler 10. For example, the body 16 can couple to the distribution plate 12 via a joint such as a ball joint or ball-and-socket joint.

[0060] **Figure 3** is a top perspective view of the sprinkler 10 of Figure 1 showing the one or more water channels 42 on an upstream side of the distribution plate 12. The distribution plate 12 can be positioned downstream of the nozzle 20. In some embodiments, the nozzle 20 is configured to direct water onto the distribution plate 12.

[0061] Water impingement on the distribution plate 12 can cause the distribution plate 12 to “nutate, or rotate and tilt side to side.” For example, the distribution plate 12 can be configured to rotate and/or tilt with respect to the longitudinal axis 46 of the nozzle 20 or some other axis thereof, and/or undergo nutation in reaction to water impingement from the nozzle 20 onto the distribution plate 12. In the illustrated embodiment, the water impingement from the nozzle 20 contacts the one or more water channels 42 on the upstream side of the distribution plate 12 imparting lateral forces on the distribution plate 12. Tilting and rotation of the distribution plate 12 can allow water to be dispersed in different directions. Dispersing water in different directions can facilitate a more even distribution of water about an area of irrigation than a sprinkler without the distribution plate 12 which nutates.

[0062] In the illustrated embodiment, the distribution plate 12 forms a component of a deflector assembly 38 which will be further described below. In certain embodiments, the deflector assembly 38 further comprises a base 58.

[0063] In certain embodiments, the deflector assembly 38 is supported by the body 16 and the flanged bolt 40 to allow the deflector assembly 38, which carries the distribution plate 12, to tilt and rotate in concert with the distribution plate 12. As mentioned above, the flanged bolt 40, which will be described in greater detail below, can be releasably coupled to the body 16.

[0064] **Figure 4** is a side perspective view of the sprinkler 10 of Figure 1 showing the distribution plate 12 mated to the base 58 to form the deflector assembly 38. The base 58 and the distribution plate 12 can be manufactured as a unitary structure. In certain embodiments, the base 58 and the distribution plate 12 are separately manufactured and then assembled to form the deflector assembly 38. In certain embodiments, the base 58 supports the distribution plate 12 via one or more legs 34. The one or more legs 34 can be a separate structure, a portion of the distribution plate 12, a portion of the base 58, or portions of both the distribution plate 12 and the base 58. In certain embodiments, the one or more legs 34 are part of both the distribution plate 12 and the base 58.

[0065] In certain embodiments, the base 58 comprises a cap 60 and a skirt 70. In some embodiments, the skirt 70 has a shape complementary to the shape of the body 16 to prevent the base 58 from interfering with the radial and side-to-side motion of the deflector assembly 38. In certain embodiments, the one or more legs 34 extend from the cap 60 in a direction towards the distribution plate 12. In certain embodiments, the skirt 70 extends from the cap 60 in a direction away from the distribution plate 12.

[0066] The cap 60 and the skirt 70 can be manufactured as a unitary structure. In certain embodiments, the cap 60 and the skirt 70 are separately manufactured and then assembled to form the base 58. In the illustrated embodiment, the cap 60 and the skirt 70 are formed as a unitary structure along with at least a portion of the one or more legs 34.

[0067] In certain embodiments, the base 58 can have one or more recesses 50 formed in at least one portion of the skirt 70. For example, the skirt 70 illustrated in **Figure 4** comprises three recesses 50. The three recesses 50 are spaced equally about the outer circumference of the sprinkler 10. Of course, the skirt 70 can comprise more or less than three recesses 50 and the recesses 50 need not be spaced equally about the outer circumference of the sprinkler 10. In some embodiments, it may be desirable to have the recesses 50 spaced equally about the outer circumference of the sprinkler 10 to balance the deflector assembly 38 as the deflector assembly 38 rotates and tilts during normal operation. In some embodiments, the one or more recesses 50 can be formed to provide access to remove or replace the nozzle 20 from the sprinkler 10 without disassembling the deflector assembly 38 from the body 16.

[0068] **Figure 5** is a side elevation view of the sprinkler 10 of **Figure 1** with the deflector assembly 38 tilted relative to the body 16. **Figure 6** is a top view of the sprinkler 10 of **Figure 5** showing an outer surface of the distribution plate 12.

[0069] **Figure 7** is a cross-sectional view of the sprinkler 10 of **Figure 1**, as viewed along the cut-plane 7-7 of **Figure 6**. **Figure 7A** is an enlarged view of a portion of the nozzle 20 including the flanged bolt 40 from **Figure 7**. In certain embodiments, the flanged bolt 40 includes a flange 36. The flange 36 can have a flat or tapered shape, or otherwise a curved surface. In some embodiments, a skirt 70 portion of the base 58 has a shape complementary to the shape of the body 16 that does not interfere with the radial and side-to-side motion of the deflector assembly 38.

[0070] **Figures 7 and 7A** are showing the distribution plate 12 located downstream of the nozzle 20 and temporarily positioned so that the central axis 44 of the distribution plate 12 is off axis from the longitudinal axis 46 of the nozzle 20. In some embodiments, the entire deflector assembly 38, including the distribution plate 12, is located downstream of the nozzle 20. In the illustrated embodiment, a portion of the deflector assembly 38, including the distribution plate 12, is located downstream of a plane 24 defined by the exit from the nozzle 20. In the illustrated embodiment, the deflector assembly 38 does not contact the sprinkler 10 at a location that is upstream of the plane 24 to not interfere with operation of the sprinkler 10.

[0071] In some embodiments, the sprinkler 10 includes a retainer 22. In some embodiments, the retainer 22 is disposed downstream of the inlet 14. In some embodiments, the retainer 22 can be connected to the body 16. In some embodiments, the retainer 22 can be removably connected to the body 16. In some embodiments, the nozzle 20 can be coupled to the body 16 and positioned downstream from the retainer 22.

[0072] In certain embodiments, the retainer 22 comprises an internal flow path. In some embodiments, at least a portion of the internal flow path can be straight, substantially straight, and/or tapered inward between an upstream end of the retainer 22 and a downstream end of the retainer 22.

[0073] In certain embodiments, the sprinkler 10 comprises a seal 26. The seal 26 is configured to prevent pressurized water from leaking between the body 16 and the nozzle 20. In some embodiments, the seal 26 is in the form of an O-ring. In some embodiments, the retainer 22 supports the seal 26. In some embodiments, the seal 26 can be positioned at least

partially within the retainer 22. In certain embodiments, the nozzle 20, the seal 26, and the retainer 22 form a nozzle subassembly 102 as will be further described below.

[0074] In certain embodiments, the nozzle 20 can be removed and reinstalled to position the nozzle 20 on the body 16 without any tools. As illustrated most clearly in **Figures 1 and 4**, a user can pinch tabs 28 and 30 on the nozzle 20 and then move the nozzle 20 slightly upwards to disengage the nozzle 20 from the body 16 and then pull laterally to remove the nozzle 20 from the sprinkler 10. The nozzle 20 similarly can be replaced by reversing the procedure. In some embodiments, the nozzle 20 can be similar to, or the same as the nozzle disclosed in **US Patent No. 8,556,196**, titled QUICK CHANGE NOZZLE of Lawyer et. al., issued on October 15, 2013. The nozzle 20 can also include an internal taper to accelerate and/or pressurize water flow out from the nozzle 20.

[0075] In certain embodiments, the body 16 can support a base retainer surface 48 relative to the inlet 14. In some embodiments, the base retainer surface 48 can be a surface of the body 16. In some embodiments, the base retainer surface 48 is formed as part of the body 16. In the illustrated embodiment, the base retainer surface 48 is disposed downstream of the inlet 14 and upstream of the distribution plate 12. In some embodiments, the base retainer surface 48 can act as a retainer to control the radial and side-to-side motion of the deflector assembly 38. In some embodiments, the base retainer surface 48 can be positioned between the flanged bolt 40 and the body 16 when assembled.

[0076] In some embodiments, the base retainer surface 48 extends radially outward of a shaft 52. In some embodiments, the shaft 52 is formed as part of the body 16. In some embodiments, the shaft 52 is positioned at the downstream end of the body 16. In certain embodiments, the flanged bolt 40 can be attached to the body 16 at the shaft 52. In some embodiments, a threaded portion 54 is disposed in the shaft 52. In some embodiments, the flanged bolt 40 can be threaded into the threaded portion 54. In some embodiments, the shaft 52 acts as a spacer to create a space between the flanged bolt 40 and the base retainer surface 48.

[0077] In some embodiments, the cap 60 of the base 58 includes bore 62. In certain embodiments, the bore 62 extends through the cap 60. In certain embodiments, the bore 62 is disposed in a center of the cap 60. The bore 62 can be sized to loosely fit over the shaft 52. In some embodiments, the base retainer surface 48, the shaft 52, and the flange 36 combine to

create a confinement structure 64. In some cases, the cap 60 can be loosely confined within the confinement structure 64 to allow proper operation of the deflector assembly 38. In some embodiments, a cross-section of the confinement structure 64 has a linear shape. In some embodiment, the cross-section of the confinement structure 64 has a curved shape such as an L-shape. In the illustrated embodiment, the cross-section of the confinement structure 64 is H shaped, or C-shaped on each side. In some embodiments, the cross-section of the confinement structure 64 is symmetrical. In some embodiments, the cross-section of the confinement structure 64 is asymmetrical. In some cases, the confinement structure 64 is positioned between the nozzle 20 and the distribution plate 12.

[0078] In some embodiments, the confinement structure 64 is positioned to focus intermittent or transitory contact between the deflector assembly 38 and the sprinkler 10 during operation of the sprinkler 10. In some embodiments where the confinement structure 64 has a curved shape such as an H or C-shape, the contact between the deflector assembly 38 and the sprinkler 10 can occur on multiple surfaces of the confinement structure 64. The shape and/or position of the shaft 52 with respect to one or more of the base retainer surface 48, the flanged bolt 40, the distribution plate 12, and the deflector assembly 38 can confine the deflector assembly 38 in such a way as to allow the deflector assembly 38 to rotate and tilt when pressurized water is flowing through the nozzle 20 and impinging on the distribution plate 12.

[0079] In the illustrated embodiment, a range of the radial and side-to-side motion of the deflector assembly 38 upon the body 16 is limited by the confinement structure 64. In this way, any resulting forces due to the deflector assembly 38 nutating during operation of the sprinkler 10 passes through the cap 60 and the confinement structure 64. By limiting the range of motion of the deflector assembly 38, the confinement structure 64 keeps the distribution plate 12 in a working alignment with the longitudinal axis 46 of the nozzle 20. The working alignment can allow water flowing out of the nozzle 20 to be directed to the distribution plate 12.

[0080] As shown in **Figures 7 and 7A** and in some embodiments, the confinement structure 64 is the only transitory or intermittent contact portion of the deflector assembly 38 with the remainder of the sprinkler 10.

[0081] **Figure 8** is a perspective exploded view of the sprinkler 10 of **Figure 1**. In some embodiments, the base 58 extends from the distribution plate 12 on the same side of the

distribution plate 12 as the one or more water channels 42. In some embodiments, the base 58 directly couples the distribution plate 12 to the body 16. In some embodiments, the base 58 indirectly couples the distribution plate 12 to the body 16 via one or more other components.

[0082] In the illustrated embodiment, the bore 62 in the cap 60 receives at least a portion of the shaft 52 of the body 16 when the base 58 is assembled to the body 16. In the illustrated embodiment, the flanged bolt 40 comprises an external threaded portion 66. The external threaded portion 66 is configured to engage with the internal threaded portion 54 within the shaft 52 to secure the base 58 between the flanged bolt 40 and the body 16. In this way, the flanged bolt 40 can be screwed into shaft 52 on the downstream end of the body 16 to form the confinement structure 64. In some embodiments, the flanged bolt 40 can also be removably attached to the body 16 by using bayonet mounts, snap rings, keys, or collars or other attachment methods (e.g., attachment structures or methods that may or may not require use of tools or specialized tools for disconnection).

[0083] As illustrated in **Figure 8**, the base retainer surface 48 can be an upper or distal surface of the body 16. The base retainer surface 48 can have a flat or tapered shape, or otherwise have a curved surface. The base retainer surface 48 can support the deflector assembly 38 when water is not flowing through the sprinkler 10, and/or provide a smooth surface for the deflector assembly 38 to move relative to the body 16 when water is flowing through the sprinkler 10.

[0084] In some embodiments, the flange 36 of the flanged bolt 40 is sized and shaped larger than the shaft 52 so that only the base retainer surface 48 portion of the body 16, the shaft 52, and the flange 36 contacts the base 58 over a range of the radial and side-to-side motion of the deflector assembly 38.

[0085] In some embodiments, contacts between one or more surfaces of the confinement structure 64 and the surfaces of the cap 60 can restrict the angular movement of the deflector assembly 38 and maintain the position of the deflector assembly 38 within a desirable range relative to the nozzle 20 during normal operation. The desirable range of positions allows water flowing from the nozzle 20 to impinge on the distribution plate 12.

[0086] In some embodiments, the confinement structure 64 can provide a resistive interface between the deflector assembly 38 and the body 16 to slow or otherwise regulate the speed of rotation of the distribution plate 12 during operation of the sprinkler 10.

[0087] **Figure 8** further provides an exploded view of the nozzle subassembly 102. The nozzle subassembly 102 can be inserted into and locked in place to the body 16. In certain embodiments, the nozzle subassembly 102 comprises the nozzle 20, the retainer 22, and the seal 26. In certain embodiments, the retainer 22 can confine the seal 26 in position to prevent pressurized water from escaping between the body 16 and the downstream end of the nozzle 20.

[0088] In the illustrated embodiment, the nozzle 20, the retainer 22, and the seal 26 are manufactured separately and subsequently assembled to form the nozzle subassembly 102. In certain other embodiments, one or more of the retainer 22 and the seal 26 is manufactured as a unitary structure with the nozzle 20. In certain other embodiments, one or more of the nozzle 20, the retainer 22, and the seal 26 can each be assembled from multiple structures. Accordingly, the nozzle subassembly 102 need not comprise three components and instead may comprise more or fewer components.

[0089] **Figure 9** is a top perspective view of the retainer 22 from **Figure 8**. In some embodiments, the retainer 22 can include one or more tabs 86, 88. In some embodiments the one or more tabs 86, 88 can be used to secure the retainer 22 to the body 16. In some embodiments, the one or more tabs 86, 88 can be used to permanently attach the retainer 22 to the body 16. In some embodiments, the one or more tabs 86, 88 can removably attach the retainer 22 to the body 16.

[0090] In the illustrated embodiment, the one or more tabs 86, 88 are coupled to the retainer 22 via two arms 82, 84. Of course, the one or more tabs 86, 88 need not be coupled to the two arms 82, 84 and instead can be directly coupled to the retainer 22. In the illustrated embodiment, the two arms 82, 84 extend outwardly from the retainer 22 with the one or more tabs 86, 88 disposed at a distal end of each arm 82, 84.

[0091] In certain embodiments, the retainer 22 comprises one or more flaps 94, 96. In the illustrated embodiment, the one or more flaps 94, 96 extend in a direction opposite to the direction of the two arms 82, 84. Of course, the one or more flaps 82, 84 need not extend in the illustrated direction. In certain embodiments, each flap 94, 96 includes a sloped surface 98, 100. The sloped surfaces 98, 100 can be configured to guide the tabs 28, 30 of the nozzle 20. For example in certain embodiments, if the retainer 22 is installed into the body 16 before installing the nozzle 20, the sloped surfaces 98, 100 can initially guide the tabs 28, 30 of the

nozzle 20 when the nozzle 20 is moved from a tilted, partially installed position towards a horizontal, fully installed position. In certain embodiments, after the tabs 28, 30 have been initially guided by the sloped surfaces 98, 100, the user will continue to rotate the nozzle 20 towards the horizontal position to cause the tabs 28, 30 to move further together until the tabs 28, 30 pass between locking bars 110 on the body 16. Once the tabs 28, 30 pass between the locking bars 110, the tabs 28, 30 will open and lock against the locking bars 110 securing the nozzle 20 in position relative to the body 16.

[0092] To remove the nozzle 20 by itself from the body 16, the user can compress the tabs 28, 30 together and then tilt the nozzle 20 away from the horizontal position. The user then removes the nozzle 20 leaving the retainer 22 in the body 16.

[0093] The user can then remove the retainer 22 and the seal 26 from the body 16 by sliding the retainer 22 and the seal 26 away from the body 12. In certain embodiments, the user can pull on the flaps 94, 96 to facilitate removal of the retainer 22 and the seal 26 from the body 16.

[0094] In certain embodiments, the body 16 comprises a slot 92 (see **Figure 7**) sized and shaped to receive the two arms 82, 84. In some embodiments the two arms 82, 84 can deflect inward towards each other as the one or more tabs 86, 88 enter the slot 92. When the retainer 22 and the seal 26 are fully inserted into the proper location in the body 16, the tabs 86, 88 protrude from the slot 92 allowing the two arms 82, 84 to spring apart and return to their normal position locking the retainer 22 in place. To remove the retainer 22 and the associated seal 26, the user can pinch the exposed one or more tabs 86, 88 together to deflect the two arms 82, 84 towards each other. The user can then push on the one or more tabs 86, 88 to slide the two arms 82, 84 out of the slot 92. The user can then pull on the flaps 94, 96 to remove the retainer 22 and the seal 26 from the body 16.

[0095] In certain embodiments, the retainer 22 comprises structure configured to engage with the seal 26. For example, the retainer 22 can include a counter bore 90 sized and shaped to retain the seal 26. In certain embodiments, the seal 26 nests in at least a portion of the counter bore 90. As further explained below, the retainer 22, the seal 26, and the nozzle 20 can be inserted in an assembled state as the nozzle subassembly 102 into the body 16. In some cases, the retainer 22 and the seal 26 can be inserted in an assembled state as the nozzle subassembly 102 into the body 16 prior to inserting the nozzle 20.

[0096] **Figure 10** is a perspective view of the body 16 and the nozzle subassembly 102 from **Figure 8** showing the seal 26 and the retainer 22 assembled to the nozzle 20 prior to insertion of the nozzle subassembly 102 into the body 16 according to a first assembly process. In some cases, the user can hold the three components together and slide the nozzle subassembly 102 into a cavity 104 in the body 16. As the tabs 86, 88 pass through the slot 92 they will move outwards to hold the nozzle subassembly 102 in position. The tabs 28, 30 will pass under the locking bars 110 and lock against the locking bars 110 further securing the nozzle subassembly 102 in position. As will be explained below, in certain embodiments, further securement of the nozzle subassembly 102 is provided by a hub 108 on the nozzle 20.

[0097] **Figure 11** is similar to **Figure 10** except the retainer 22 and the seal 26 of the nozzle subassembly 102 has been inserted into the body 16 prior to insertion of the nozzle 20 into the body 16 according to a second assembly process. **Figure 12** is similar to **Figure 7** except it shows the nozzle 20 being assembled to the retainer 22 and the seal 26 by tilting the nozzle 20 after the retainer 22 and the seal 26 have already been installed in the body 16 according to the second assembly process.

[0098] **Figures 11 and 12** show that the nozzle 20 can alternatively be installed in the cavity 104 after the retainer 22 and the seal 26 are attached to the body 16. As shown in **Figure 11**, the user can first tilt the nozzle 20 to an angle that will allow the nozzle 20 to slide over the retainer 22 as the user inserts it into the cavity 104. As best seen in **Figure 12** in certain embodiments, the cavity 104 can include a notch 106. The notch 106 can provide space for the nozzle 20 to be inserted into the cavity 104 at an angle as illustrated in **Figure 11**. In some embodiments, the notch 106 is in the form of a recessed cavity.

[0099] In certain embodiments, when the nozzle 20 is fully inserted into the cavity 104, a hub 108 on the nozzle 20 is confined by the notch 106. The user can rotate the nozzle 20 in a downward direction towards the inlet 14 using the hub 108 as a pivot within the notch 106. As the user rotates the nozzle 20 downward, the tabs 28, 30 of the nozzle 20 can initially slide against the sloped surfaces 98, 100 as the tabs 28, 30 pass between the flaps 94, 96 slightly compressing the tabs 28, 30 together. The user can continue to rotate the nozzle 20 until the tabs 28, 30 pass by the locking bars 110.

