

in the fluid. These air bubbles may adhere to the plunger **106** and sidewall surfaces and are typically difficult to remove during a priming sequence. The resulting air bubbles may increase the chances of air embolism by injection of small amounts of air, particularly in angiography procedures. As noted, particularly with high pressure CV imaging procedures, any air bubbles in the syringe and/or fluid path must be avoided to prevent air embolism. According to these embodiments, the fluid diverting ribs **30** minimize an amount of air bubbles in the fluid in the syringe **2**. Previous work had shown that a fluid diverter in the middle of the flow path through the nozzle reduces bubble formation during fill, see for example International PCT Publication No. WO 2017/0914643 091643, the disclosure of which is incorporated by reference herein. The described fluid diverting ribs **30** provide a similar effect without the need for a fluid diverter feature in the flow path, thus simplifying manufacture and injection molding of the syringe **2**. The amount of air bubbles in the fluid in the filled syringe **2** may be minimized by the fluid flowing along the internal surfaces of the distal end wall **14** and the cylindrical sidewall **8** of the syringe **2**, rather than dripping/flowing directly from the syringe fluid nozzle **10** to the plunger surface. In one embodiment of the present disclosure, the fluid diverting ribs **30** may also increase the illuminated circumferential halo effect described herein to identify whether air bubbles are present in the syringe **2**. As observed with the plurality of radial ribs **24**, the fluid diverting ribs **30** may magnify and further reflect/refract incident electromagnetic radiation, increasing the brightness of the observed illuminated halo at the around the circumference of the distal portion of the conical distal end **6** of the syringe **2**. In specific embodiments, at least a portion of the plurality of fluid diverting ribs **30** may have different cross-sectional profiles. In other embodiments, at least a portion of the plurality of fluid diverting ribs **30** may extend from the inner surface of the fluid nozzle **10** for different distances into the distal portion of the conical distal end **6** of the syringe **2**.

[0084] According to various embodiments, the plurality of fluid diverting ribs **30** may also allow for increased filling speeds, for example potentially due to more laminar flow of the fluid into the syringe **2** as the fluid passes the fluid diverting ribs **30**. Thus, the time between procedures may be substantially decreased as the syringes may be filled faster than conventional syringes. In addition, the fill rate may be increased since the formation of bubbles during filling is reduced, resulting in smaller prime volumes and lower production of waste fluids associated with greater prime volumes.

[0085] According to various embodiments, the presently described features may increase the ease of injection molding a syringe **2**. For example, syringes **2** may be formed from a medical grade plastic, such as PET, polycarbonate, polyethylene, and blends thereof, and may

CLAIMS:

We Claim:

1. A syringe comprising:
 - a proximal end, a distal end, and a cylindrical sidewall extending between the proximal end and the distal end, wherein the distal end comprises a conical distal end wall and a fluid nozzle at a distal end of the conical distal end wall;
 - a cylindrical load bearing wall extending axially from the cylindrical sidewall past a proximal end of the conical distal end wall; and
 - a plurality of radial ribs positioned around a periphery of an outer surface of the conical distal end wall, wherein a longitudinal axis of the plurality of radial ribs extends radially inward from the cylindrical load bearing wall towards the fluid nozzle over at least a portion of the conical distal end wall.
2. The syringe of claim 1, wherein the plurality of radial ribs defines a plurality of fluid retention channels between each pair of adjacent radial ribs, wherein the plurality of fluid retention channels is are configured to retain a volume of liquid by capillary adhesion ~~when the syringe is rotated from a first upward facing position to a second downward facing position.~~
3. The syringe of claim 2, wherein the plurality of fluid retention channels are configured to retain a volume of the liquid ranging from 0.1 to 0.8 milliliters.
- ~~4. The syringe of claim 2, wherein a volume of the liquid that the plurality of fluid retention channels holds is at least partially determined from a distance between each adjacent pair of the plurality of radial ribs, a height of each adjacent pair of the plurality of radial ribs, and a distance that each pair of radial ribs distally extend radially inward from the conical distal end wall.~~
- ~~54.~~ The syringe of any one of claims 1 to ~~43~~, wherein the plurality of radial ribs increases a load strength of the conical distal end wall.
- ~~65.~~ The syringe of any one of claims 1 to ~~54~~, wherein the plurality of radial ribs increases a load strength of the cylindrical load bearing wall.

76. The syringe of any one of claims 1 to 65, wherein at least one of the plurality of radial ribs extends a different radial distance inward from the cylindrical load bearing wall over the conical distal end wall than the remaining radial ribs of the plurality of radial ribs.

87. The syringe of any one of claims 1 to 76, wherein the cylindrical load bearing wall is configured to abut a retaining surface of a retaining arm of a fluid injector to retain the syringe within a pressure jacket during a pressurized injection procedure.

98. The syringe of any one of claims 1 to 87, wherein the cylindrical load bearing wall extends axially from the cylindrical sidewall of the syringe at an angle of from 1 degree to 30 degrees relative to a longitudinal axis of the syringe.

109. The syringe of any one of claims 1 to 98, wherein a distal surface of the cylindrical load bearing wall is angled radially from a more proximal inner portion to a more distal outer portion relative to the longitudinal axis of the syringe.

110. The syringe of claim 109, wherein ~~the~~ an angle of the distal surface of the cylindrical load bearing wall is configured to prevent entry of fluid between the cylindrical sidewall of the syringe and a pressure jacket in which the syringe is placed.

121. The syringe of claim 109 or claim 110, wherein ~~the~~ an angle of the distal surface of the cylindrical load bearing wall is configured to increase a radially inward force on ~~the~~ a retaining arm of ~~the~~ a fluid injector.

