

SELF-ORIENTING SYRINGE AND SYRINGE INTERFACE

BACKGROUND OF THE DISCLOSURE

Field of the Disclosure

[0001] The present disclosure relates generally to a system including a self-orienting, front-loading syringe for use with a fluid injector and, further, to a connection interface for securing the syringe to the fluid injector and to a method for loading and removal of the syringe to and from the fluid injector.

Description of Related Art

[0002] In many medical diagnostic and therapeutic procedures, a medical practitioner, such as a physician, injects a patient with one or more medical fluids. In recent years, a number of injector-actuated syringes and fluid injectors for pressurized injection of medical fluids, such as a contrast solution (often referred to simply as "contrast"), a flushing agent, such as saline, and other medical fluids, have been developed for use in procedures such as angiography, computed tomography (CT), ultrasound, magnetic resonance imaging (MRI), positron emission tomography (PET), and other molecular imaging procedures. In general, these fluid injectors are designed to deliver a preset amount of fluid at a preset pressure and/or flow rate.

[0003] In some injection procedures, the medical practitioner places a catheter or a needle connected to tubing, or other fluid delivery connection into a vein or artery of the patient. The catheter or the tubing is connected to either a manual or to an automatic fluid injection mechanism. Automatic fluid injection mechanisms typically include at least one syringe connected to at least one fluid injector having, for example, at least one powered linear piston. The at least one syringe includes, for example, a source of contrast and/or a source of flushing fluid. The medical practitioner enters settings into an electronic control system of the fluid injector for a fixed volume of contrast and/or saline and a fixed rate of injection for each.

[0004] The injected contrast and/or saline are delivered to a patient's vasculature through the catheter or needle inserted into the patient's body, such as the patient's arm or groin area. A dose of contrast is referred to as a bolus. Once the bolus of contrast is delivered to the desired site, that area is imaged using a conventional imaging technique, such as angiography imaging or scanning, computed tomography (CT), ultrasound, magnetic resonance imaging (MRI), positron emission tomography (PET), and other molecular imaging procedures. The

presence of the contrast becomes clearly visible against the background of the surrounding tissue.

[0005] Various front-loading connection interfaces have been developed to facilitate the loading and removal of the syringe to and from the fluid injector. In some embodiments, the syringe having a retention feature is inserted into a syringe port on the fluid injector by aligning the syringe with a corresponding locking feature provided on the fluid injector. It is often necessary for the medical practitioner to manually align the retention feature of the syringe with the corresponding locking feature on the fluid injector before the syringe can be loaded onto the injector. In some cases, there are only one or two possible alignments for loading, such as shown in United States Patent No. 6,336,913. In these syringes, the operator must rotate the syringe to find an alignment that allows the syringe to engage the fluid injector. It is then necessary for the operator to manually rotate the syringe relative to the locking feature to create a strong enough engagement for operation of the injector. In another embodiment disclosed in United States Patent No. 6,652,489, there is no need to rotationally align the syringe or to rotate the syringe for installation or engagement. To remove the syringe, the operator must rotate the syringe at least 45 degrees, and more commonly 90 degrees, about its longitudinal axis. After rotation, the operator must then physically pull the syringe out of the injector. In some embodiments, the operator must pull on the syringe at the same time while rotating the syringe. Such syringe injector features require additional time and effort to load/remove the syringe from the injector, resulting in increased time for a medical injection procedure.

[0006] Accordingly, there is a need in the art for an improved syringe and injector attachment, interface, and/or locking feature that allows the operator to more easily disengage or release the syringe from the fluid injector, for example to relieve the operator of the effort of simultaneously pulling and rotating the syringe. There is a further need in the art for reducing or eliminating the need for the operator to rotationally align the syringe with the fluid injector during engagement of the syringe with the fluid injector. While various syringe connection interfaces and methods are known in the medical field, improved syringe designs, syringe retention mechanisms, connection interfaces between the syringe and the fluid injector and methods for loading and removing the syringe to and from the fluid injector continue to be in demand.

SUMMARY OF DISCLOSURE

[0007] In view of the disadvantages of the existing connection interfaces between the syringe and the fluid injector, there is a need in the art for an improved connection interface between the syringe and the fluid injector that overcomes the deficiencies of the prior art. There is an additional need for improved syringes, syringe retention mechanisms, and methods for engaging and disengaging the syringe to and from the fluid injector so that the syringe does not have to be manually rotationally aligned about its longitudinal axis relative to the fluid injector to allow easy loading or removal/ejection of the syringe to and from the fluid injector.

[0008] In one embodiment, a syringe may include a barrel having a proximal end, a distal end, and a substantially circumferential sidewall extending between the proximal end and the distal end along a longitudinal axis. At least one syringe retaining member may protrude radially outwardly relative to an outer surface of the sidewall. The at least one syringe retaining member may taper axially along the outer surface of the sidewall in a direction from the distal end toward the proximal end. The at least one syringe retaining member may be configured for engagement with a locking mechanism on a fluid injector to releasably lock the syringe with the fluid injector. A taper of the at least one syringe retaining member may be configured to rotationally guide the syringe into self-oriented alignment with the locking mechanism and axially eject the syringe upon rotation of the syringe.