[0100] When the nozzle 20 is in the operating position, the tabs 28, 30 will spring to an outward locked position. In some cases, the combination of the hub 108 being confined

in the notch 106 and the tabs 28, 30 latching to the locking bars 110 will keep the nozzle 20 in its proper orientation for normal usage of the sprinkler 10. When the nozzle 20 is in its operating position, it will be in the position best show in **Figure 7**. in some cases, to remove the nozzle 20, a user can pinch the tabs 28, 30 together to release them from the locking bars 110 and tilt the nozzle upwards to then pull it out of the cavity 104.

[0101] **Figure 13** is a top perspective view of the distribution plate 12 of the sprinkler 10 of **Figure 1** showing the one or more water channels 42 radially angled to cause the distribution plate 12 to rotate in a clockwise direction (see Figure 6) when the water from the nozzle 20 impinges on the distribution plate 12. In some embodiments, the one or more water channels 42 are disposed on a downstream side of the distribution plate 12. The downstream side of the distribution plate 12 faces the nozzle 20. The one or more water channels 42 can channel the water exiting the nozzle 20 to be ejected in a controlled direction. In some embodiments, the one or more water channels 42 can be radially angled to cause the deflector assembly 38 to rotate when the water from the nozzle 20 impinges the distribution plate 12. In some embodiments, the one or more water channels 42 can be curved. In some embodiments, such as shown in **Figure 20**, the one or more water channels 42 can be identical or substantially identical in shape.

[0102] **Figure 14** is a bottom perspective view of the distribution plate 12 that shows an asymmetrical form of the one or more water channels 42. In certain embodiments, the one or more legs 34 of the distribution plate 12 attached to the base 58. In some embodiments, there can be two, three, four, or more legs 34. In the illustrated embodiment, there are three legs 34. In some embodiments, the legs 34 can have a larger diameter section 74 and a smaller diameter section 72.

[0103] **Figure 15** is a top perspective view of the base 58. In some embodiments, the base 58 can have one or more windows 76. The size, shape and number of the windows 76 can vary as required to achieve the desired mass for the base 58.

[0104] In some embodiments, the base 58 can incorporate one or more posts 78. In some embodiments, the base 58 can have two or more posts 78. In the illustrated embodiment, the base 58 can have three posts 78. In some embodiments, the one or more posts 78 can include a hole 80. In certain embodiments, the hole 80 can extend partially through the post 78. In certain embodiments, the hole 80 can extend entirely through the post 78. In certain

embodiments, each hole 80 is sized and shaped to receive the smaller diameter section 72 of the one or more legs 34.

[0105] **Figure 16** is a front view of the deflector assembly 38. In certain embodiments, the deflector assembly 38 comprises the base 58 and the distribution plate 12. In some embodiments, the distribution plate 12 can be formed by a mold in a conventional manner resulting in the distribution plate 12 having a consistent wall thickness throughout the distribution plate 12. In some embodiments, the geometry is modified so that the thickness of the material varies in specific areas of the distribution plate 12. In certain embodiments, a first region of the distribution plate 12 has a first thickness and a second region of the distribution plate 12 has a second thickness. In other embodiments, the distribution plate 12 has regions with three or more different wall thicknesses. In this way, the distribution plate 12 can be manufactured with thicker or thinner cross sections.

[0106] In certain embodiments, the distribution plate 12 can present various harmonic characteristics that can negatively affect the quality of the sprinkler's performance. It has been found that varying the mass of the distribution plate 12 can reduce or eliminate the harmonics developed during normal operation. For example, testing has shown that adding mass in particular areas of the distribution plate 12 can have the positive effect of reducing or eliminating negative or undesirable harmonic properties during normal operation. In certain embodiments, a wall thickness in the particular areas of the distribution plate 12 is increased to add mass at that particular area. In certain embodiments, mass is increased in the particular areas by co-molding materials that have a different density to form the distribution plate 12. In certain embodiments, the distribution plate 12 can be manufactured to have the additional mass at the particular areas or the mass can be added to the distribution plate 12 after its manufacture.

[0107] In the illustrated embodiment, the distribution plate 12 comprises a web 114 located between curved surfaces 112 of the adjacent water channels 42. In certain embodiments, mass is increased at the web 114 by, for example, locally co-molding and/or increasing the wall thickness in the region of the web 114. For example, the wall thickness in the particular area of the web 114 can be increased as compared to the wall thickness of the curved surfaces 112. In the illustrated embodiment, the wall thickness of the curved surfaces 112 of the one or more water channels 42 is formed with a thinner cross section than the web

114 that connects between the water channels 42. The added mass to the web 114 between the water channels 42 can have the positive effect of reducing or eliminating negative or undesirable harmonic properties during normal operation of the sprinkler 10. In certain embodiments, the mass is attached to the web 114 in the form of a weight or other structure.

[0108] **Figure 17** is a bottom view of the deflector assembly 38 showing a portion of the one or more water channels 42 as viewed through the bore 62 in the base 58. **Figure 18** is a cross-sectional view of the deflector assembly 38 as viewed along the cut-plane 18-18 of **Figure 17**. In certain embodiments, the deflector assembly 38 is assembled by inserting the smaller diameter sections 72 of the one or more legs 34 of the deflector plate 12 into holes 80 in the base 58. In some cases, the one or more legs 34 can be sized to achieve a loose fit, a slip fit, or a press fit when inserted into the respective hole 80.

[0109] In some embodiments, each of the one or more legs 34 can have an end 116. In some embodiments, the end 116 can include features such as a hole, cone, or threads. In some cases, the end 116 can be larger than the smaller diameter section 72 of the leg 34. In some cases, the end 116 can be smaller than, or the same size as the diameter of the smaller diameter section 72 of the leg 34. In certain embodiments, the one or more legs 34 can be retained in the holes 80 by a screw, ultrasonic welding, adhesive, or other suitable attachment method.

[0110] As best seen in **Figure 18A** in comparison to **Figure 18**, the illustrated embodiment of the deflector assembly 38 is held together by the end 116 of the leg 34 expanding or deforming after the leg 34 is inserted into the hole 80 of the base 58. In **Figure 18**, the ends 116 of the one or more legs 34 have not yet expanded or deformed to prevent the leg 34 from being retracted from the hole 80. In some embodiments, the end 116 can be deformed using pressure, heat, ultrasonic vibration, orbital forming or any combination of the above. In certain embodiments, the end 116 is pinched together to fit the end 116 into the hole 80. Once the leg 34 is inserted a sufficient depth into the hole 80, the end 116 protrudes from the hole 80 and then naturally expands back to its original shape locking the leg 34 in the hole 80.

[0111] **Figures 19** through **22** illustrate the distribution plate 12 with the water channels 42 having an asymmetrical shape. In certain embodiments, the cross-sectional shape of the one or more water channels 42 can be asymmetric. For example, a first side 120 of the

water channel 42 can be nearly straight while an opposite second side 122 can be radiused. In certain embodiments, the cross-sectional shape of the one or more water channels 42 is asymmetric across a vertical line passing through a vertex or bottom of the water channel 42. In certain embodiments, the cross-sectional shape of the one or more water channels 42 is asymmetric across a vertical line passing through a midpoint of a width of the water channel 42 as measured at the top of the water channel 42.

[0112] In certain embodiments, the one or more water channels 42 can have an exit geometry that comprises one or more arcs on a first side of the vertex that have different degrees of curvature than one or more opposite arcs on a second side of the vertex. For example, an arc on the first side 120 can have a degree of curvature different than a degree of curvature of an arc on the opposite second side 122 relative to the vertex. In certain embodiments, the one or more water channels 42 can have an exit geometry that comprises one or more arcs on the first side 120 of the midpoint that have different degrees of curvature than one or more opposite arcs on the second side 122 of the midpoint. For example, an arc on the first side 120 can have a degree of curvature different than a degree of curvature of an arc on the opposite second side 122 relative to the midpoint.

[0113] As is illustrated in **Figure 19**, the water channel 42 can have an exit geometry that is near straight on one side, such as the first side 120, and radiused on the opposite second side 122. In certain embodiments, a radiused section 124 can blend the first side 120 and the opposite second side 122 together in an off center arrangement relative to the cross-sectional shape of the exit.

[0114] **Figure 20** is a bottom view of the distribution plate 12 illustrating the first side 120, the second side 122 and the radiused section 124. In certain embodiments, near a center of the distribution plate 12, a leading edge 126 of the radiused section 124 is centered, or close to centered relative to the midpoint of the water channel 42. Near the outer edge of the distribution plate 12 or exit 128, the leading edge 126 of the radiused section 124 gradually moves away from the center of the water channel 42, or closer to the first side 120 of the water channel 42. In certain embodiments, the radiused section 124 follows an arcuate path between the center of the distribution plate 12 and the outer edge of the distribution plate 12.

[0115] **Figure 21** illustrates an approximate water path 130 of the sprinkler 10 when the nozzle 20 has a small diameter or a small water flow path. When the nozzle 20 has

the small diameter, the asymmetrical shape of the water channel 42 can provide a smaller or reduced cross-section for the water to flow through. This smaller cross-section can improve the uniformity of the stream of water leaving the water channel 42 at the exit 128 in comparison with a traditional symmetric channel such as a U-shaped water channel. Additionally, the asymmetrical shape of the water channel 42 can direct the small stream of water along the water path 130 in a direction that moves the water path 130 from the midpoint or center of the water channel 42 to be closer to the first side 120 at the exit 128. This movement of the water path 130 along the distribution plate 12 can increase the drive or rotational force the water stream applies against the distribution plate 12 as compared to a traditional symmetric water channel. This added drive force can help the distribution plate 12 and the deflector assembly 38 to operate more reliability and at a desirable speed of rotation when a relatively small amount of water is flowing from the nozzle 20.

[0116] **Figure 22** illustrates an approximate water path 140 of the sprinkler 10 when the nozzle 20 has a large diameter or larger water flow path. When the nozzle 20 has the large diameter, the asymmetrical shape of the water channel 42 can provide a larger or increased cross-section for the water to flow through. Additionally, the asymmetrical shape of the water channel 42 can direct a majority of the large stream of water along the water path 140 in a direction that is generally parallel with the wall 120, which provides an adequate drive or rotational force to the distribution plate 12. With the majority of the water stream flowing generally parallel to the first side 120, the relatively large stream of water can provide adequate drive force to the distribution plate 12 without over driving the distribution plate 12, or otherwise causing the distribution plate 12 to operate at a greater than desired rotational speed. Without the water channel 42 having the asymmetrical shape, the distribution plate 12 and the deflector assembly 38 may have either too little drive force when the nozzle 20 has a small diameter or too much drive force when the nozzle 20 has a larger diameter. The asymmetrical shape of the water channel 42 allows the distribution plate 12 to achieve a desirable speed of rotation that optimizes the performance of the sprinkler 10 for multiple sizes of nozzle 20.

[0117] **Figures 23 to 38** illustrate various embodiments of sprinklers. Various attributes of the sprinklers are shown in broken lines to illustrate that they may or may not be present and that their position, orientation, shape, style, number, etc. can be different according to the different embodiments. The broken lines form no part of the designs. For example,

Figures 31-38 show a sprinkler with a nozzle 20 in broken lines. The nozzle 20 is shown in broken lines to indicate that the nozzle 20 forms no part of the design.

Terminology

[0118] Although certain embodiments and examples are disclosed herein, inventive subject matter extends beyond the examples in the specifically disclosed embodiments to other alternative embodiments and/or uses, and to modifications and equivalents thereof. Thus, the scope of the claims appended hereto is not limited by any of the particular embodiments described above. For example, in any method or process disclosed herein, the acts or operations of the method or process may be performed in any suitable sequence and are not necessarily limited to any particular disclosed sequence. Various operations may be described as multiple discrete operations in turn, in a manner that may be helpful in understanding certain embodiments; however, the order of description should not be construed to imply that these operations are order dependent. Additionally, the structures, systems, and/or devices described herein may be embodied as integrated components or as separate components. For purposes of comparing various embodiments, certain aspects and advantages of these embodiments are described. Not necessarily all such aspects or advantages are achieved by any particular embodiment. Thus, for example, various embodiments may be carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other aspects or advantages as may also be taught or suggested herein.

[0119] Features, materials, characteristics, or groups described in conjunction with a particular aspect, embodiment, or example are to be understood to be applicable to any other aspect, embodiment or example described in this section or elsewhere in this specification unless incompatible therewith. All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. The protection is not restricted to the details of any foregoing embodiments. The protection extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

[0120] Furthermore, certain features that are described in this disclosure in the context of separate implementations can also be implemented in combination in a single implementation. Conversely, various features that are described in the context of a single implementation can also be implemented in multiple implementations separately or in any suitable subcombination. Moreover, although features may be described above as acting in certain combinations, one or more features from a claimed combination can, in some cases, be excised from the combination, and the combination may be claimed as a subcombination or variation of a subcombination.

[0121] Moreover, while operations may be depicted in the drawings or described in the specification in a particular order, such operations need not be performed in the particular order shown or in sequential order, or that all operations be performed, to achieve desirable results. Other operations that are not depicted or described can be incorporated in the example methods and processes. For example, one or more additional operations can be performed before, after, simultaneously, or between any of the described operations. Further, the operations may be rearranged or reordered in other implementations. Those skilled in the art will appreciate that in some embodiments, the actual steps taken in the processes illustrated and/or disclosed may differ from those shown in the figures. Depending on the embodiment, certain of the steps described above may be removed, others may be added. Furthermore, the features and attributes of the specific embodiments disclosed above may be combined in different ways to form additional embodiments, all of which fall within the scope of the present disclosure. Also, the separation of various system components in the implementations described above should not be understood as requiring such separation in all implementations, and it should be understood that the described components and systems can generally be integrated together in a single product or packaged into multiple products.

[0122] For purposes of this disclosure, certain aspects, advantages, and novel features are described herein. Not necessarily all such advantages may be achieved in accordance with any particular embodiment. Thus, for example, those skilled in the art will recognize that the disclosure may be embodied or carried out in a manner that achieves one advantage or a group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

[0123] For expository purposes, the term “horizontal” as used herein is defined as a plane parallel to the plane or surface of the floor or ground of the area in which the device being described is used or the method being described is performed, regardless of its orientation. The term “floor” can be interchanged with the term “ground.” The term “vertical” refers to a direction perpendicular to the horizontal as just defined. Terms such as “above,” “below,” “bottom,” “top,” “side,” “higher,” “lower,” “upper,” “over,” and “under,” are defined with respect to the horizontal plane.

[0124] Conditional language used herein, such as, among others, “can,” “could,” “might,” “may,” “e.g.,” and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or steps. Thus, such conditional language is not generally intended to imply that features, elements and/or steps are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without other input or prompting, whether these features, elements and/or steps are included or are to be performed in any particular embodiment. The terms “comprising,” “including,” “having,” and the like are synonymous and are used inclusively, in an open-ended fashion, and do not exclude additional elements, features, acts, operations, and so forth. Also, the term “or” is used in its inclusive sense (and not in its exclusive sense) so that when used, for example, to connect a list of elements, the term “or” means one, some, or all of the elements in the list.

[0125] Conjunctive language such as the phrase “at least one of X, Y, and Z,” unless specifically stated otherwise, is otherwise understood with the context as used in general to convey that an item, term, etc. may be either X, Y, or Z. Thus, such conjunctive language is not generally intended to imply that certain embodiments require the presence of at least one of X, at least one of Y, and at least one of Z.

[0126] Language of degree used herein, such as the terms “approximately,” “about,” “generally,” and “substantially” as used herein represent a value, amount, or characteristic close to the stated value, amount, or characteristic that still performs a desired function or achieves a desired result. For example, the terms “approximately”, “about”, “generally,” and “substantially” may refer to an amount that is within less than 10% of, within less than 5% of, within less than 1% of, within less than 0.1% of, and within less than 0.01%

of the stated amount. As another example, in certain embodiments, the terms “generally parallel” and “substantially parallel” refer to a value, amount, or characteristic that departs from exactly parallel by less than or equal to 15 degrees, 10 degrees, 5 degrees, 3 degrees, 1 degree, 0.1 degree, or otherwise.

[0127] Although the sprinkler has been disclosed in the context of certain embodiments and examples, it will be understood by those skilled in the art that the sprinkler and subassemblies extends beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the embodiments and certain modifications and equivalents thereof. For example, some embodiments are configured to operate oriented such that the distribution plate is positioned below the nozzle and the nozzle directs water downward. Accordingly, it is intended that the scope of the sprinkler herein-disclosed should not be limited by the particular disclosed embodiments described above, but should be determined only by a fair reading of the claims that follow.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	HISEN.046A
		Application Number	
Title of Invention	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
--------------------------	---

Inventor Information:

Inventor	1				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	William	A.	Pratesi		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Minneola	State/Province	FL	Country of Residence	US

Mailing Address of Inventor:

Address 1	876 Park Valley Circle				
Address 2					
City	Minneola	State/Province	FL		
Postal Code	34715	Country	US		

Inventor	2				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Jerry	D.	Lawyer		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Clermont	State/Province	FL	Country of Residence	US

Mailing Address of Inventor:

Address 1	614 East Highway 50 #236				
Address 2					
City	Clermont	State/Province	FL		
Postal Code	34711	Country	US		

Inventor	3				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Jacob	K.	Keller		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	HISEN.046A
		Application Number	
Title of Invention	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS		

City	Minneapolis	State/Province	FL	Country of Residence	US
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Mailing Address of Inventor:

Address 1	1032 Lakeview Oaks Drive				
Address 2					
City	Minneapolis	State/Province	FL		
Postal Code	34715	Country	US		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.					

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ An Address is being provided for the correspondence information of this application.			
Customer Number	20995		
Email Address	efiling@knobbe.com	Add Email	Remove Email

Application Information:

Title of the Invention	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS		
Attorney Docket Number	HISEN.046A	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	32	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐ Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	HISEN.046A
		Application Number	
Title of Invention	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS		

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	20995		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status		Remove
Application Number	Continuity Type	Prior Application Number
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.		