1312. The syringe of any one of claims 1 to 121, wherein at least one of the cylindrical load bearing wall and the plurality of radial ribs enhances a refraction halo effect at a distal portion of the conical distal end wall of electromagnetic radiation emitted from at least one electromagnetic radiation source in a piston or plunger head of a fluid injector.

1413. The syringe of any one of claims 1 to 1312, further comprising a neck associated with the fluid nozzle at the distal end of the syringe, wherein the neck including includes a fluid passageway having a plurality of longitudinal fluid diverting ribs extending radially inward at least partially into the fluid passageway from an inner surface of the neck.

~~15~~14. The syringe of claim ~~14~~13, wherein the plurality of longitudinal fluid diverting ribs are configured to divert a fluid flowing through the neck into the syringe so that the fluid flows along an internal surface of the conical distal end wall and an internal surface of the cylindrical sidewall of the syringe.

~~16~~15. The syringe of claim ~~14~~13 or claim ~~15~~14, wherein the plurality of longitudinal fluid diverting ribs are configured to minimize an amount of air bubbles in the fluid in the syringe.

~~17~~16. The syringe of claim ~~16~~15, wherein the amount of air bubbles in the fluid in the syringe is minimized by the fluid flowing along the internal surface of the distal end wall and the internal surface of the cylindrical sidewall of the syringe.

~~18~~17. The syringe of any one of claims ~~14~~13 to ~~17~~16, wherein at least a portion of the plurality of longitudinal fluid diverting ribs have different profiles.

~~19~~18. The syringe of any one of claims ~~14~~13 to ~~18~~17, wherein at least a portion of the plurality of longitudinal flow diverting ribs extend from the inner surface of the neck at different distances into the fluid passageway.

~~20~~19. The syringe of any one of claims 1 to ~~19~~18, wherein the plurality of radial ribs extend along the outer surface of the conical distal end wall at an angle relative to a longitudinal axis of the syringe such that a distance between the each adjacent pair of the plurality of radial ribs tapers from the cylindrical load bearing wall to the fluid nozzle.

~~21~~20. A syringe comprising:

a proximal end, a distal end, and a cylindrical sidewall extending between the proximal end and the distal end, wherein the distal end comprises a conical distal end wall and a fluid nozzle at a distal end of the conical distal end wall;

a plurality of longitudinal fluid diverting ribs extending inwardly from an inner surface of the fluid nozzle; and

a plurality of radial ribs positioned around a periphery of an outer surface of the conical distal end wall, wherein a longitudinal axis of the plurality of radial ribs extends radially inward from the cylindrical load bearing wall towards the fluid nozzle over at least a portion of the conical distal end wall.

~~2221.~~ The syringe of claim ~~24~~20, further comprising a cylindrical load bearing wall extending axially from the cylindrical sidewall past a proximal end of the conical distal end wall.

~~2322.~~ The syringe of claim ~~24~~20 or claim ~~22~~21, wherein the plurality of radial ribs defines a plurality of fluid retention channels between each pair of adjacent radial ribs, wherein the plurality of fluid retention channels ~~is~~are configured to retain a volume of liquid by capillary adhesion ~~when the syringe is rotated from a first upward facing position to a second downward facing position.~~

~~2423.~~ The syringe of claim ~~23~~22, wherein the plurality of fluid retention channels are configured to retain a volume of the liquid ranging from 0.1 to 0.8 milliliters.

~~25.~~ ~~The syringe of claim 23, wherein a volume of the liquid that the plurality of fluid retention channels holds is at least partially determined from a distance between each adjacent pair of the plurality of radial ribs, a height of each adjacent pair of the plurality of radial ribs, and a distance that each pair of radial ribs distally extend radially inward from the conical distal end wall.~~

~~26~~24. A syringe comprising:

a proximal end, a distal end, and a cylindrical sidewall extending between the proximal end and the distal end, wherein the distal end comprises a conical distal end wall and a fluid nozzle at a distal end of the conical distal end wall; and

a plurality of fluid diverting ribs extending inwardly from an inner surface of the fluid nozzle,

wherein the plurality of fluid diverting ribs enhances a refraction halo effect at a distal portion of the conical distal end wall of electromagnetic radiation emitted from at least one electromagnetic radiation source in a piston or plunger head of a fluid injector.

~~27~~25. The syringe of claim ~~26~~24, further comprising a cylindrical load bearing wall extending axially from the cylindrical sidewall past a proximal end of the conical distal end wall.

2826. The syringe of claim 26-24 or claim 2725, further comprising a plurality of radial ribs positioned around a periphery of an outer surface of the conical distal end wall, wherein a longitudinal axis of the plurality of radial ribs extends radially inward from the cylindrical load bearing wall towards the fluid nozzle over at least a portion of the conical distal end wall.

2927. The syringe of claim 2826, wherein the plurality of radial ribs defines a plurality of fluid retention channels between each pair of adjacent radial ribs, wherein the plurality of fluid retention channels ~~is~~are configured to retain a volume of liquid by capillary adhesion when the syringe is rotated from a first upward facing position to a second downward facing position.

3028. The syringe of claim 2927, wherein the plurality of fluid retention channels are configured to retain a volume of the liquid ranging from 0.1 to 0.8 milliliters.

~~31. The syringe of claim 29, wherein a volume of the liquid that the plurality of fluid retention channels holds is at least partially determined from a distance between each adjacent pair of the plurality of radial ribs, a height of each adjacent pair of the plurality of radial ribs, and a distance that each pair of radial ribs distally extend radially inward from the conical distal end wall.~~