[0009] The at least one syringe retaining member may have at least one first surface tapered axially in a direction from the distal end toward the proximal end. The at least one syringe retaining member may further have a second surface configured to guide the syringe into self-oriented alignment with the locking mechanism. The first surface and the second surface on the syringe retaining member may be linear, segmented, curved, continuous, discontinuous, or planar. The second surface may be tapered axially in a direction opposite the first surface. The at least one syringe retaining member may be monolithically formed on the outer surface of the syringe. The at least one syringe retaining member may be separated from the outer surface of the syringe. The at least one syringe retaining member may have a base surface arranged substantially perpendicularly relative to the longitudinal axis. At least a portion of the at least one syringe retaining member may protrude substantially perpendicularly relative to the outer surface of the syringe. Individual syringe retaining

members in the plurality of syringe retaining members may be shaped substantially the same or may have two or more different shapes.

[0010] In some embodiments, a plurality of syringe retaining members may be spaced around at least a portion of the outer surface of the syringe. The plurality of syringe retaining members may be separated at substantially equal angular intervals around the outer surface of the syringe. The plurality of syringe retaining members may be separated at unequal angular intervals around the outer surface. The plurality of syringe retaining members may be aligned longitudinally at or near the proximal end relative to the longitudinal axis. At least one of the plurality of syringe retaining members may be offset toward the proximal end of the barrel. At least one of the plurality of syringe retaining members may be offset toward the distal end of the barrel.

[0011] In some embodiments, the at least one syringe retaining member may have one or more locking tabs having at least one stop surface for preventing a rotation of the syringe within the locking mechanism. The at least one syringe retaining member may have at least one first lug and at least one second lug. The at least one first lug may be the same or different from the at least one second lug. The at least one first lug may be offset longitudinally along the longitudinal axis relative to the at least one second lug. At least one of the first lug and the second lug may have an inclined release member protruding at an angle from the outer surface of the barrel to a top surface of the at least one of the first lug and the second lug. The at least one syringe retaining member may have at least one hollow portion and in certain embodiments at least one reinforcing member may be provided in the at least one hollow portion. A flange may protrude radially outwardly from the outer surface of the sidewall relative to the longitudinal axis and distally of the at least one syringe retaining member. The flange may extend around at least a portion of the outer surface of the sidewall. The flange may have a longitudinal stop surface for limiting a length of a longitudinal insertion of the syringe into the locking mechanism. The at least one syringe retaining member may have a shape with a triangular outline, an arrowhead-shaped outline, a rectangular outline, or a rounded outline. The at least one syringe retaining member may have a top surface shaped to correspond to the outer surface of the syringe. The at least one syringe retaining member may be configured for being received within a clearance space on the locking mechanism.

[0012] In some embodiments, a syringe may have a barrel with a proximal end, a distal end, and a sidewall extending substantially circumferentially between the proximal end and the distal end along a longitudinal axis. The syringe may have at least one syringe retaining member protruding radially outwardly relative to an outer surface of the sidewall. The at least one syringe retaining member may have at least one surface tapered axially along the outer surface of the sidewall in a direction from the distal end toward the proximal end. The at least one syringe retaining member may be configured for engagement with a locking mechanism on a fluid injector to releasably lock the syringe with the fluid injector. The at least one surface may be configured to rotationally guide the syringe into self-oriented alignment with the locking mechanism and may further be configured to axially eject the syringe upon rotation of the syringe.

[0013] In other embodiments, a syringe may have a barrel with a proximal end, a distal end, and a sidewall extending substantially circumferentially between the proximal end and the distal end along a longitudinal axis. The syringe may have at least one syringe retaining member protruding radially outwardly relative to an outer surface of the sidewall. The at least one syringe retaining member may have a first surface and a second surface, such that the first surface is offset axially and radially relative to the second surface. The at least one syringe retaining member may be configured for engagement with a locking mechanism on a fluid injector to releasably lock the syringe with the fluid injector. At least one of the first and the second surface may be configured to rotationally guide the syringe into self-oriented alignment with the locking mechanism and the first surface and the second surface may further be configured to axially eject the syringe upon rotation of the syringe.

[0014] In some embodiments, a fluid injection apparatus may include at least one syringe having a cylindrical barrel with a distal end, a proximal end, a sidewall, and a longitudinal axis extending therebetween. The barrel may have at least one syringe retaining member protruding radially outwardly from an outer surface of the sidewall. The at least one syringe retaining member may have a surface tapered axially in a direction toward the proximal end. The apparatus may further include an injector having an injector housing defining at least one syringe port for receiving the at least one syringe and a locking mechanism associated with the at least one syringe port for securing the at least one syringe within the at least one syringe port. The locking mechanism may be configured for engaging the at least one syringe retaining member of the syringe to releasably lock the at least one syringe within the

at least one syringe port and to axially eject the at least one syringe from the at least one syringe port upon rotation of the syringe.