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	HISEN.046A
		Application Number	
Title of Invention	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS		

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. ☐ NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.	
--	--

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	HISEN.046A
		Application Number	
Title of Invention	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	HISEN.046A
		Application Number	
Title of Invention	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.			
Applicant	1		Remove
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.			
Clear			
☒ Assignee	Legal Representative under 35 U.S.C. 117		Joint Inventor
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest	
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:			
Name of the Deceased or Legally Incapacitated Inventor:			
If the Applicant is an Organization check here. ☒			
Organization Name	Senninger Irrigation, Inc.		
Mailing Address Information For Applicant:			
Address 1	13505 Granville Avenue		
Address 2			
City	Clermont	State/Province	FL
Country	US	Postal Code	34711
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button. Add			

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	HISEN.046A
		Application Number	
Title of Invention	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS		

Assignee	1			
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
				Remove
If the Assignee or Non-Applicant Assignee is an Organization check here.				☐
Prefix	Given Name	Middle Name	Family Name	Suffix
Mailing Address Information For Assignee including Non-Applicant Assignee:				
Address 1				
Address 2				
City		State/Province		
Country ⁱ		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.				Add

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the **INITIAL** filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/James F. Herkenhoff/		Date (YYYY-MM-DD)	2020-06-12
First Name	James F.	Last Name	Herkenhoff	Registration Number
				51241
Additional Signature may be generated within this form by selecting the Add button.				Add

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	HISEN.046A
		Application Number	
Title of Invention	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

- 1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
- 2 A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
- 3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
- 4 A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
- 5 A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
- 6 A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
- 7 A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
- 8 A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
- 9 A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

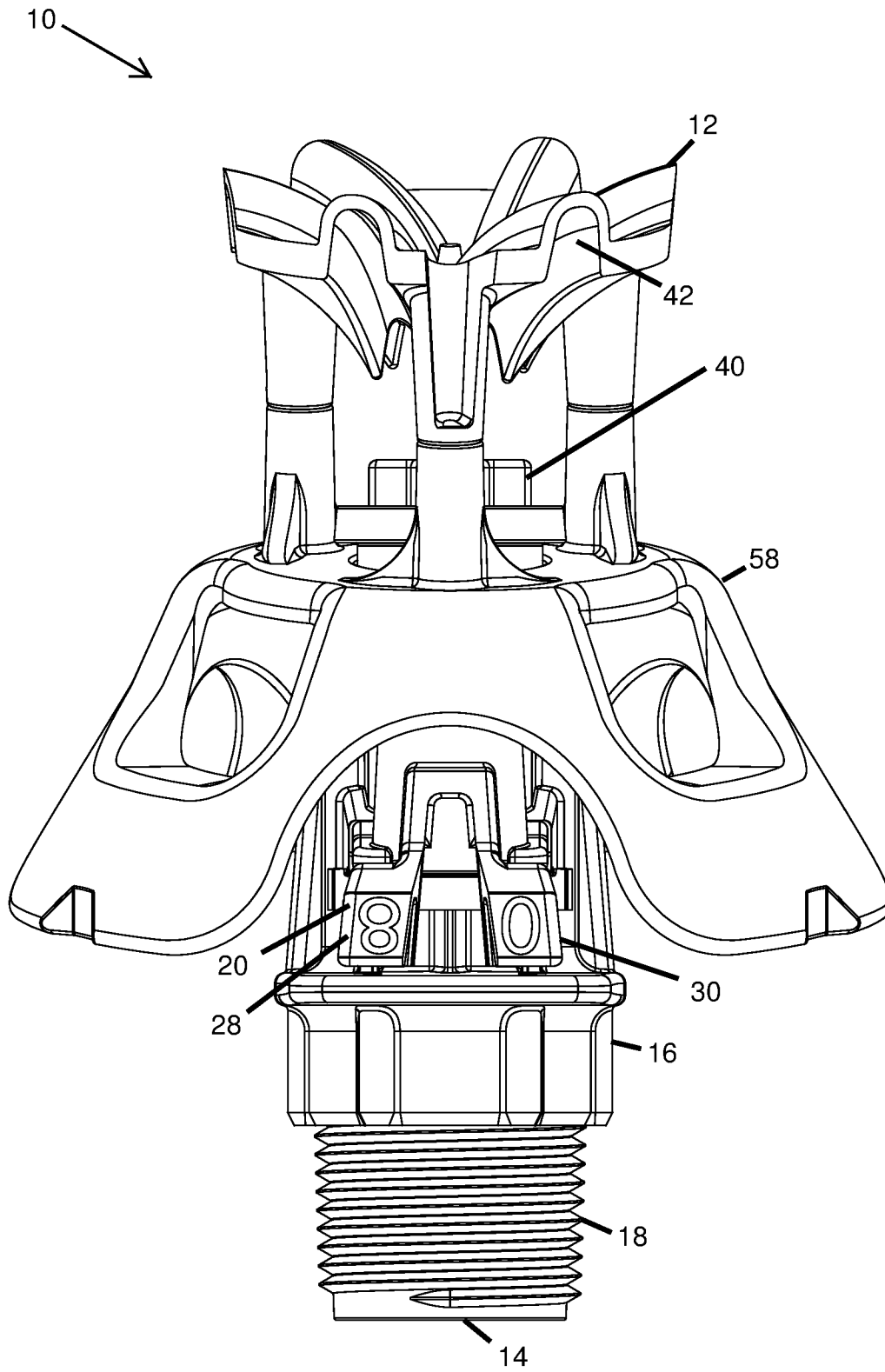


FIG. 1

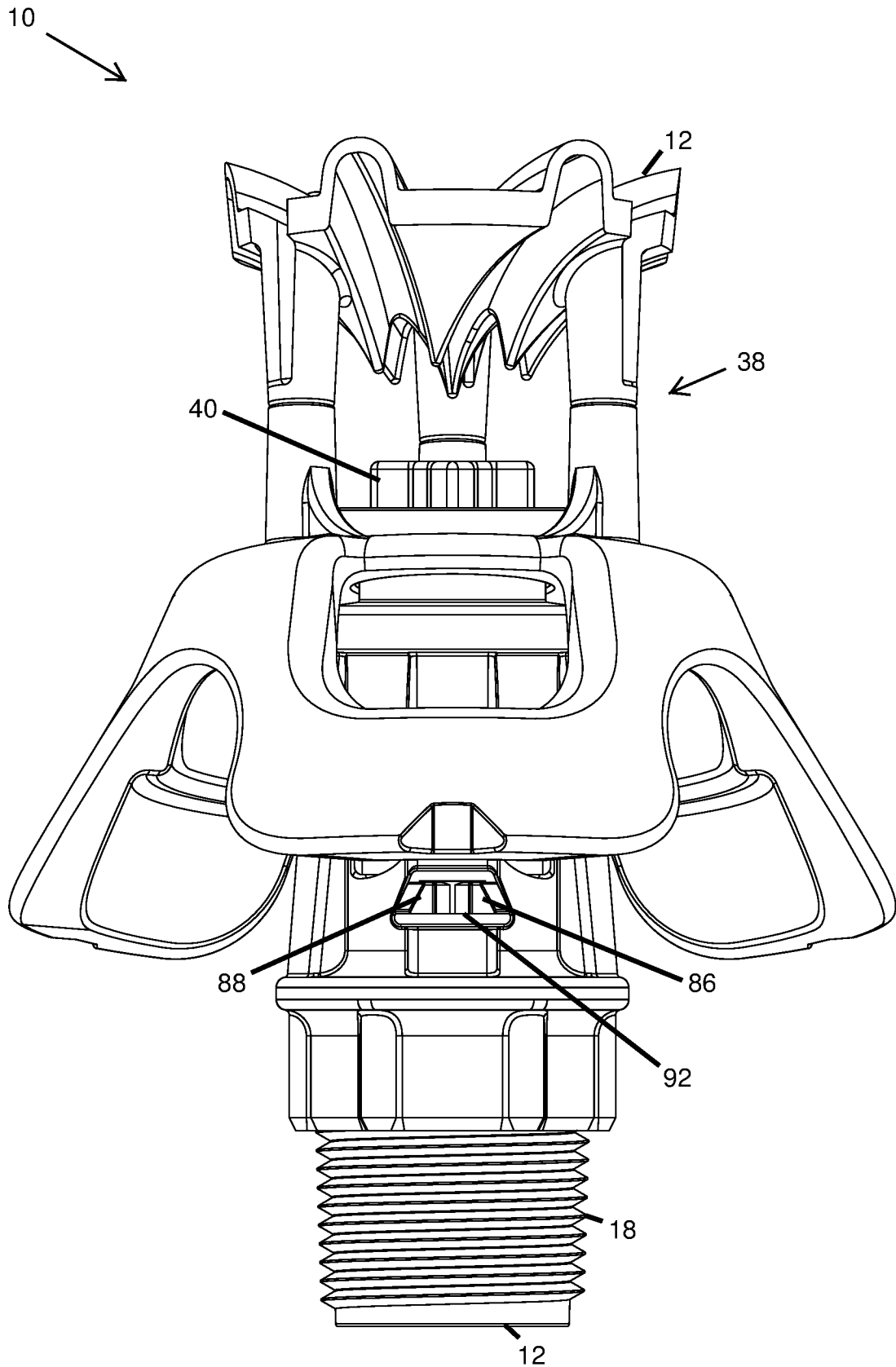


FIG. 2

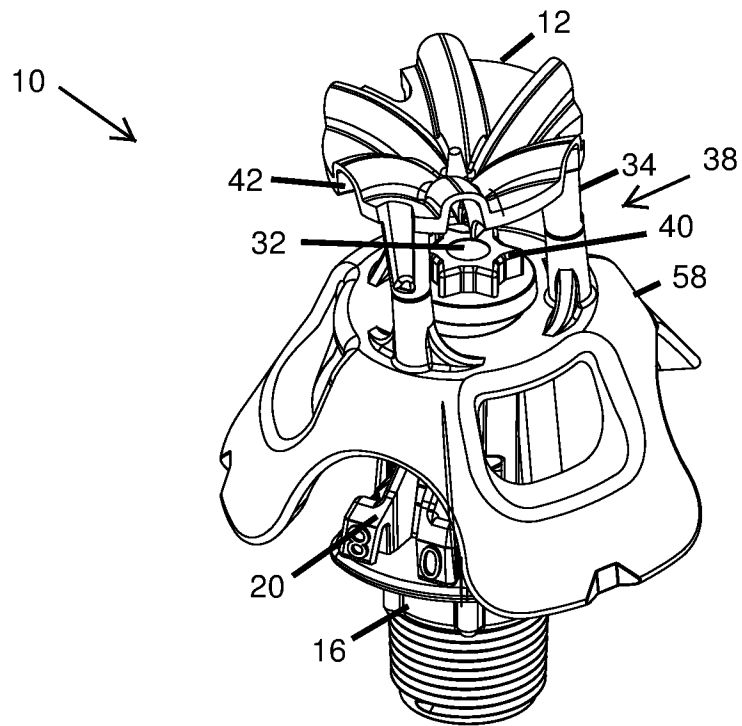


FIG. 3

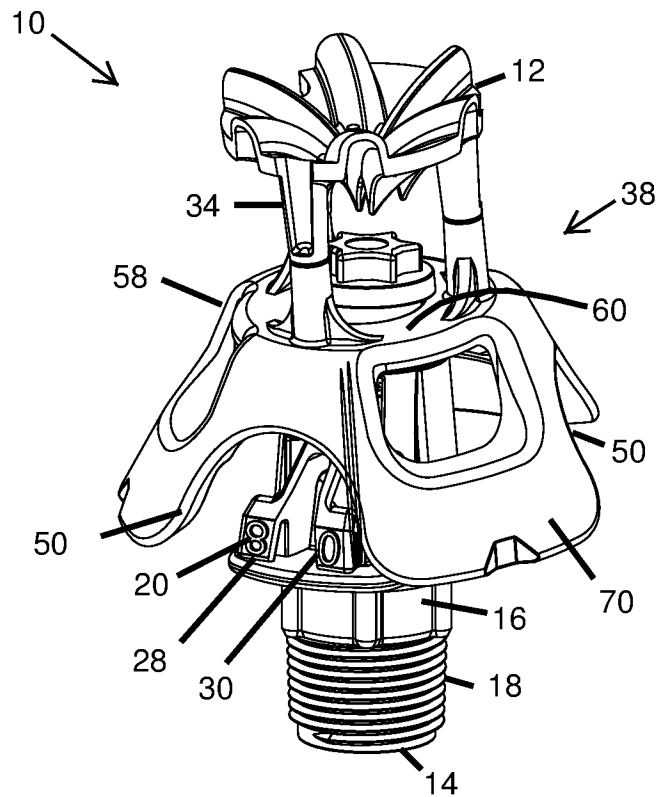


FIG. 4

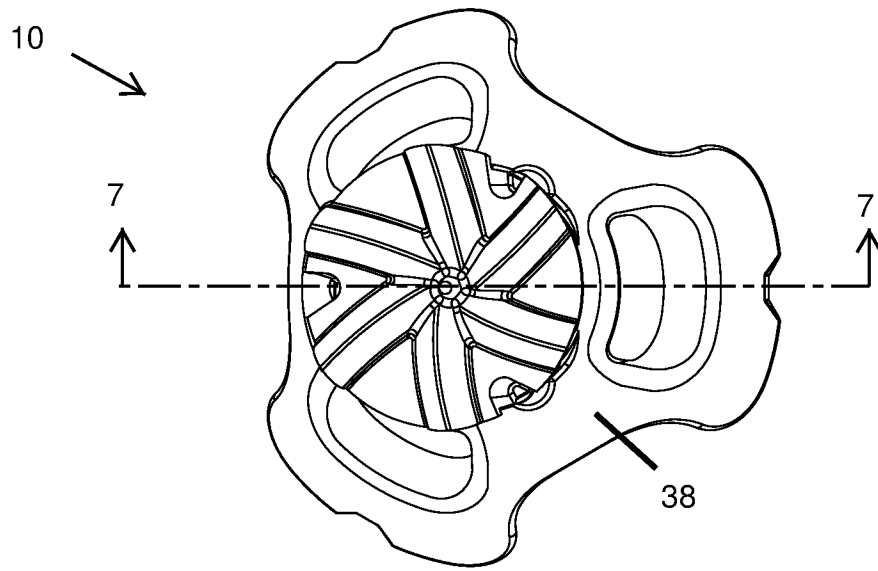


FIG. 6

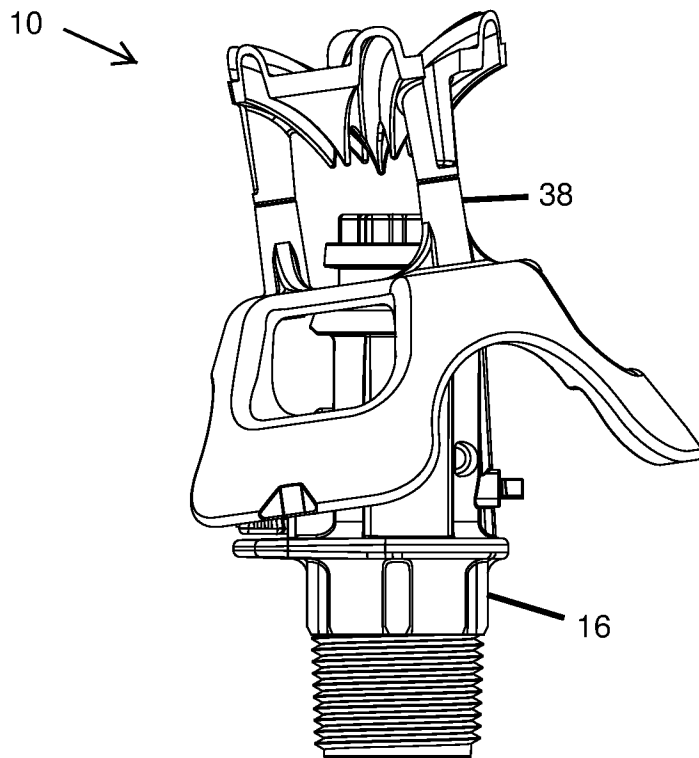
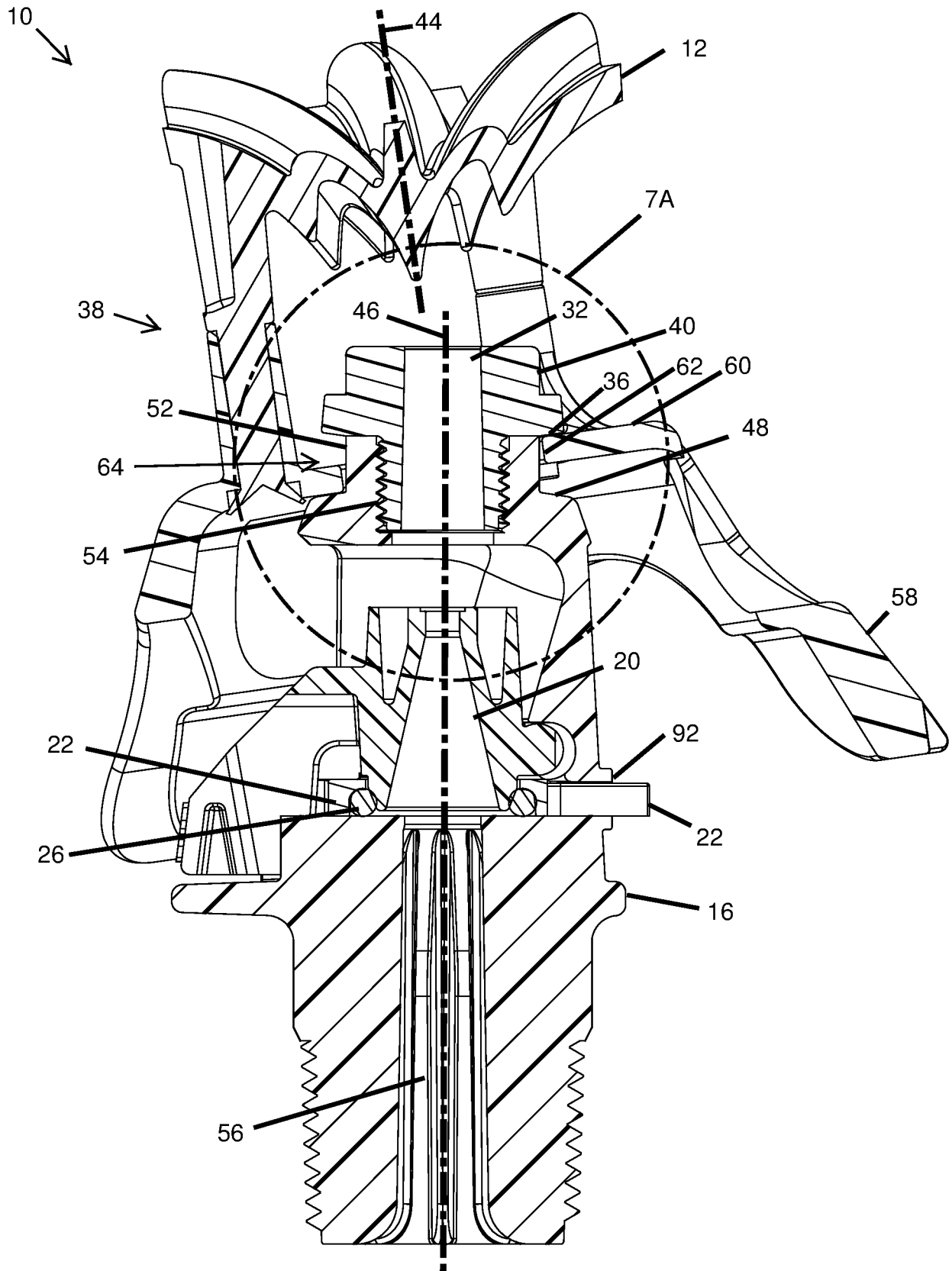
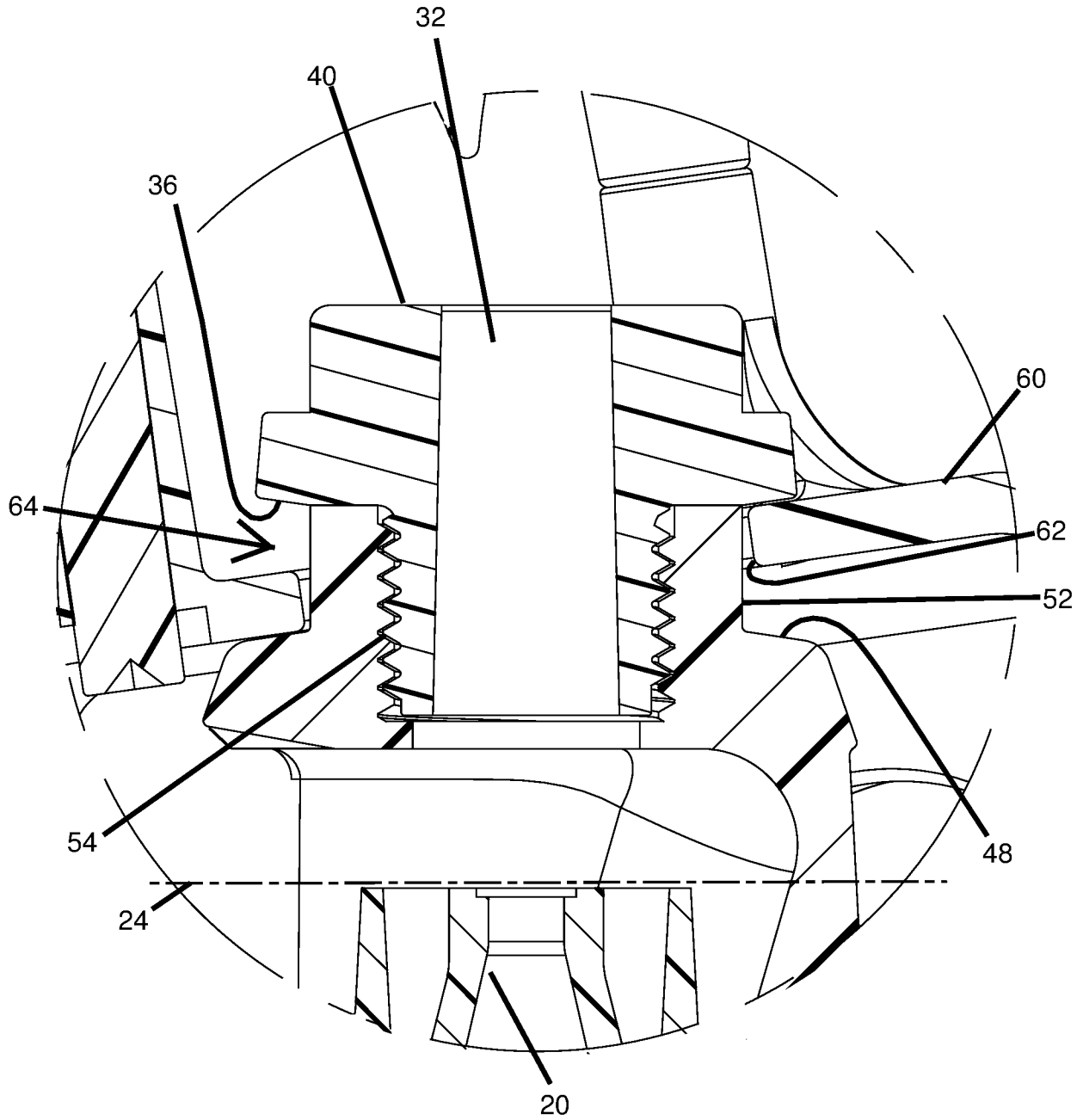


FIG. 5



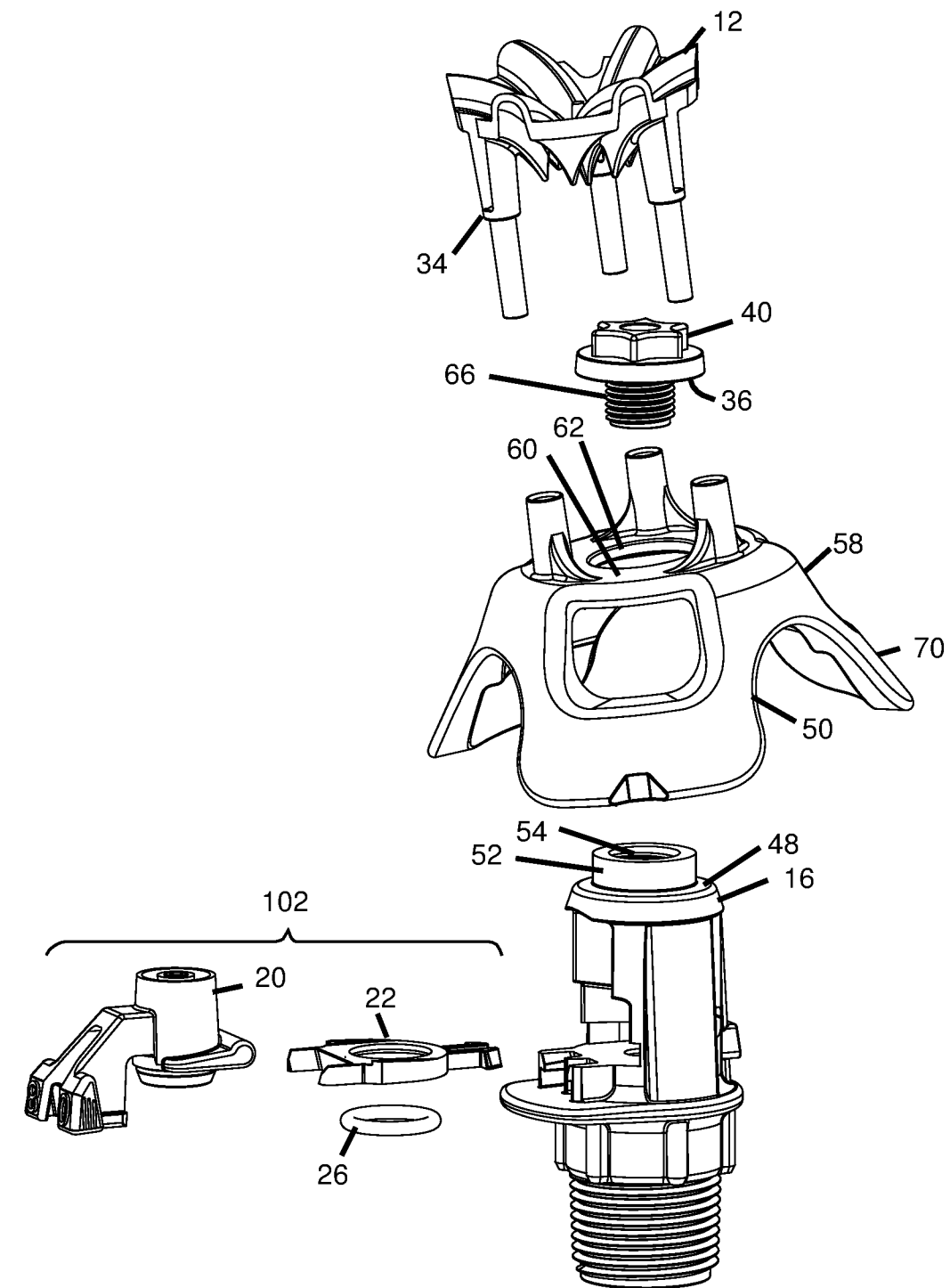
Section 7-7

FIG. 7



Detail 7A

FIG. 7A

*FIG. 8*

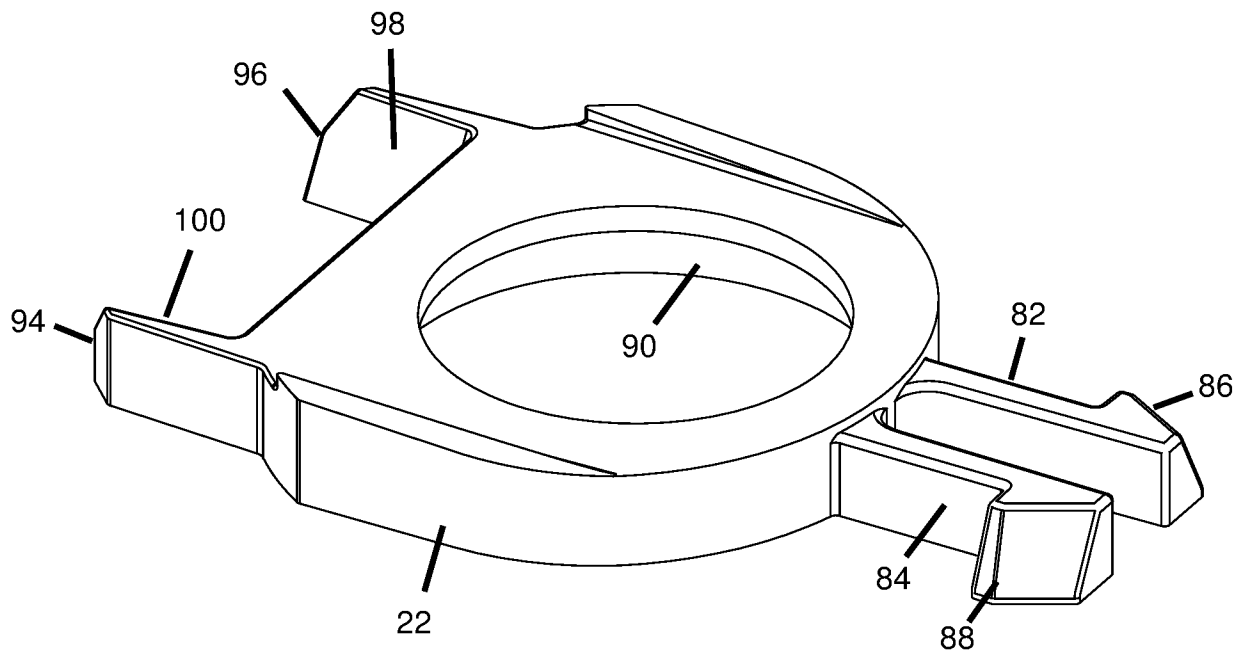
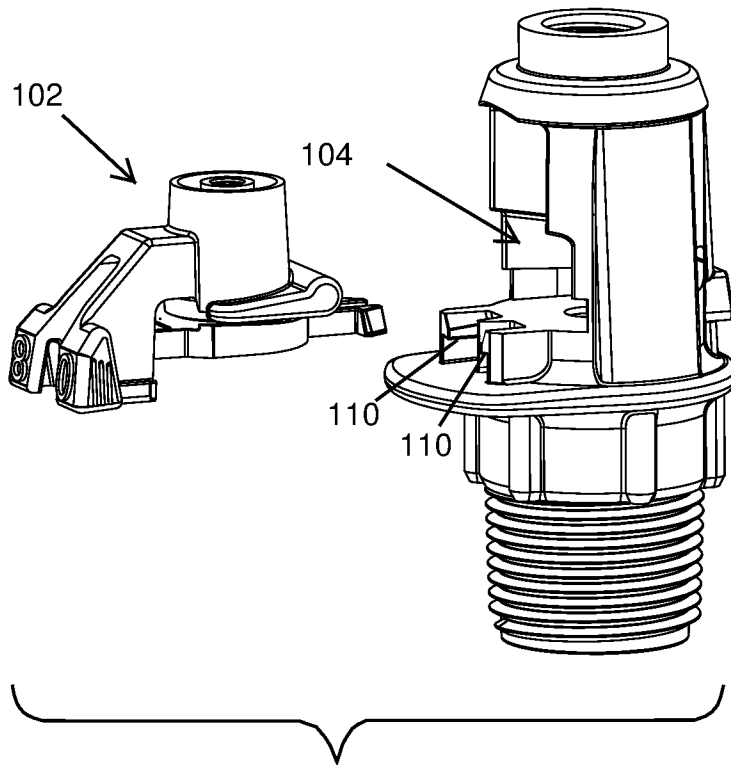
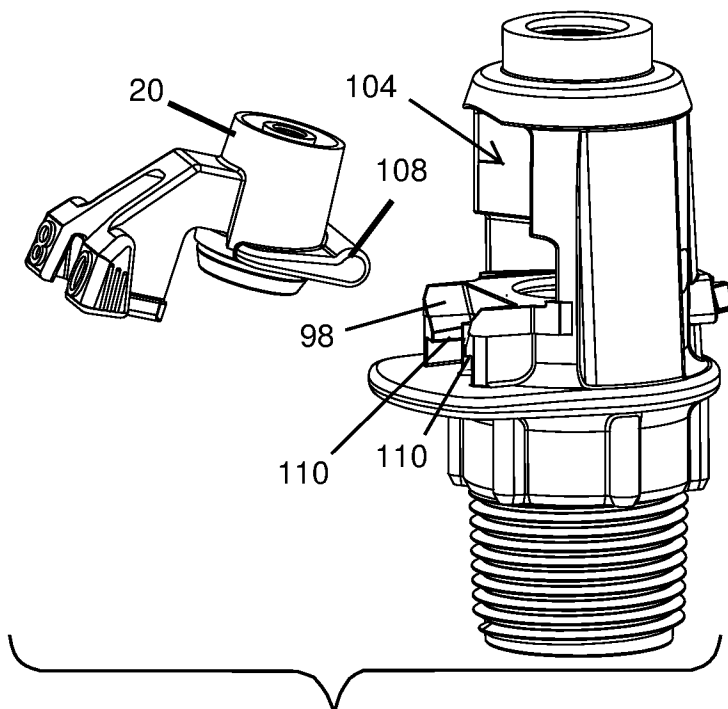