[0015] In some embodiments, the first surface may be configured to rotationally guide the at least one syringe into self-alignment alignment with the locking mechanism. The locking mechanism may include a housing having a proximal end, a distal end, and a central opening extending therebetween, a first retaining ring at the distal end of the housing, and a second retaining ring within the central opening of the housing between the proximal end and the first retaining ring. The second retaining ring may be rotatable relative to the first retaining ring to operatively engage the at least one syringe retaining member of the syringe. The first retaining ring may have at least one first recess configured to receive the at least one syringe retaining member when the proximal end of the at least one syringe is inserted into the at least one syringe port. The at least one first recess may project radially outwardly into an inner sidewall of the first retaining ring. Lateral surfaces of the at least one first recess may define a guide path for guiding a movement of the at least one syringe retaining member within the at least one first recess. The at least one first recess may have at least one guide surface for guiding the first surface of the at least one syringe into the at least one first recess. The first surface of the at least one syringe retaining member may engage at least a portion of the at least one guide surface upon movement of the at least one syringe in a proximal direction. The at least one guide surface may be angled or curved relative to the longitudinal axis in a direction from the distal end toward the proximal end. A plurality of syringe retaining members may be spaced around at least a portion of the outer surface of the sidewall of the at least one syringe, such as near the proximal end, and a plurality of first recesses may be spaced apart around at least a portion of an inner surface of the first retaining ring.

[0016] In other embodiments, the second retaining ring may have one or more locking elements on at least a portion of an inner sidewall of the second retaining ring. The one or more locking elements may extend radially outward into an inner sidewall of the second retaining ring. The one or more locking elements may be separated by one or more second recesses. The one or more second recesses may be configured to receive the at least one syringe retaining member when the proximal end of the at least one syringe is inserted through the first retaining ring. The first retaining ring may include one or more first recesses and the second retaining ring may include one or more second recesses configured for

receiving the at least one syringe retaining member upon rotation of the second retaining ring into selective alignment with the one or more first recesses. At least one elastically resilient member may be coupled with the second retaining ring. At least one sensor may be operatively associated with the injector for sensing information about the syringe. The at least one sensor may be configured for reading information encoded on an encoding device on the syringe.

[0017] In some embodiments, a method of loading a syringe into a locking mechanism of a syringe port of a fluid injector may include providing a syringe having at least one syringe retaining member protruding radially outwardly from an outer surface of a syringe sidewall with at least one tapering surface tapering in a direction from a distal end toward a proximal end of the syringe, and engaging the at least one tapering surface of the syringe with at least a portion of the locking mechanism to rotationally guide the syringe into self-oriented alignment with the locking mechanism. The method may further include self-orienting the syringe within the syringe port.

[0018] According to another aspect, the present disclosure provides a syringe comprising: a barrel having a proximal end, a distal end, and a sidewall extending substantially circumferentially between the proximal end and the distal end along a longitudinal axis; and at least one syringe retaining member having at least one first lug protruding radially outward relative to an outer surface of the sidewall, the at least one first lug comprising a base surface and at least one third surface, wherein the at least one third surface is tapered axially relative to the longitudinal axis of the barrel in a proximal direction, wherein the at least one first lug is configured for engagement with a locking mechanism in a syringe port on a fluid injector, and wherein at least a portion of the at least one third surface axially ejects the syringe from the syringe port upon rotation of the syringe.

[0019] According to a further aspect the present disclosure provides, the syringe of the previous aspect, wherein the at least one first lug further comprises a proximal point at the proximal end of the at least one third surface, wherein at least a portion of the at least one third surface rotationally guides the syringe into self-orienting alignment with the locking mechanism.

[0020] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one third surface is one of a planar surface, a segmented surface, an arcuate surface, a curved surface, a discontinuous surface defining a

tapered surface, and combinations thereof. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one third surface is an arcuate surface.

[0021] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the base surface releasably engages a locking surface of the locking mechanism in the syringe port to releasably lock the syringe with the fluid injector.

[0022] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first lug further comprises at least one first surface, wherein the at least one first surface extends from a first end of the base surface to a most proximal end of the at least one third surface.

[0023] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first surface and the most proximal end of the at least one third surface are joined together at a rounded point or a sharp point.

[0024] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first surface and the most proximal end of the at least one third surface are joined together at a rounded point.

[0025] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first lug further comprises at least one second surface, wherein the at least one second surface extends from a second end of the base surface to a most distal end of the at least one third surface.

[0026] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the base surface, the at least one first surface, the at least one second surface, and the at least one third surface define a border of a top surface of the at least one first lug.

[0027] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the top surface has a curvature shaped to correspond to a circumferential curvature of the sidewall of the barrel.

[0028] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the top surface comprises a plurality of separate surfaces defining the top surface. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first lug has at least one hollow

section defined by the plurality of separate surfaces of the top surface and projecting radially inward from the top surface.

[0029] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, further comprising at least one second lug extending radially outward from the sidewall of the barrel and comprising a second base surface for releasably engaging a locking surface of the locking mechanism in the syringe port to releasably lock the syringe with the fluid injector.