FIG. 9

*FIG. 10**FIG. 11*

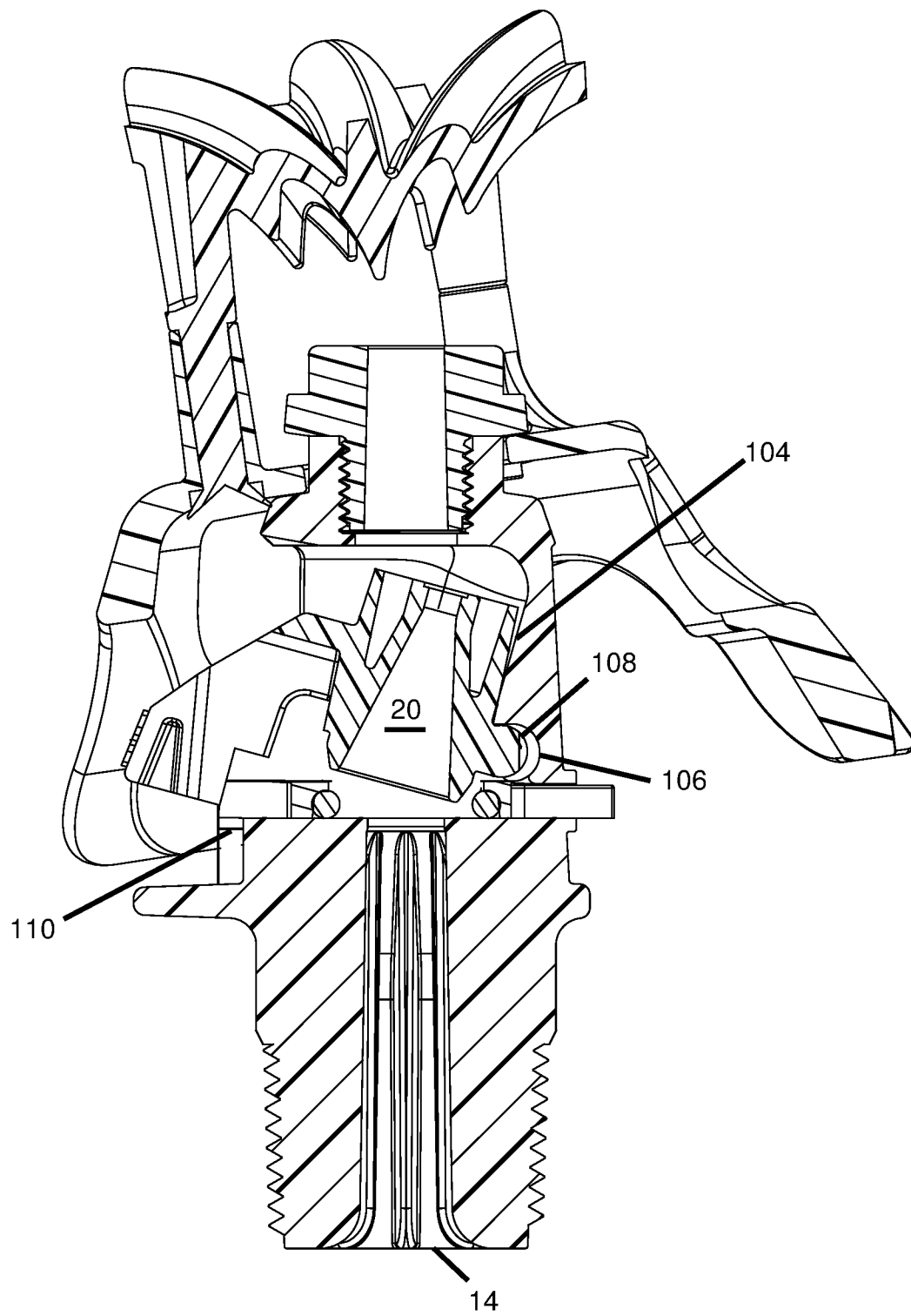


FIG. 12

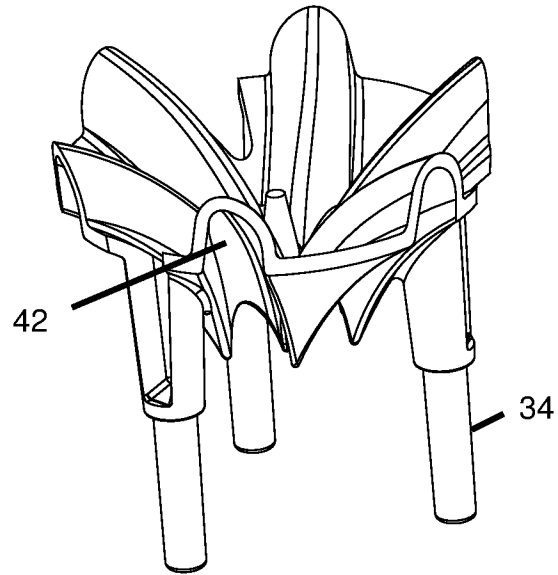


FIG. 13

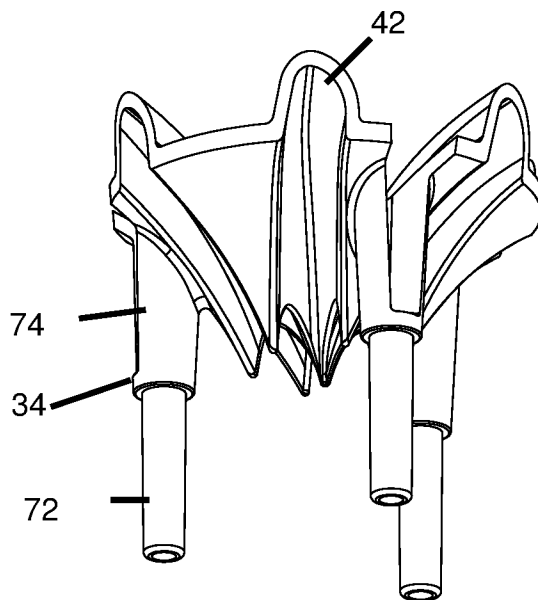


FIG. 14

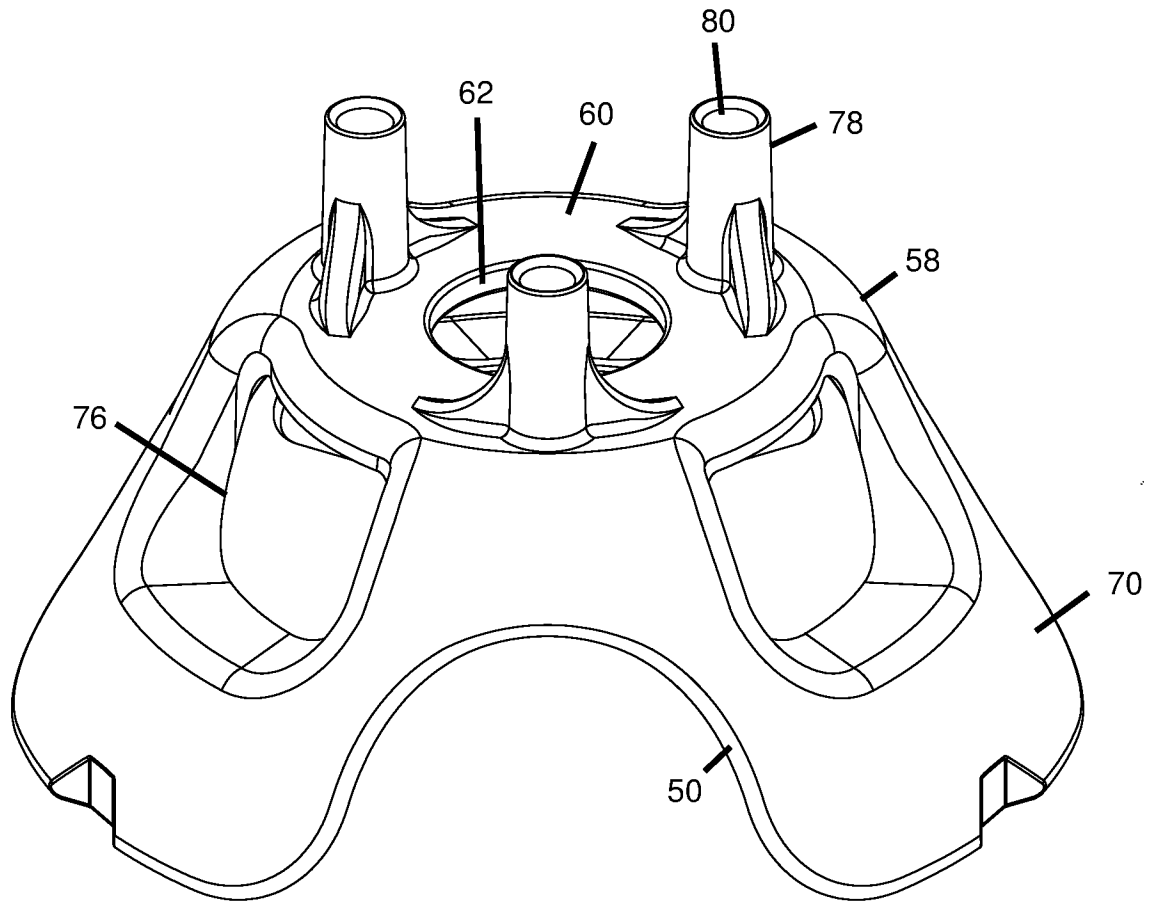
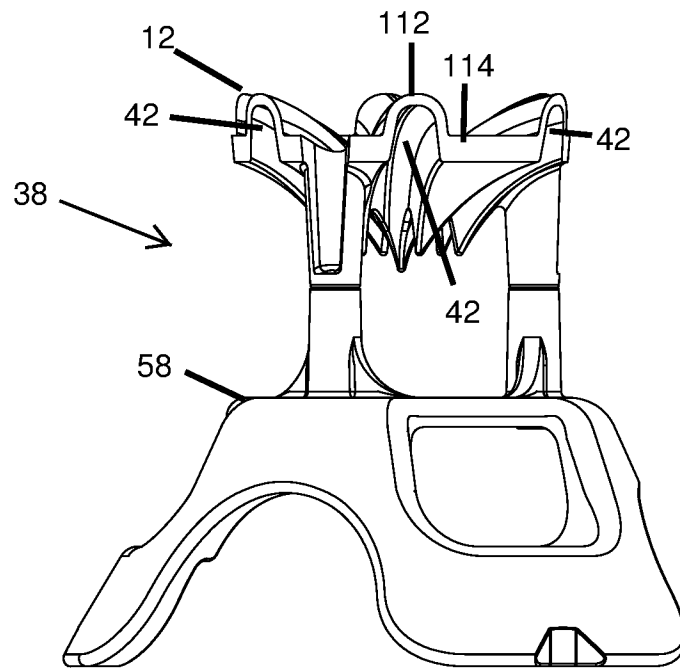
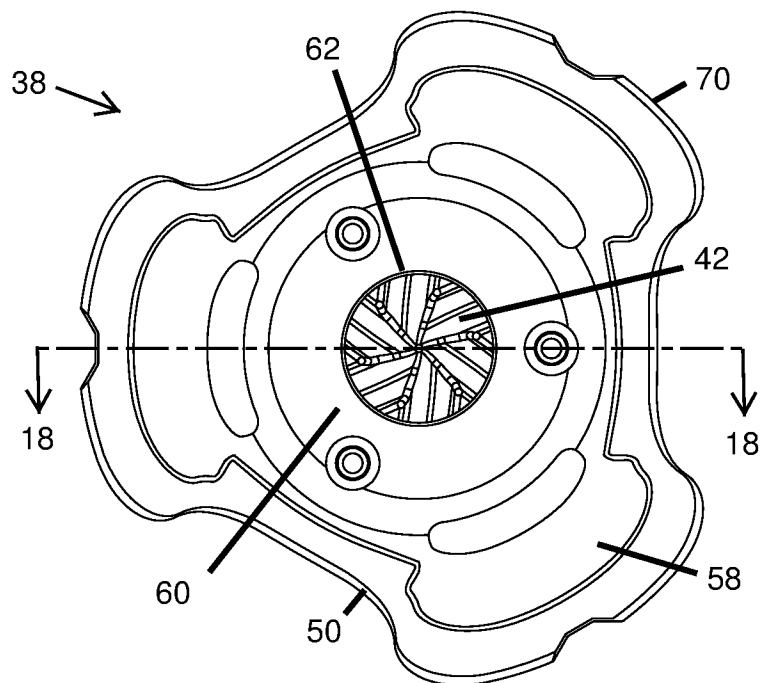


FIG. 15

*FIG. 16**FIG. 17*

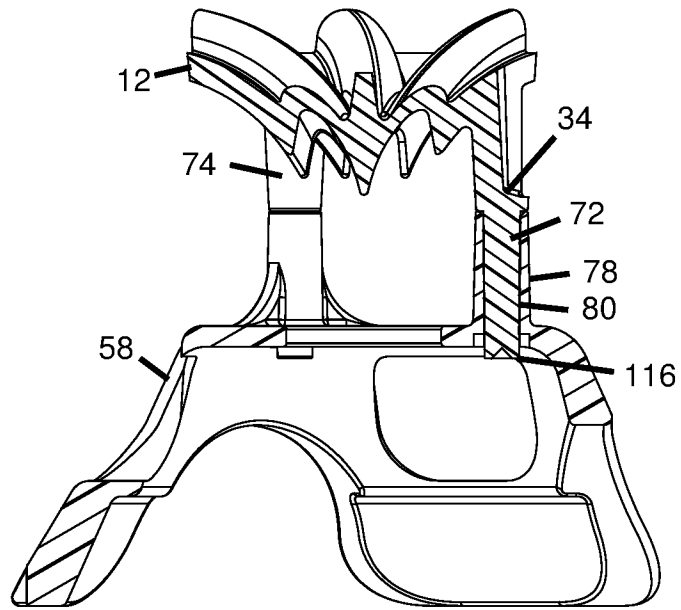


FIG. 18

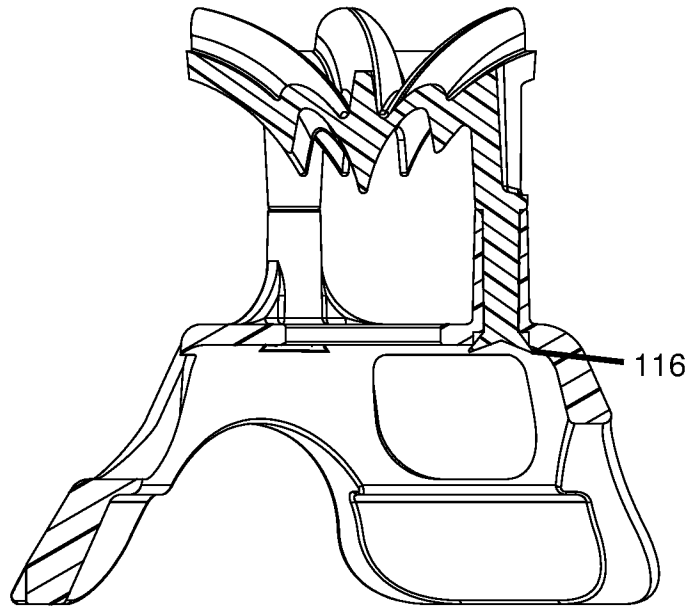


FIG. 18A

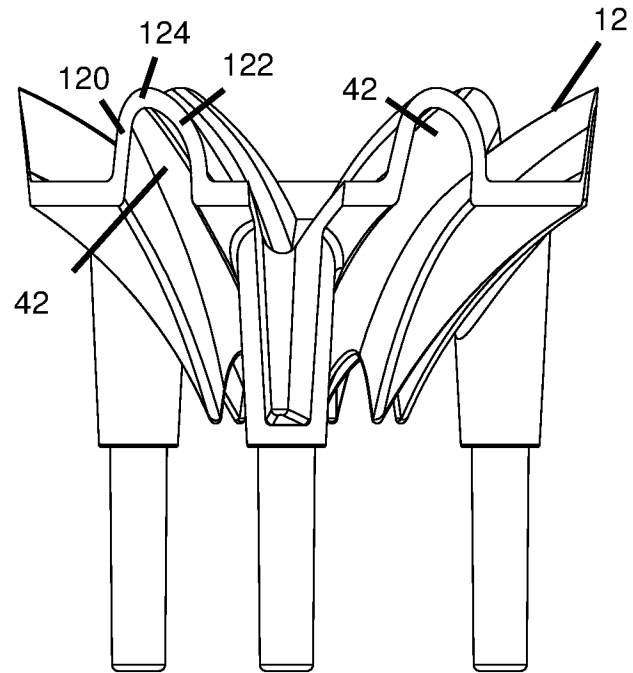


FIG. 19

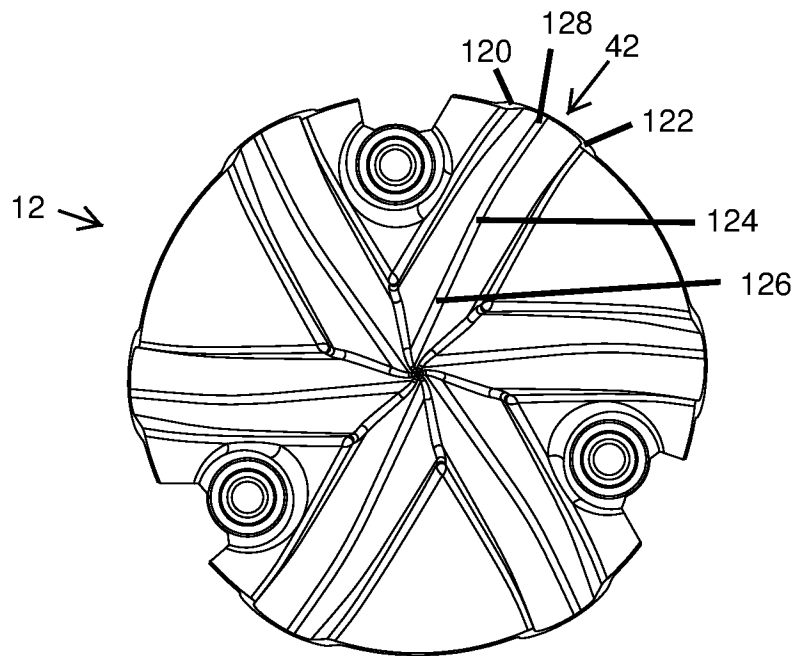


FIG. 20

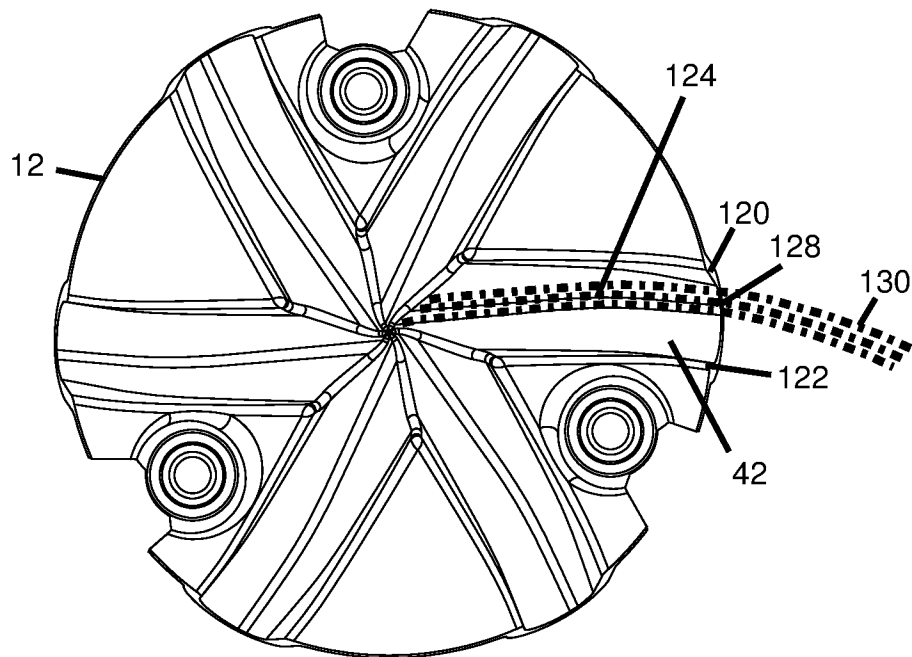


FIG. 21

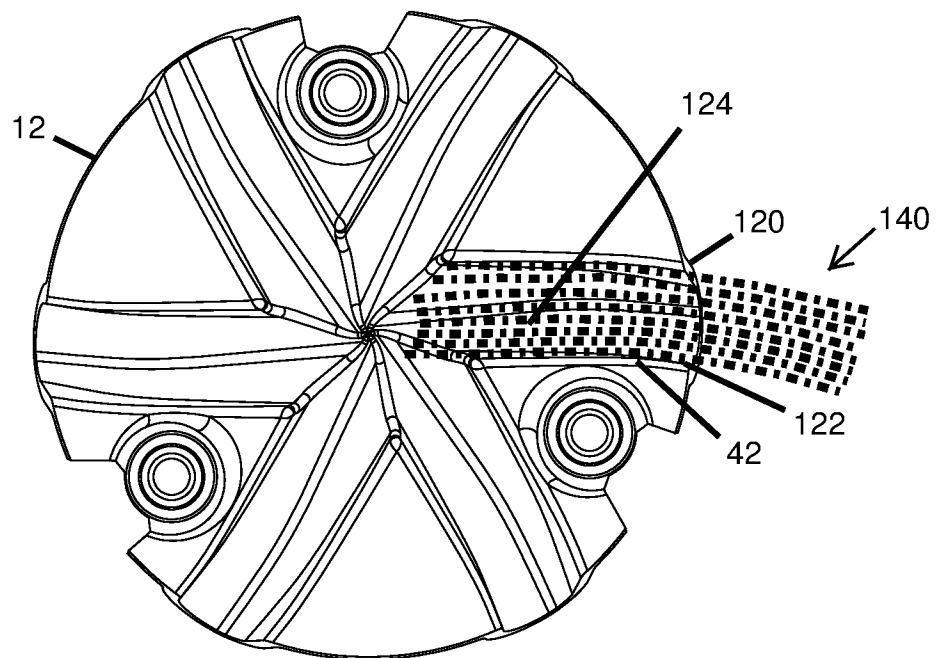


FIG. 22

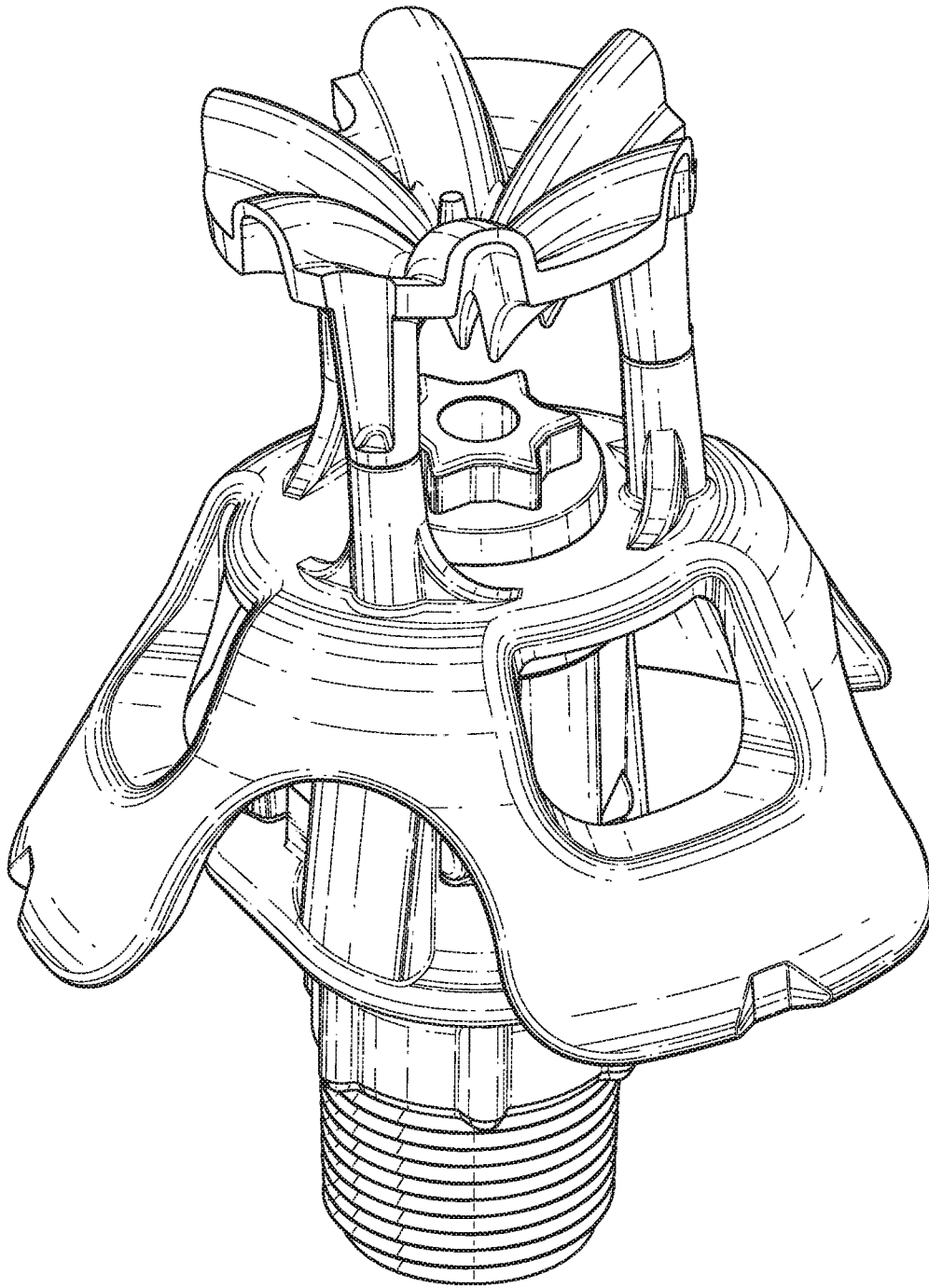


FIG. 23

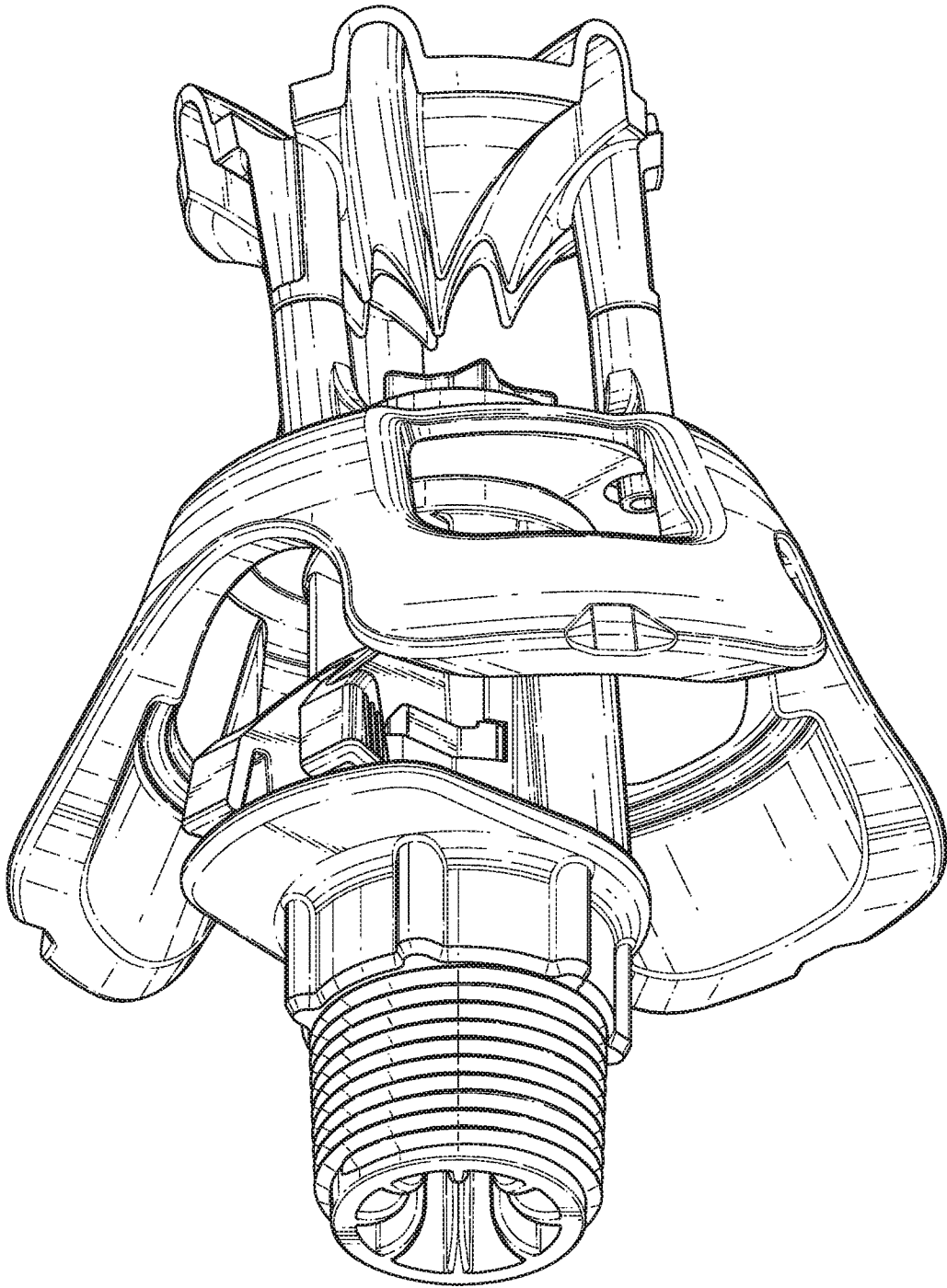


FIG. 24

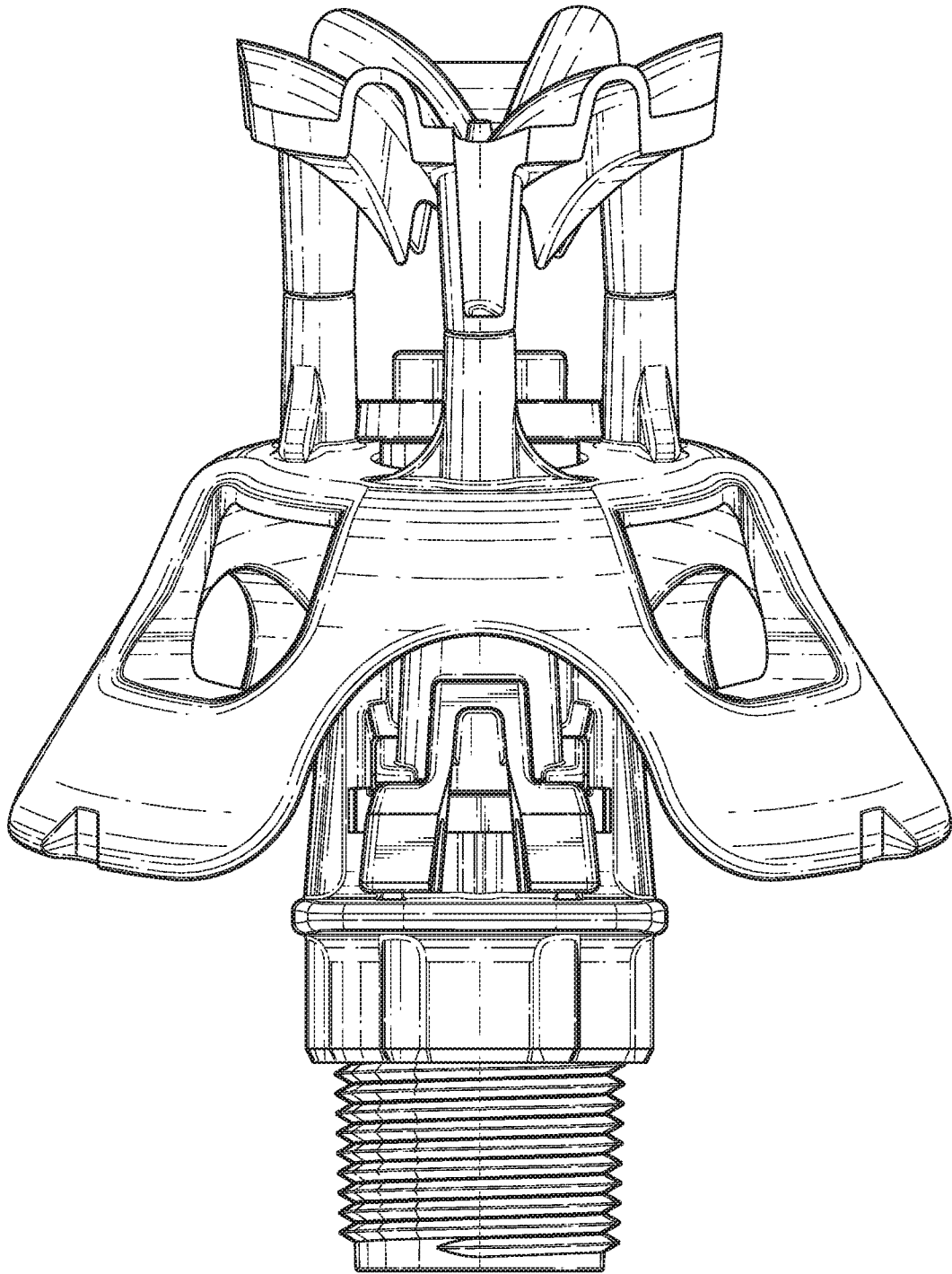


FIG. 25

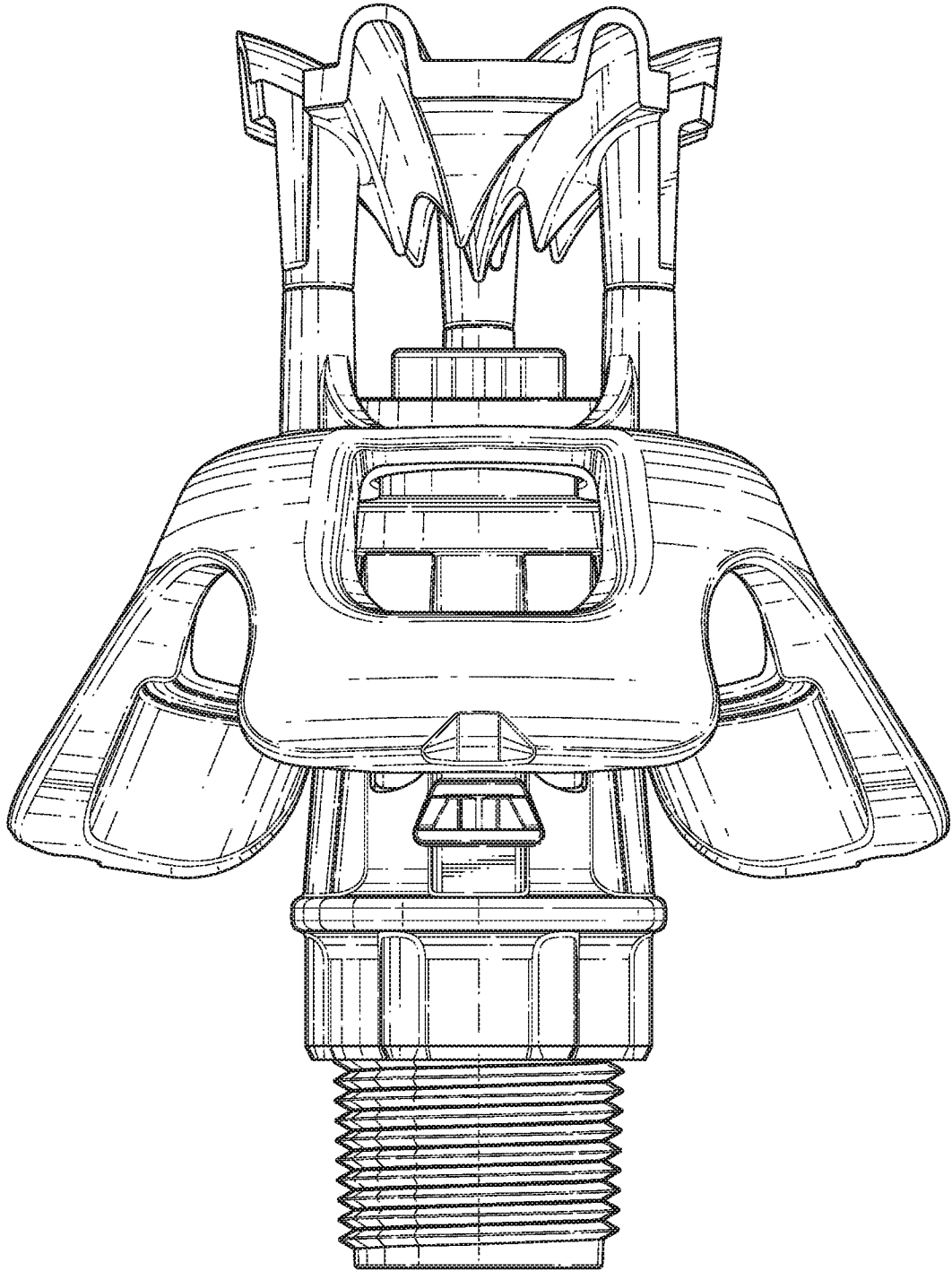


FIG. 26

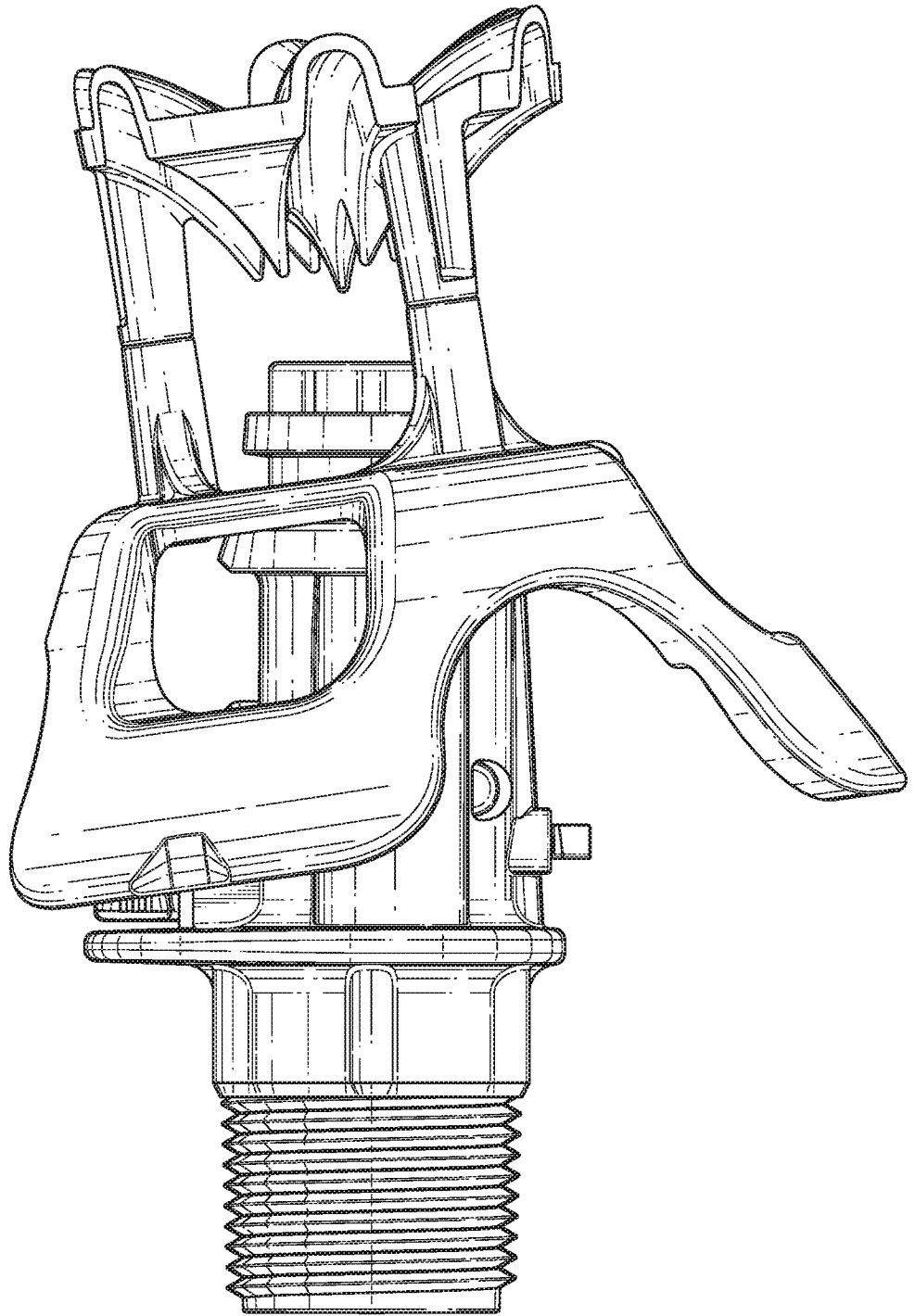


FIG. 27

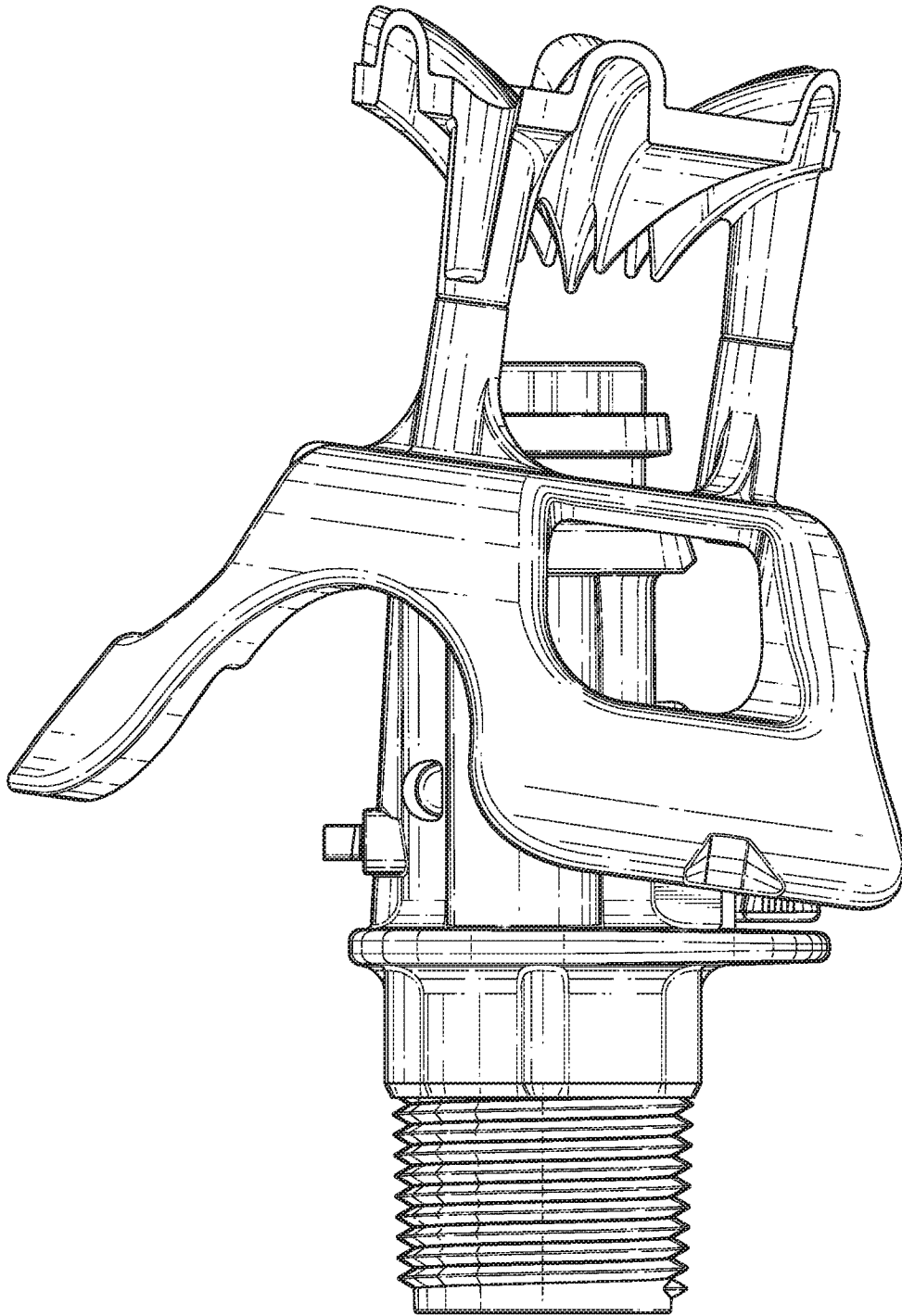


FIG. 28

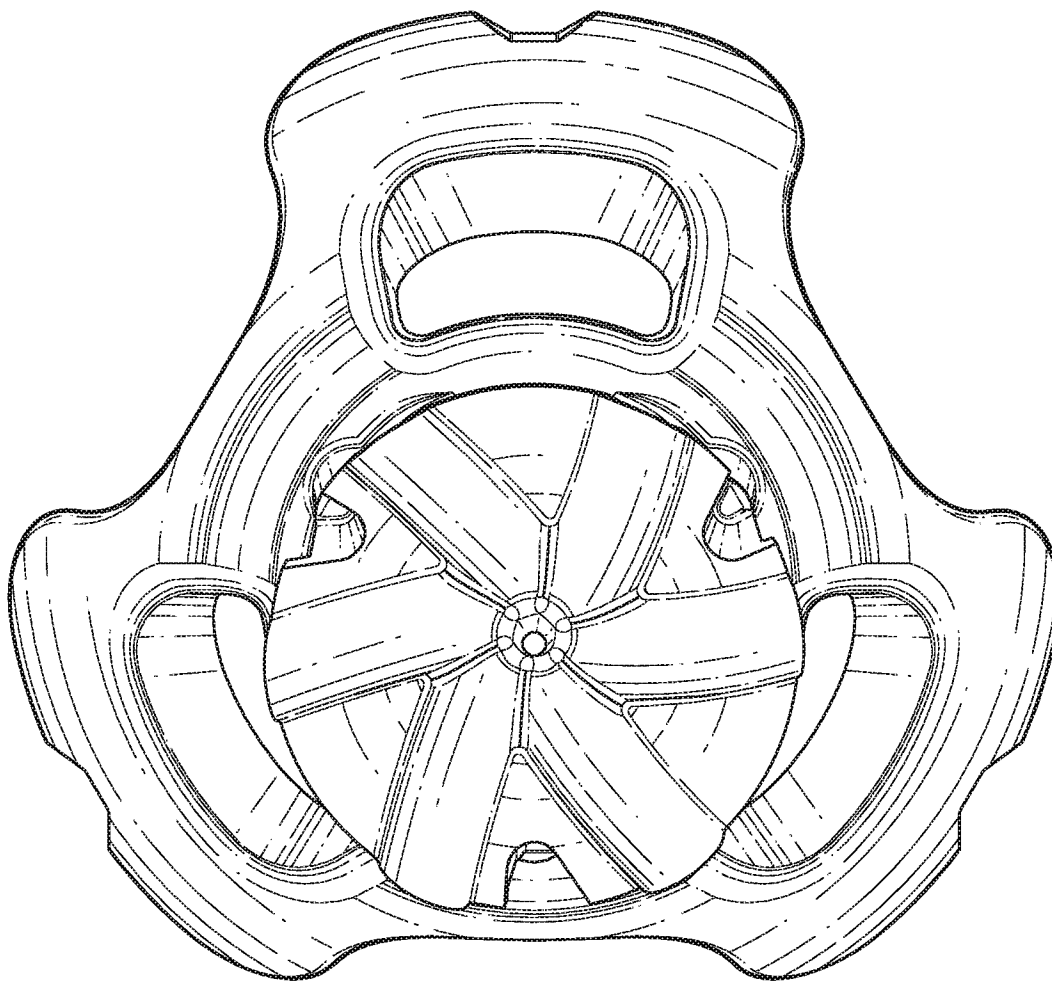


FIG 29

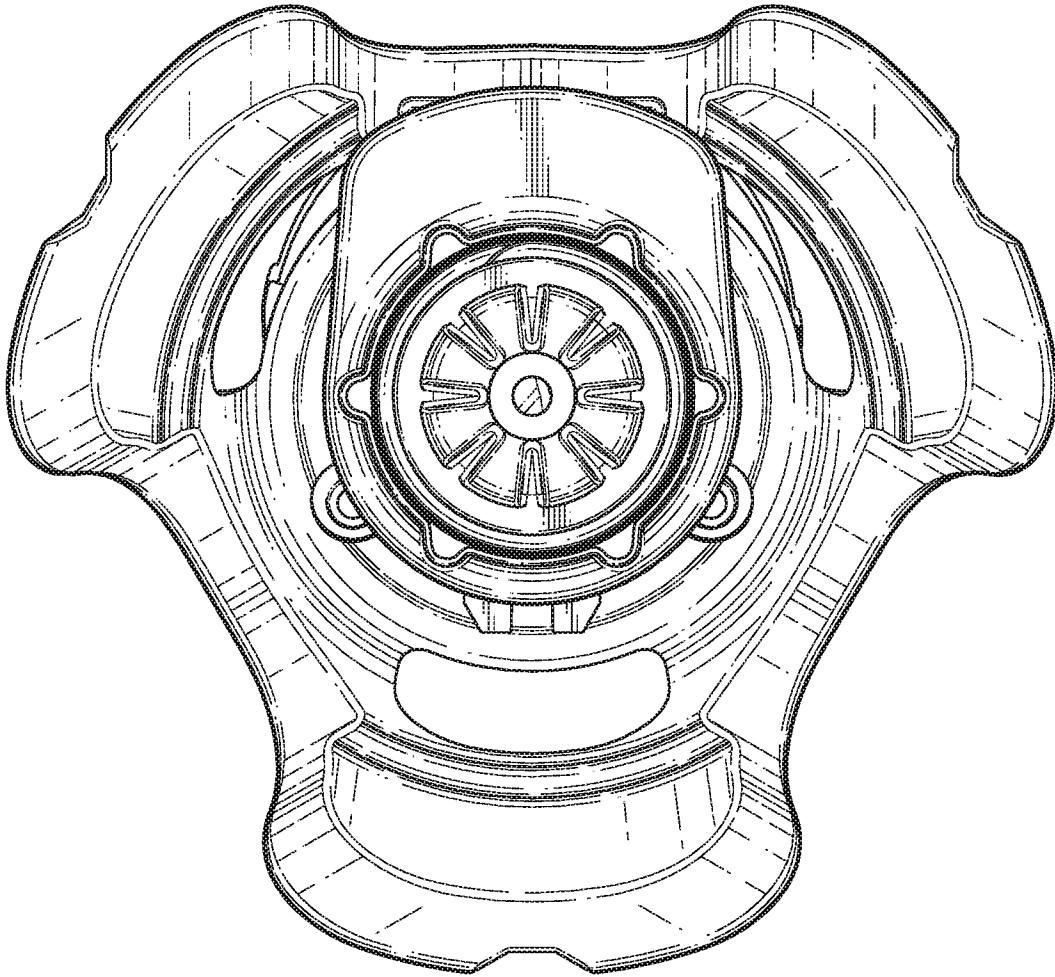


FIG 30

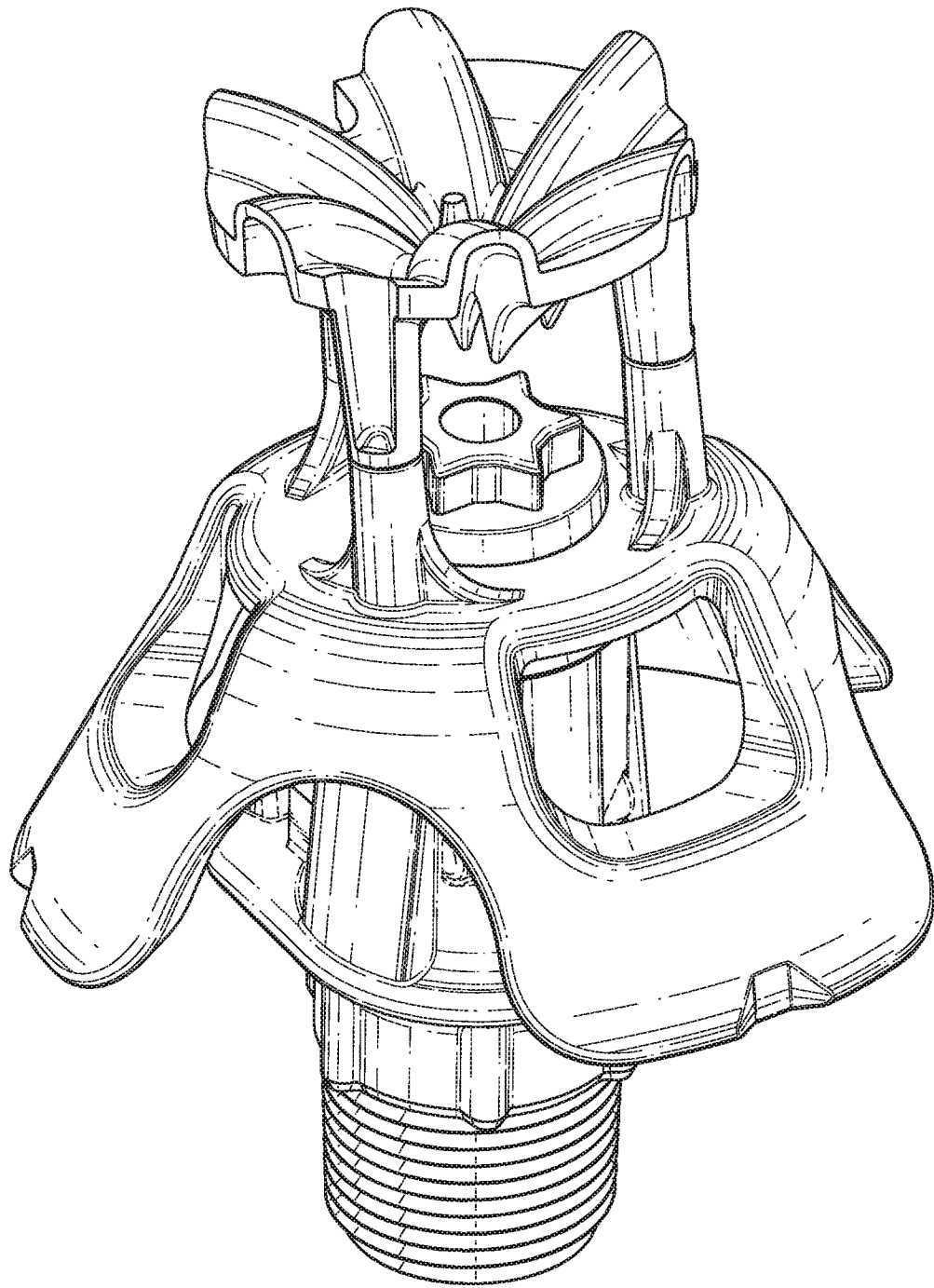


FIG. 31

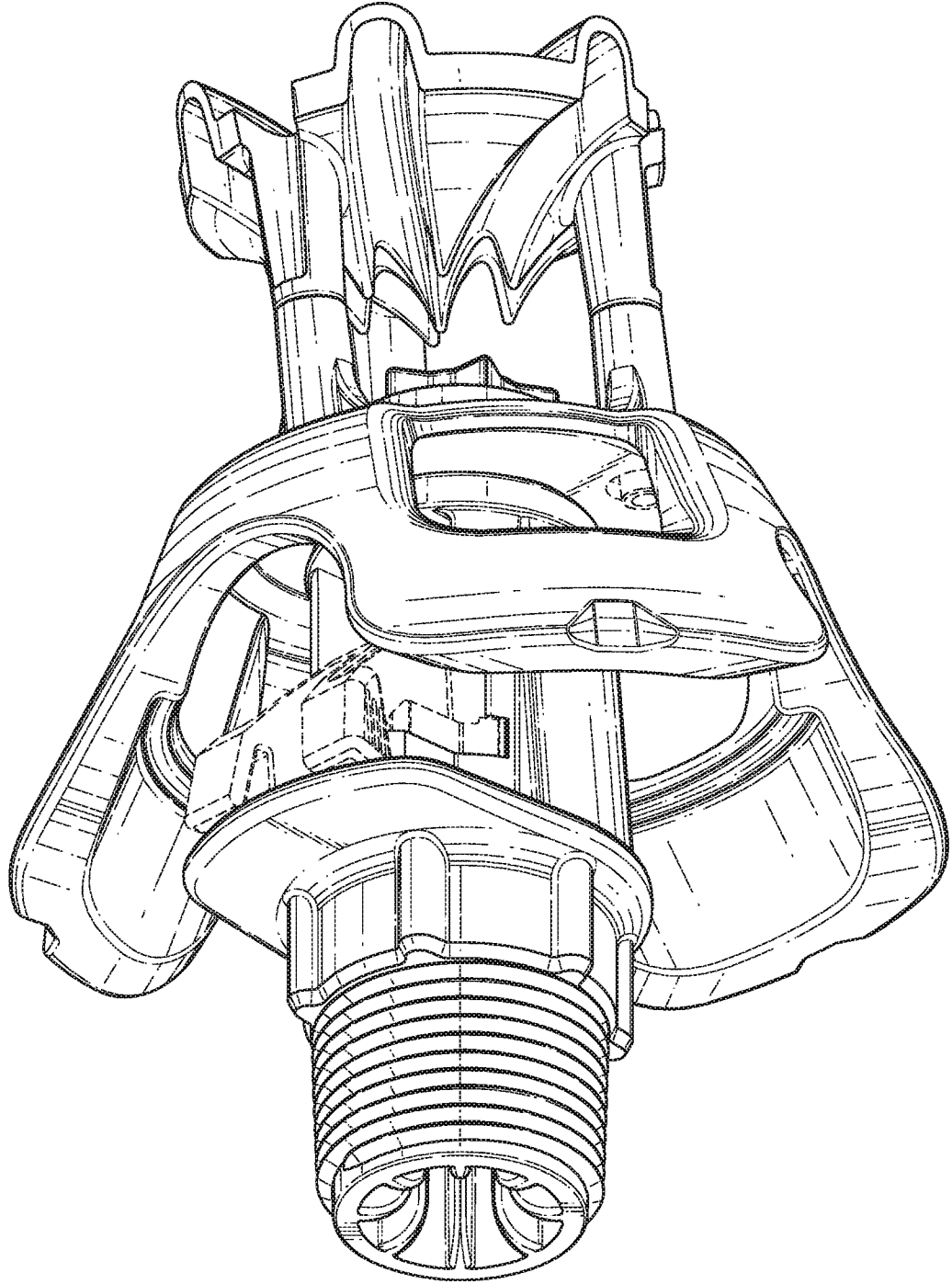


FIG. 32

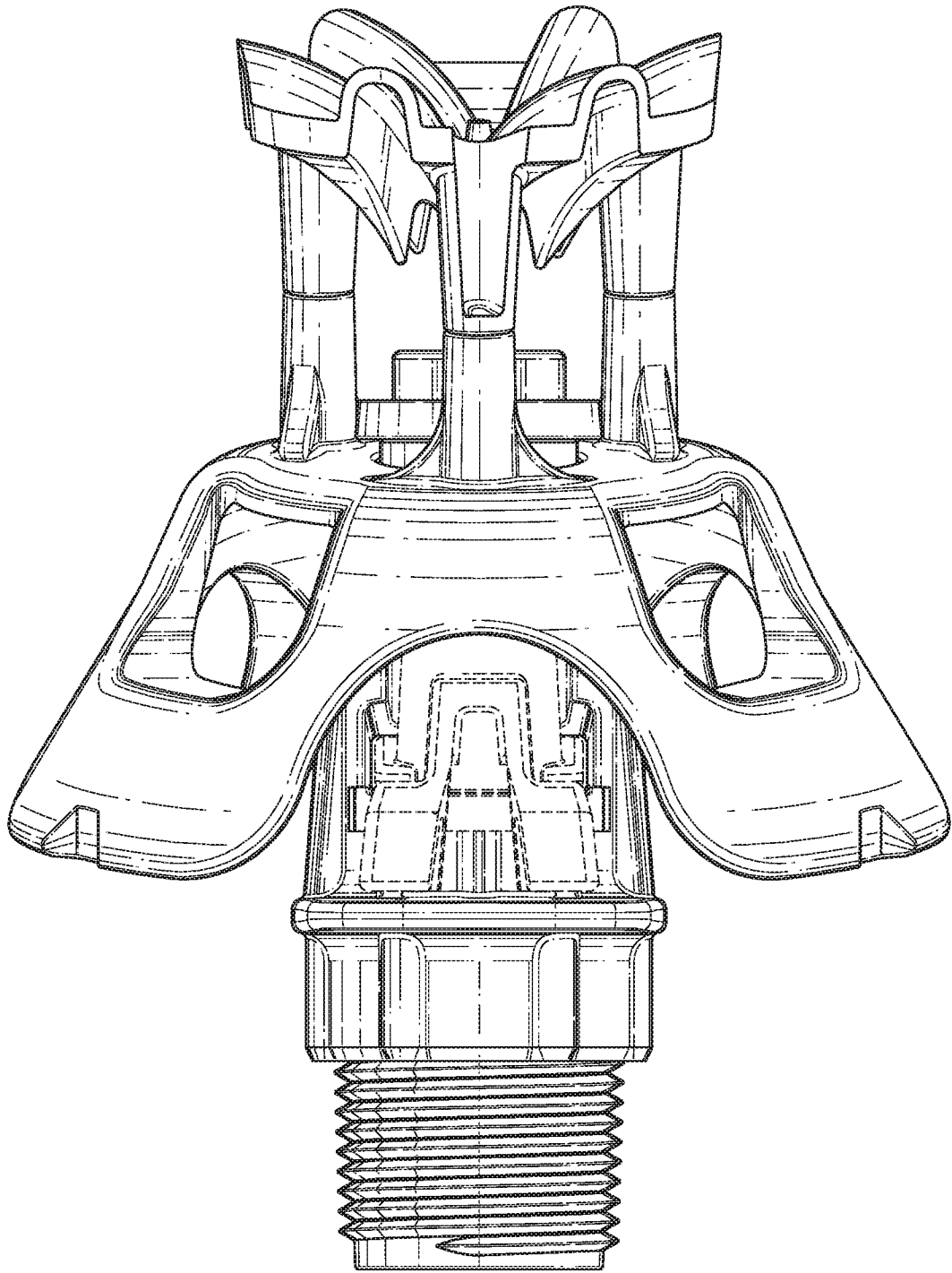


FIG. 33

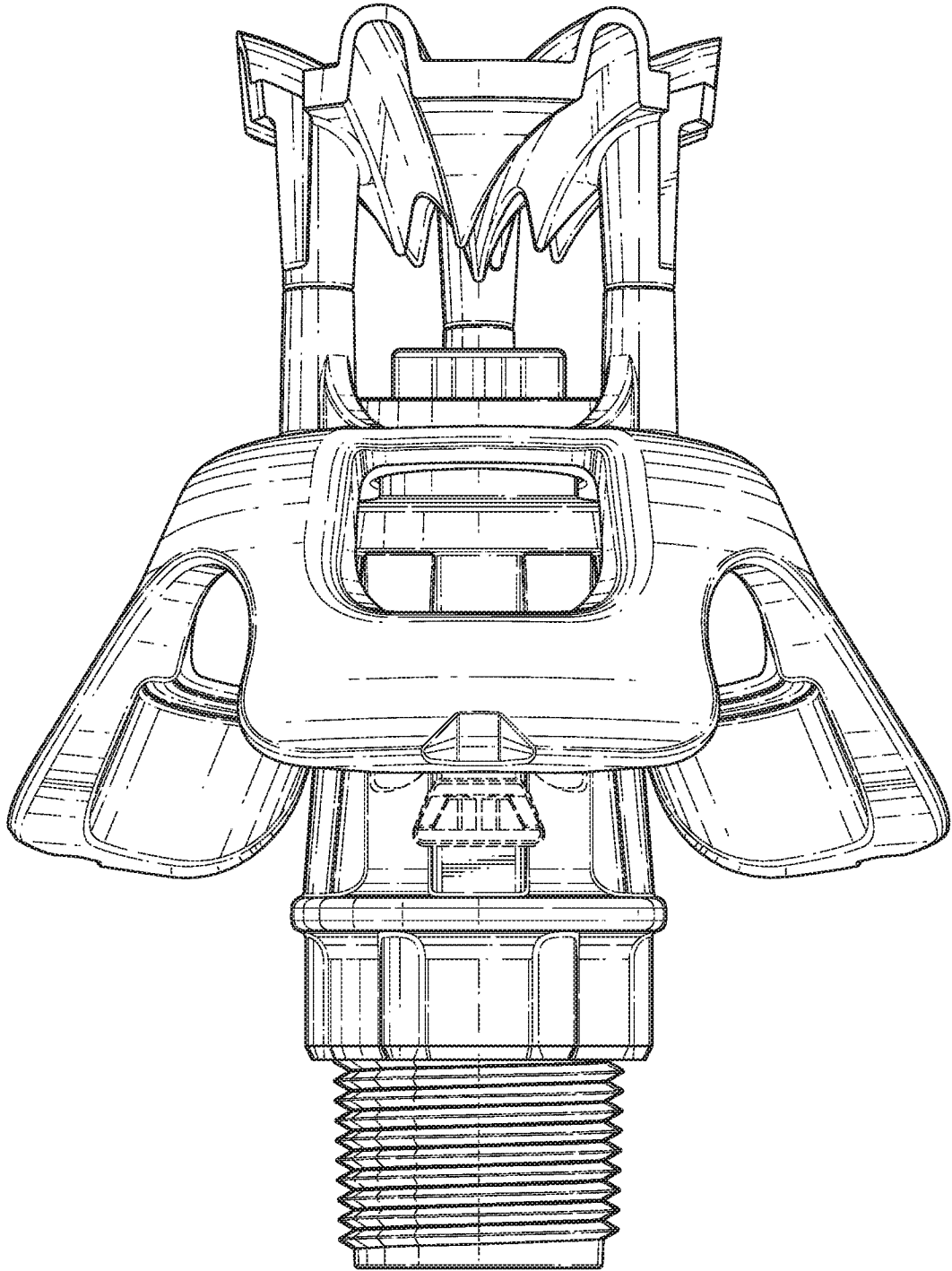


FIG. 34

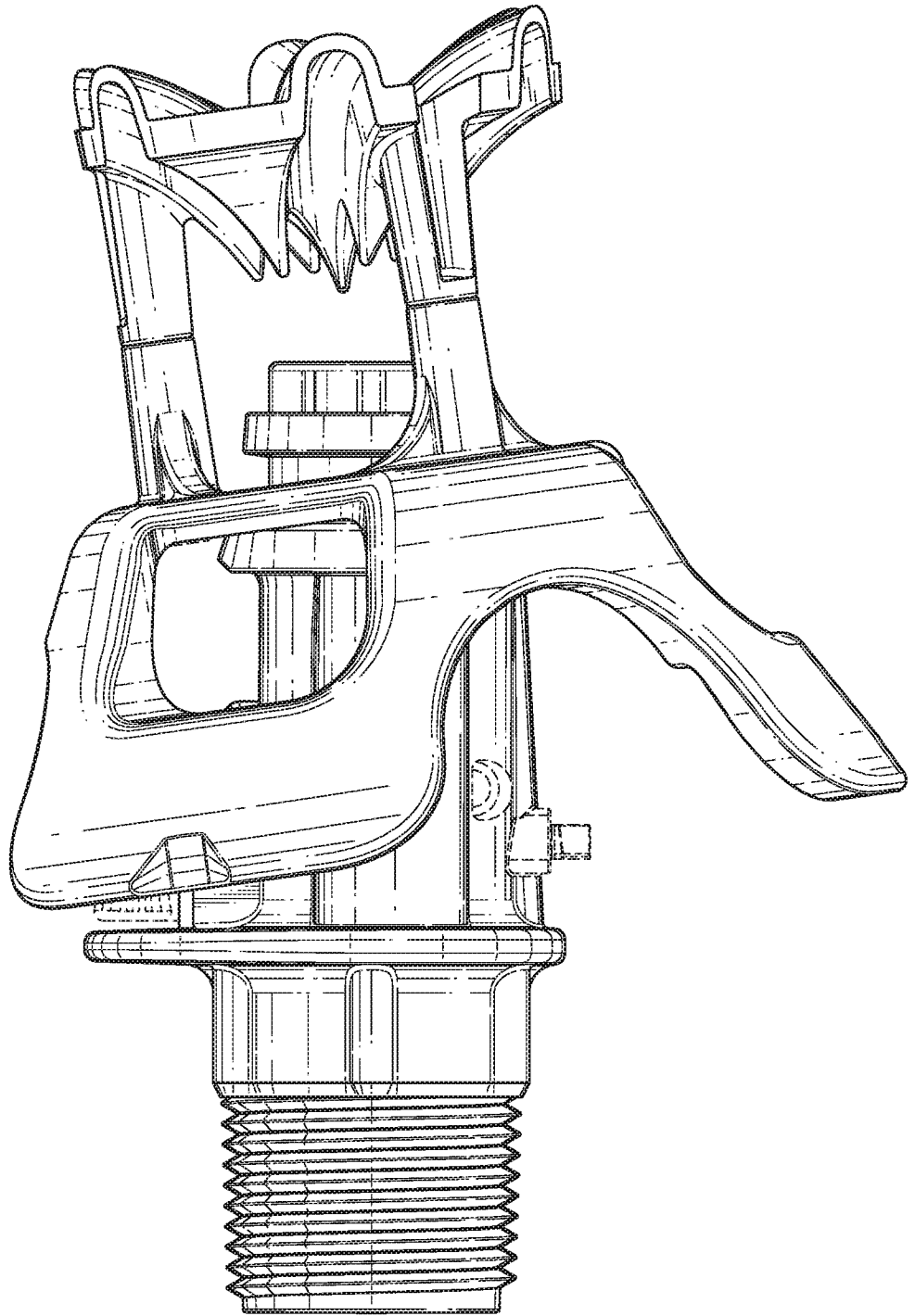


FIG. 35

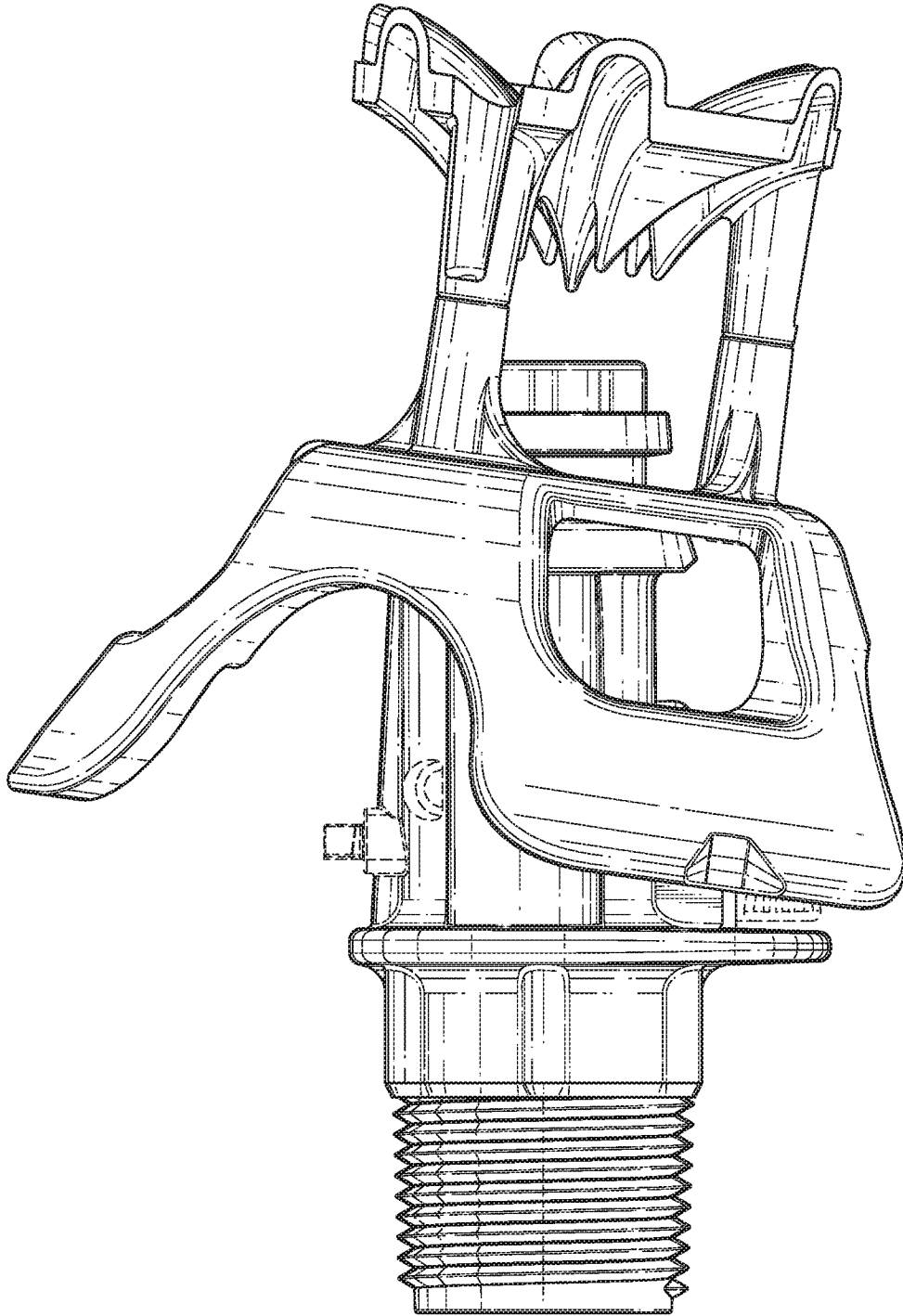


FIG. 36

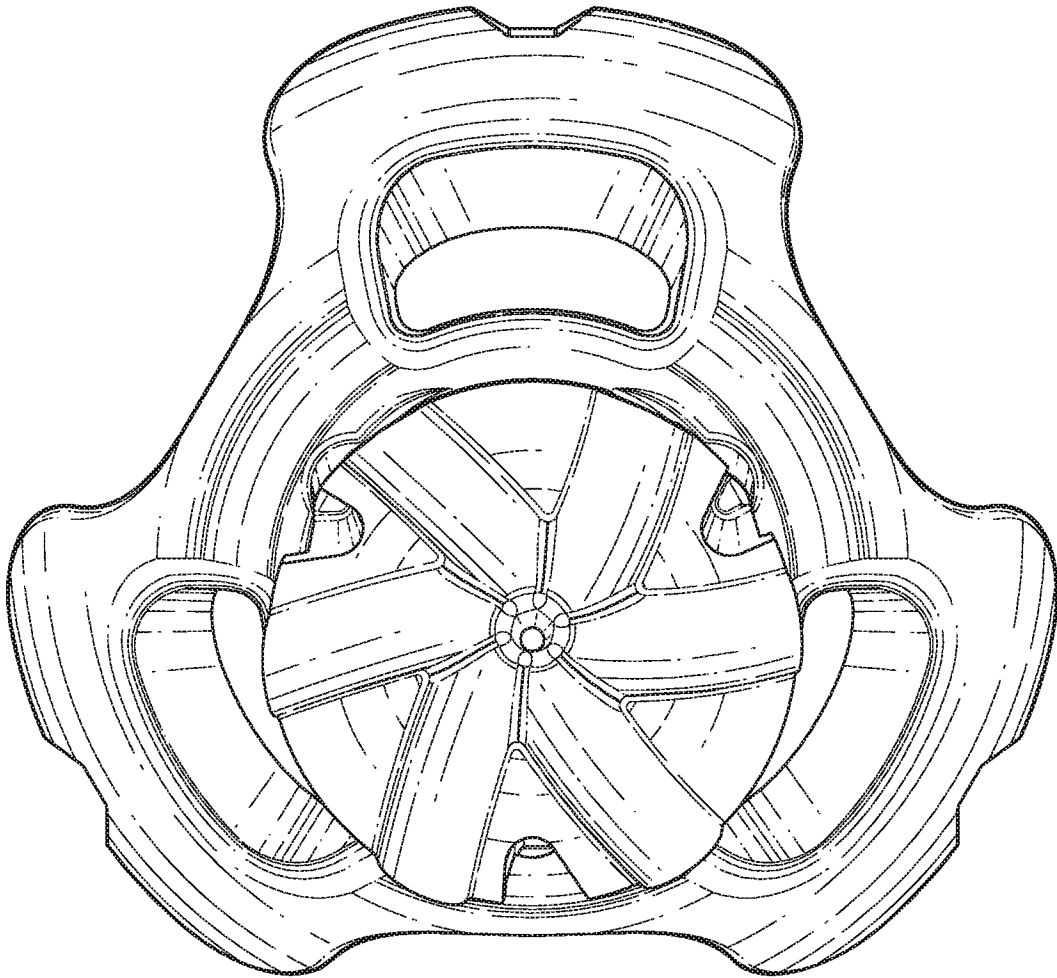


FIG. 37

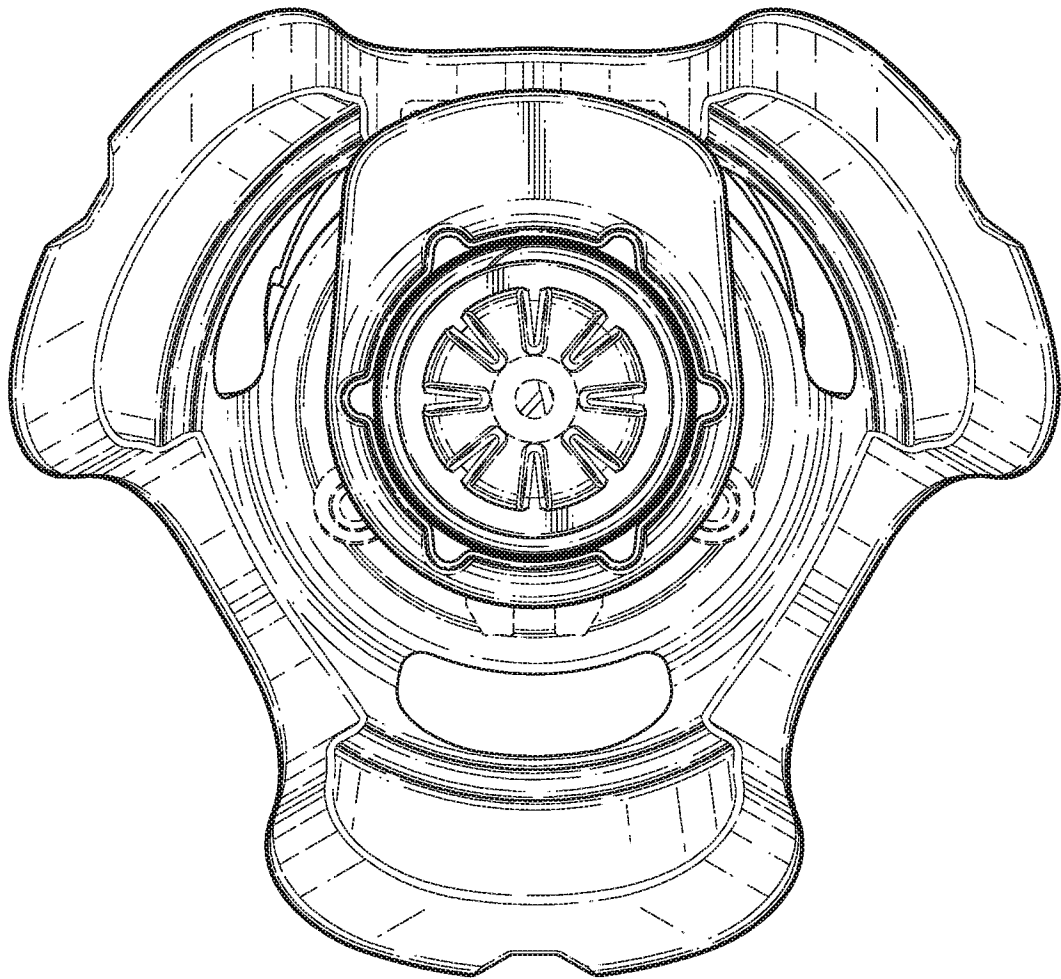


FIG. 38

Electronic Acknowledgement Receipt

EFS ID:	39710326
Application Number:	16900760
International Application Number:	
Confirmation Number:	3690
Title of Invention:	SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS
First Named Inventor/Applicant Name:	William A. Pratesi
Customer Number:	20995
Filer:	James F. Herkenhoff/Fabiola Esmerio
Filer Authorized By:	James F. Herkenhoff
Attorney Docket Number:	HISEN.046A
Receipt Date:	12-JUN-2020
Filing Date:	
Time Stamp:	20:01:12
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 1720
RAM confirmation Number	E20206BK01390976
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	HISEN_046A-Decs.pdf	2359392	no	4
			063f018acb737e401d9fa31baf2e6fa2a92d5d5c		
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
2		HISEN_046A_POA.PDF	254219	yes	2
			ee9adc5782687052e2e9a2f0f48ce17702e2697a		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Power of Attorney		2	2	
	Transmittal Letter		1	1	
Warnings:					
Information:					
3		HISEN_046A_App.PDF	153359	yes	30
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	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Abstract		30	30	
	Claims		26	29	
	Specification		1	25	
Warnings:					
Information:					

4	Application Data Sheet	HISEN_046A_ADS.PDF	1256049	no	9
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Warnings:

Information:

5	Drawings-only black and white line drawings	HISEN_046A_Draws.PDF	9163368	no	32
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Warnings:

Information:

6	Fee Worksheet (SB06)	fee-info.pdf	34970	no	2
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Warnings:

Information:

Total Files Size (in bytes):			13221357		
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

COMBINED DECLARATION & ASSIGNMENT (37 CFR 1.63(e))

Application Data Sheet filed previously or concurrently