[0030] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the base surface of the at least one first lug and the second base surface of the at least one second lug are the same longitudinal distance from the proximal end of the barrel of the syringe.

[0031] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first lug and the at least one second lug are evenly spaced around the circumference of the barrel.

[0032] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the syringe comprises two first lugs. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, the two first lugs are on opposite sides of the circumference of the barrel.

[0033] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the syringe comprises four second lugs. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein a first pair of the four second lugs are adjacent to each other and a second pair of the four second lugs are adjacent to each other around the circumference of the barrel, but the first pair of the second lugs are not adjacent to the second pair of the second lugs.

[0034] According to another aspect, the present disclosure provides a syringe comprising: a barrel having a proximal end, a distal end, and a sidewall extending substantially circumferentially between the proximal end and the distal end along a longitudinal axis; and at least one syringe retaining member having at least one first lug protruding radially outward relative to an outer surface of the sidewall, the at least one first lug comprising a base surface, at least one third surface, and a proximal point at a most proximal end of the at least one third surface, wherein the at least one third surface is tapered axially relative to the longitudinal axis of the barrel in a proximal direction ending at the proximal point, wherein the at least

one first lug is configured for engagement with a locking mechanism in a syringe port on a fluid injector to releasably lock the syringe with the fluid injector, and wherein the proximal point and at least a portion of the at least one third surface rotationally guide the syringe into self-orienting alignment with the locking mechanism .

[0035] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein at least a portion of the at least one third surface axially ejects the syringe from the syringe port upon rotation of the syringe.

[0036] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one third surface is one of a planar surface, a segmented surface, an arcuate surface, a curved surface, a discontinuous surface defining a tapered surface, and combinations thereof. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one third surface is an arcuate surface.

[0037] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first lug further comprises at least one first surface, wherein the at least one first surface extends from a first end of the base surface to the most proximal end of the at least one third surface to form the proximal point. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the proximal point of the at least one first lug comprises a rounded point or a sharp point. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the proximal point of the at least one first lug comprises a rounded point.

[0038] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first lug further comprises at least one second surface, wherein the at least one second surface extends from a second end of the base surface to a distal end of the at least one third surface.

[0039] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the base surface, the at least one first surface, the at least one second surface, and the at least one third surface define a border of a top surface of the at least one first lug.

[0040] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the top surface has a curvature shaped to correspond to a circumferential curvature of the sidewall of the barrel.

[0041] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the top surface comprises a plurality of separate surfaces defining the top surface. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first lug has at least one hollow section defined by the plurality of separate surfaces of the top surface and projecting radially inward from the top surface.

[0042] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, further comprising at least one second lug extending radially outward from the sidewall of the barrel and comprising a second base surface for releasably engaging a locking surface of the locking mechanism in the syringe port to releasably lock the syringe with the fluid injector.

[0043] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the base surface of the at least one first lug and the second base surface of the at least one second lug are the same longitudinal distance from the proximal end of the barrel of the syringe.

[0044] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the at least one first lug and the at least one second lug are evenly spaced around the circumference of the barrel.

[0045] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the syringe comprises two first lugs. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the two first lugs are on opposite sides of the circumference of the barrel.

[0046] According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein the syringe comprises four second lugs. According to a further aspect the present disclosure provides, the syringe of any of the previous aspect, wherein a first pair of the four second lugs are adjacent to each other and a second pair of the four second lugs are adjacent to each other around the circumference of the barrel, but the first pair of the second lugs are not adjacent to the second pair of the second lugs.

[0047] According to another aspect, the present disclosure provides a syringe comprising: a barrel having a proximal end, a distal end, and a sidewall extending substantially circumferentially between the proximal end and the distal end along a longitudinal axis; and at least one syringe retaining member having at least one first lug protruding radially outward relative to an outer surface of the sidewall, the at least one first lug comprising a base surface, at least one third surface, and a proximal point at a most proximal end of the at least one third surface, wherein the base surface is substantially perpendicular to the longitudinal axis of the barrel and the at least one third surface is tapered axially relative to the longitudinal axis of the barrel in a proximal direction ending at the proximal point, wherein the at least one lug is configured for engagement with a locking mechanism in a syringe port on a fluid injector to releasably lock the syringe with the fluid injector, wherein the proximal point and at least a portion of the at least one third surface rotationally guides the syringe into self-orienting alignment with the locking mechanism, and wherein at least a portion of the at least one third surface axially ejects the syringe from the syringe port upon rotation of the syringe.