Docket No.: HISEN.046A

Page 1 of 4

Title: SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS

Inventors: William A. Pratesi; Jerry D. Lawyer; and Jacob K. Keller

Declaration

This Declaration is directed to the application identified above that is attached.

As a named inventor, I declare that:

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 USC 1001 by fine or imprisonment of not more than five (5) years, or both.

I have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

Assignment from Inventors

WHEREAS, **above-identified inventors** (individual(s) hereinafter "ASSIGNOR") invented certain new and useful improvements, technology, inventions, developments, ideas, ornamental designs, or discoveries related to **SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS** (collectively hereinafter referred to as the "Work") for which an application for Letters Patent in the United States (identified above) has been filed or prepared for filing with the United States Patent and Trademark Office (hereinafter the "Application"), and ASSIGNOR desires to assign or confirm assignment of the Work and the Application to the below identified Assignee.

AND WHEREAS, **Senninger Irrigation, Inc.**, with its principal place of business at **13505 Granville Avenue, Clermont, Florida, 34711** (hereinafter the "ASSIGNEE"), desires to acquire or confirm ownership of the entire right, title, and interest in and to the Application and the Work.

NOW, THEREFORE, for good and valuable consideration of which receipt is hereby acknowledged, ASSIGNOR hereby acknowledges that ASSIGNOR has sold, assigned, transferred, and set over, and by these presents does hereby sell, assign, transfer, and set over, unto said ASSIGNEE, its successors, legal representatives, and assigns, the entire right, title, and interest throughout the world in and to the Application and the Work, including: all provisional applications relating to the Work and the Application; all nonprovisional applications claiming priority to aforementioned provisional(s) and/or the Application, including, all divisions, continuations, continuations-in-part, and reissues, and all Letters Patent of the United States which may be granted thereon and all reissues and extensions thereof; and all rights of priority under International Conventions and any related Letters Patent which may hereafter be granted or filed in any country or countries foreign to the United States, all extensions, renewals, and reissues thereof.

ASSIGNOR hereby authorizes and requests the Commissioner of Patents of the United States, and any Official of any country or countries foreign to the United States, whose duty it is to issue patents on applications as aforesaid, to issue all related Letters Patent to the ASSIGNEE, its successors, legal representatives, and assigns.

AND ASSIGNOR DOES HEREBY sell, assign, transfer, and convey to ASSIGNEE, its successors, legal representatives, and assigns all claims for damages and all remedies arising out of any violation of the

COMBINED DECLARATION & ASSIGNMENT (37 CFR 1.63(e))*Application Data Sheet filed previously or concurrently***Docket No.:** HISEN.046A

Page 2 of 4

Title: SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS**Inventors:** William A. Pratesi; Jerry D. Lawyer; and Jacob K. Keller

rights assigned hereby that may have accrued prior to the date of assignment to ASSIGNEE, or may accrue hereafter, including, but not limited to, the right to sue for, collect, and retain damages for past infringements of said Letters Patent before or after issuance.

AND ASSIGNOR DOES HEREBY covenant and agree that ASSIGNOR will: communicate to said ASSIGNEE, its successors, legal representatives, and assigns any facts known to ASSIGNOR respecting the Work; testify in any legal proceeding; assist in the preparation of any other Patent Property relating to the Application and the Work or any improvements made thereto; sign/execute all lawful papers; authorize the filing of, execute, and make all rightful oaths and/or declarations in connection with the Application and the Work including any improvements made thereto; any patent applications filed therefrom, and any continuing application filed from any of the aforementioned applications; and generally do everything possible to aid the ASSIGNEE, its successors, legal representatives, and assigns, to obtain and enforce proper patent protection for the Work in all countries.

Legal Name of Inventor: William A. Pratesi

IN TESTIMONY WHEREOF, I hereunto set my hand and seal this 10th day of June, 2020.

Signature: 

Signature before a Notary is desirable but not required. When signed in presence of a Notary, please attach the appropriate notarial documentation.

COMBINED DECLARATION & ASSIGNMENT (37 CFR 1.63(e))

Application Data Sheet filed previously or concurrently

Docket No.: HISEN.046A

Page 3 of 4

Title: SERVICEABLE SPRINKLER WITH NUTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS

Inventors: William A. Pratesi; Jerry D. Lawyer; and Jacob K. Keller

Legal Name of Inventor: Jerry D. Lawyer

IN TESTIMONY WHEREOF, I hereunto set my hand and seal this 9th day of June, 2020.

Signature: _____

Signature before a Notary is desirable but not required. When signed in presence of a Notary, please attach the appropriate notarial documentation.

COMBINED DECLARATION & ASSIGNMENT (37 CFR 1.63(e))

Application Data Sheet filed previously or concurrently

Docket No.: HISEN.048A

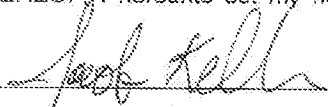
Page 4 of 4

Title: SERVICEABLE SPRINKLER WITH ROTATING DISTRIBUTION PLATE AND ASYMMETRICAL WATER CHANNELS

Inventors: William A. Pratesi; Jerry D. Lawyer; and Jacob K. Keller

Legal Name of Inventor: Jacob K. Keller

IN TESTIMONY WHEREOF, I hereunto set my hand and seal this 12 day of June, 2020.

Signature: 

Signature before a Notary is desirable but not required. When signed in presence of a Notary, please attach the appropriate notarial documentation.

32949369