[0048] These and other features and characteristics of syringes, syringe connection interfaces, and systems having syringes and/or syringe connection interfaces, as well as the methods of operation and functions of the related elements of structures and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description and the appended claims with reference to the accompanying drawings, all of which form a part of this specification, wherein like reference numerals designate corresponding parts in the various figures. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only. As used in the specification and the claims, the singular form of “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

[0049] **FIG. 1A** is a schematic view of a system including a fluid injector and a syringe according to an embodiment of the present disclosure;

[0050] **FIG. 1B** is a perspective view of a syringe according to one embodiment of the present disclosure;

[0051] **FIG. 2A** is an exploded perspective view of a connection interface for securing a syringe to a fluid injector according to one embodiment;

[0052] **FIG. 2B** is a detailed perspective view of the assembled connection interface shown in **FIG. 2A**;

[0053] **FIG. 2C** is a cross-sectional view of the connection interface shown in **FIG. 2A** with a syringe loaded into a syringe port;

[0054] **FIG. 2D** is a cross-sectional perspective view of the connection interface shown in **FIG. 2C**;

[0055] **FIG. 3A** is a front, exploded perspective view of a connection interface for securing a syringe to a fluid injector according to another embodiment;

[0056] **FIG. 3B** is a rear, exploded perspective view of the connection interface shown in **FIG. 3A**;

[0057] **FIG. 3C** is a cross-sectional view of the connection interface shown in **FIG. 3A** with a syringe loaded into a syringe port;

[0058] **FIG. 3D** is a cross-sectional view of the connection interface of **FIG. 3C** showing the syringe being loaded into the syringe port;

[0059] **FIG. 3E** is a cross-sectional view of the connection interface of **FIG. 3C** showing the syringe locked relative to the syringe port;

[0060] **FIG. 3F** is a cross-sectional view of the connection interface of **FIG. 3C** showing a first step in unlocking the syringe from the syringe port;

[0061] **FIG. 3G** is a cross-sectional view of the connection interface of **FIG. 3C** showing a second step in unlocking the syringe from the syringe port;

[0062] **FIG. 3H** is a cross-sectional view of the connection interface of **FIG. 3C** showing a third step in unlocking the syringe from the syringe port;

[0063] **FIGS. 4A-4M** show cylindrical plan projection views of connection interfaces for securing a syringe to a fluid injector according to various other embodiments;

[0064] **FIGS. 5A-5Z** show various embodiments of syringe retaining members on a syringe;

[0065] **FIG. 6A** is a perspective view of a coupling configured for connecting a syringe of the present disclosure to an injector;

[0066] **FIG. 6B** is a perspective view of an adapter configured for connecting a syringe to an injector of the present disclosure;

[0067] **FIGS. 7A-7B** are perspective views of alternative embodiments of connection portions of the coupling shown in **FIG. 6A**;

[0068] FIG. 8A is a schematic diagram of forces on an embodiment of a syringe retaining member and connection interface during ejection of a syringe from a fluid injector;

[0069] FIG. 8B is a graph of a slip angle for syringe ejection as a function of a coefficient of friction between a syringe retaining member and a locking mechanism;

[0070] FIG. 8C is a graph of a ratio of a rotational force on a syringe during ejection relative to a restoring force of a locking mechanism as a function of an angle of tapered surfaces at a connection interface;

[0071] FIG. 9A is a schematic diagram of forces on an embodiment of a syringe retaining member and connection interface during an insertion of a syringe into a fluid injector;

[0072] FIG. 9B is a graph of a slip angle for syringe ejection as a function of a coefficient of friction between a syringe and a locking mechanism; and

[0073] FIGS. 10A-10H show various embodiments of syringe retaining members on the syringe.

DETAILED DESCRIPTION

[0074] For purposes of the description hereinafter, the terms “upper”, “lower”, “right”, “left”, “vertical”, “horizontal”, “top”, “bottom”, “lateral”, “longitudinal”, and derivatives thereof shall relate to the disclosure as it is oriented in the drawing figures. When used in relation to a syringe, the term “proximal” refers to a portion of a syringe nearest the to an injector when a syringe is oriented for connecting to an injector. The term “distal” refers to a portion of a syringe farthest away from an injector when a syringe is oriented for connecting to an injector. The term “radial” refers to a direction in a cross-sectional plane normal to a longitudinal axis of a syringe extending between proximal and distal ends. The term “circumferential” refers to a direction around an inner or outer surface of a sidewall of a syringe. The term “axial” refers to a direction along a longitudinal axis of a syringe extending between the proximal and distal ends. The term “self-orienting” means that a syringe orients itself to the correct orientation within a syringe port during insertion without effort by a technician. The terms “axial taper”, “axial tapering”, and “tapering axially” mean an angle of inclination of at least one virtual or real surface on a syringe in a cylindrical plan projection view in a direction from a distal end toward a proximal end of a syringe. It is to be understood, however, that the disclosure may assume alternative variations and step sequences, except where expressly specified to the contrary. It is also to be understood that

the specific devices and processes illustrated in the attached drawings, and described in the following specification, are simply exemplary embodiments of the disclosure. Hence, specific dimensions and other physical characteristics related to the embodiments (*i.e.*, aspects, variants, variations) disclosed herein are not to be considered as limiting.

[0075] Referring to the drawings in which like reference characters refer to like parts throughout the several views thereof, the present disclosure is generally directed to syringe and a connection interface for connecting a syringe to a fluid injector.

[0076] With reference to **FIG. 1A**, a fluid injector **10** (hereinafter referred to as “injector **10**”), such as an automated or powered fluid injector, is adapted to interface with and actuate at least one syringe **12**, each of which may be independently filled with a medical fluid **F**, such as contrast media, saline solution, or any desired medical fluid. The injector **10** may be used during a medical procedure to inject the medical fluid into the body of a patient by driving a plunger **26** of the at least one syringe **12** with at least one piston. The injector **10** may be a multi-syringe injector, wherein several syringes **12** may be oriented in a side-by-side or other relationship and include plungers **26** separately actuated by respective pistons associated with the injector **10**. In embodiments with two syringes arranged in a side-by-side relationship and filled with two different medical fluids, the injector **10** may be configured to deliver fluid from one or both of the syringes **12**.

[0077] The injector **10** may be enclosed within a housing **14** formed from a suitable structural material, such as plastic or metal. The housing **14** may be of various shapes and sizes depending on the desired application. For example, the injector **10** may be a free-standing structure configured to be placed on the floor or may be a smaller design for placement on a suitable table or support frame. The injector **10** includes at least one syringe port **16** for connecting the at least one syringe **12** to respective piston elements. As will be described hereinafter, in some embodiments, the at least one syringe **12** includes at least one syringe retaining member configured for retaining the syringe **12** within the syringe port **16** of the injector **10**. The at least one syringe retaining member is configured to operatively engage a locking mechanism provided on or in the syringe port **16** of the injector **10** to facilitate self-oriented loading and/or removal of the syringe **12** to and from the injector **10**, as will be described herein. The syringe retaining member and the locking mechanism together define a connection interface for connecting the syringe **12** to the injector **10**.

[0078] At least one fluid path set **17** may be fluidly connected with the at least one syringe **12** for delivering medical fluid **F** from the at least one syringe **12** to a catheter, needle, or other fluid delivery connection (not shown) inserted into a patient at a vascular access site. Fluid flow from the at least one syringe **12** may be regulated by a fluid control module (not shown). The fluid control module may operate various, pistons, valves, and/or flow regulating structures to regulate the delivery of the medical fluid, such as saline solution and contrast, to the patient based on user selected injection parameters, such as injection flow rate, duration, total injection volume, and/or ratio of contrast media and saline. One embodiment of a suitable front-loading fluid injector that may be modified for use with the above-described system including at least one syringe and at least one syringe interface for self-oriented loading and releasable retaining of the at least one syringe with the fluid injector described herein with reference to **FIG. 1A** is disclosed in United States Patent No. 5,383,858 to Reilly et al. which is incorporated by reference in its entirety. Another embodiment of relevant multi-fluid delivery systems that may be modified for use with the present system are found in United States Patent No. 7,553,294 to Lazzaro et al.; United States Patent No. 7,666,169 to Cowan et al.; International Patent Application No. PCT/US2012/037491 (published as WO 2012/155035); and United States Patent Application Publication No. 2014/0027009 to Riley et al.; all of which are assigned to the assignee of the present application, and the disclosures of which are incorporated herein by reference. Other embodiments may include new fluid injector systems designed to include various embodiments of the interface described herein.

[0079] Having described the general structure and function of the injector **10**, the at least one syringe **12** will now be discussed in greater detail. With reference to **FIG. 1B**, the syringe **12** generally has a cylindrical syringe barrel **18** formed from glass, metal, or a suitable medical-grade plastic. The barrel **18** has a proximal end **20** and a distal end **24**, with a sidewall **19** extending therebetween along a length of a longitudinal axis **15** extending through a center of the barrel **18**. The barrel **18** may be made from a transparent or translucent material, and may include at least one fluid verification member **11** for verifying a presence of the fluid **F** within the syringe barrel **18**. A nozzle **22** extends from the distal end **24** of the barrel **18**. The barrel **18** has an outer surface **21** and an inner surface **23** that defines an interior volume **25** configured for receiving the fluid therein. The proximal end **20** of the barrel **18** may be sealed with the plunger **26** that is slidable through the barrel **18**. The

plunger 26 forms a liquid-tight seal against the inner surface 23 of sidewall 19 of the barrel 18 as it is advanced therethrough. The plunger 26 may have a rigid inner element 28 configured for engagement with the piston of the injector 10. The plunger 26 may further include an elastomeric cover 29 disposed over at least a portion of the rigid inner element 28. The elastomeric cover 29 is configured to engage the inner surface 23 of the barrel 18 and provide a liquid-tight seal against the sidewall 19 of the barrel 18 as it is advanced therethrough.

[0080] A drip flange 36 may extend radially outward from the outer surface 21 of the syringe barrel 18 relative to the longitudinal axis 15. The drip flange 36 may extend around at least a portion of the outer circumference of the barrel 18. In one embodiment, the drip flange 36 is positioned distally along the longitudinal axis 15 relative to a syringe retaining member 32. The drip flange 36 may be configured to prevent fluid that drips from the nozzle 22 from entering the syringe port 16 on the injector 10. In this manner, the drip flange 36 helps reduce the amount of fluid that may enter the syringe port 16 and jam or otherwise interfere with the connection interface 100 (shown in FIG. 2A) and/or the interior mechanics and electronics of the injector 10. In some embodiments, the drip flange 36 defines a stop surface that delimits the insertion section 30 of the syringe 12. The drip flange 36 may be formed integrally with the barrel 18 or it may be affixed or otherwise secured to the outer surface 21 of the barrel 18 using, for example, a frictional fit and/or an adhesive, welding, or by molding. In other embodiments, the drip flange 36 may be formed on the outer surface 21 of the barrel 18 by etching, laser cutting, or machining.

[0081] With continued reference to FIG. 1B, the proximal end 20 of the syringe 12 is sized and adapted for being removably inserted in the syringe port 16 of the injector 10 (shown in FIG. 1A). In some embodiments, the proximal end 20 of the syringe 12 defines an insertion section 30 that is configured to be removably inserted into the syringe port 16 of the injector 10 while the remaining portion of the syringe 12 remains outside of the syringe port 16. As will be described in detail herein, in certain embodiments, the proximal end 20 of the syringe 12 includes one or more syringe retaining members 32 adapted to form a locking engagement with a corresponding locking mechanism in the syringe port 16 of the injector 10 for releasably retaining the syringe 12 in the syringe port 16. The combination of the syringe having the one or more syringe retaining members 32 and the locking mechanism 35 (shown in FIG. 2A) of the injector 10 defines a connection interface for loading and unloading the

syringe **12** to and from the injector **10**. In some embodiments, at least a portion of the one or more syringe retaining members **32** may cooperate with at least a portion of the locking mechanism to self-orient the syringe **12** relative to the syringe port **16** such that the syringe **12** may be releasably inserted into and locked with the syringe port **16**.

[0082] With reference to **FIGS. 2A-2D**, a connection interface **100** for loading and unloading the at least one syringe **12** (**FIG. 1B**) from the at least one syringe port **16** of the injector **10** (shown in **FIG. 1A**) is shown in accordance with one embodiment. The syringe **12** and the injector **10** include the connection interface **100** having at least one syringe retaining member **32** provided on the syringe **12** and a corresponding locking mechanism **35** provided on the syringe port **16** of the injector **10**. In one embodiment, the at least one syringe retaining member **32** is provided on or near the proximal end **20** of the syringe barrel **18** and/or on at least a part of the insertion section **30**. For example, the at least one syringe retaining member **32** may be provided on an outer surface **21** of the syringe barrel **18** on at least a portion of the insertion section **30**. The at least one syringe retaining member **32** may be formed integrally with the barrel **18** or it may be affixed or otherwise secured to the outer surface **21** of the barrel **18** using, for example, a frictional fit and/or an adhesive, welding, or by molding. In other embodiments, the at least one syringe retaining member **32** may be formed on the outer surface **21** of the barrel **18** by etching, laser cutting, or machining.

[0083] Referring to **FIG. 1B**, the at least one syringe retaining member **32** may be formed as including one or more lugs **34** that protrude radially outwardly from the outer surface **21** of the syringe barrel **18** relative to the longitudinal axis **15**. In some embodiments, a plurality of lugs **34** may be separated radially about the circumference of the barrel **18**. In such embodiments, the lugs **34** are separated from each other by portions of the outer surface **21** of the barrel **18**. Together, each lug **34** and the outer surface **21** of the barrel **18** on one radially adjacent side (left or right) of the lug **34** define the syringe retaining member **32**. In embodiments where more than two lugs **34** are provided, the lugs **34** may be evenly or unevenly spaced apart in a radial direction on the outer surface **21** of the barrel **18**. In one exemplary and non-limiting embodiment with six syringe retaining members **32** having equal angular separation therebetween, such as shown in **FIG. 1B**, each syringe retaining member **32** extends over 60 degrees and is therefore separated by 60 degrees from syringe retaining member **32** adjacent on either side. In such embodiment, each lug **34** may extend over 30 degrees of the circumference of the barrel **18** while the portion of the outer surface **21** of the

barrel **18** that defines the remainder of the syringe retaining member **32** extends over the remaining 30 degrees. In other embodiments, each lug **34** may extend at an angle α (shown in **FIG. 2B**), which may be more than 30 degrees or less than 30 degrees of the circumference of the barrel **18**. Similarly, each portion of the outer surface **21** of the barrel **18** between adjacent lugs **34** may extend at an angle β (shown in **FIG. 2B**), which may be more than 30 degrees or less than 30 degrees of the circumference of the barrel **18**. In some embodiments, the syringe retaining members **32** may have unequal angular extension and/or unequal angular spacing between the syringe retaining members **32** about the outer circumference of the barrel **18**. Furthermore, the one or more syringe retaining members **32** may be aligned longitudinally along the longitudinal axis **15** from the proximal end **20**. In other embodiments, at least one lug **34** may be offset longitudinally relative to the remaining lugs in a direction toward the proximal end **20** or the distal end **24**. In an embodiment in which one or more lugs **34** is absent, the corresponding syringe retaining member **32** can be defined by the clearance surface(s) which is the outer surface **21** of the barrel **18** between adjacent lugs **34**. While embodiments having each syringe retaining member **32** extending over 60 degrees are exemplified in the attached drawings, syringes with retaining members **32** having other angles of separation, for example $360/x$ degrees where x is value from 1 and 36, are also within the scope of the present disclosure.

[0084] With reference to **FIGS. 2A-2B**, each of the one or more lugs **34** may have a generally triangular, rectangular, polygonal, or arrowhead shape. The one or more lugs **34** protrude radially outwardly from the outer surface **21** of the barrel **18** in a direction substantially perpendicular to the outer surface **21**. In some embodiments, the one or more lugs **34** or portions of lugs **34** protrude radially outwardly from the outer surface **21** of the barrel **18** at an obtuse or acute angle between the outer surface **21** of the barrel **18** and a top surface **46** of the one or more lugs **34**. In some embodiments, the lugs **34** may have an identical shape to each other. In other embodiments, at least one of the lugs **34** may have a shape different from a shape of the remaining lugs **34**.

[0085] In some embodiments, each of the one or more lugs **34** has a base surface **38** that may be substantially perpendicular to the longitudinal axis **15** of the barrel **18** in a radial cross-sectional plane. In other embodiments, the base surface **38** may be angled relative to the direction of the longitudinal axis **15** as it extends around the outer circumference of the barrel **18** in a radial cross-sectional plane. The base surface **38** may be planar, segmented,

arcuate, curved, or a combination thereof. In some embodiments, the base surface **38** may have a plurality of individual sections that together define the base surface **38**. The plurality of individual sections of the base surface **38** may define a surface that may be planar, segmented, arcuate, curved, or a combination thereof.

[0086] In certain embodiments, at least one first surface **40** may extend from at least one end of the base surface **38** in a direction substantially parallel or tapered to the longitudinal axis **15**. With reference to **FIG. 2B**, a pair of first surfaces **40** is shown on opposite ends of the base surface **38**. In some embodiments, at least one first surface **40** may be tapered axially relative to the longitudinal axis **15** in a proximal or a distal direction of the longitudinal axis **15**. The axial tapering of the at least one first surface **40** relative to the longitudinal axis **15** may be defined as an angle of inclination of the first surface **40** in a cylindrical plan projection view in a direction from the distal end **24** toward the proximal end **20**. The first surfaces **40** may be tapered in a same direction or opposite directions relative to the direction of the longitudinal axis **15**. The at least one first surface **40** may be directly connected with the base surface **38**. In some embodiments, at least one first surface **40** may be disconnected from the base surface **38**. The at least one first surface **40** may be planar, segmented, arcuate, curved, or a combination thereof. In some embodiments, the at least one first surface **40** may have a plurality of individual sections that together define the at least one first surface **40**. The plurality of individual sections of the at least one first surface **40** may define a surface that may be planar, segmented, arcuate, curved, or a combination thereof.

[0087] At least one second surface **42** extends from at least one first surface **40** or the base surface **38**. With reference to **FIG. 2B**, a pair of second surfaces **42** is shown extending from the proximal ends of first surfaces **40**. In some embodiments, at least one second surface **42** may be tapered axially and circumferentially (and optionally radially) relative to the longitudinal axis **15** in a proximal or a distal direction of the longitudinal axis **15**. In some embodiments, at least one second surface **42** may be tapered axially relative to the longitudinal axis **15** in a proximal direction. The axial and circumferential tapering of the at least one second surface **42** relative to the longitudinal axis **15** may be defined as an angle of inclination of the second surface **42** in a cylindrical plan projection view in a direction from the distal end **24** toward the proximal end **20**. For example, the at least one second surface **42** may be tapered at an angle γ (shown in **FIG. 2B**) relative to a plane normal to the longitudinal axis **15**. Each of the second surfaces **42** may be tapered at a same or different

angle γ relative to the plane normal to the longitudinal axis 15. The second surfaces 42 may join together at a rounded or a sharp point 44. At least one second surface 42 may be directly connected with at least one of the first surface 40, the base surface 38, and the point 44. In some embodiments, at least one second surface 42 may be disconnected from at least one of the first surface 40, the base surface 38, and the point 44. In some embodiments, the pair of second surfaces 42 may be omitted such that only the first surfaces 40 may join at the rounded or sharp point 44. In other embodiments, the rounded or sharp point 44 may be disconnected from the first surfaces 40 or the second surfaces 42. The at least one second surface 42 may be planar, segmented, arcuate, curved, or a combination thereof. In some embodiments, the at least one second surface 42 may have a plurality of individual sections that together define the at least one second surface 42. The plurality of individual sections of the at least one second surface 42 may define a surface that may be planar, segmented, arcuate, curved, or a combination thereof.

[0088] The base surface 38, the first and second surfaces 40, 42, and the point 44 define a border or an outline of the top surface 46 of each of the one or more lugs 34. In some embodiments, the top surface 46 may be shaped to correspond to the curvature of the syringe barrel 18. In other embodiments, the top surface 46 of one or more of the lugs 34 may be angled relative to the outer surface 21 of the syringe barrel 18 such that a first end of the top surface 46 is higher than a second end of the top surface 46 relative to the surface of the syringe barrel 18. The top surface 46 may be continuous and uninterrupted, or it may be comprised of a plurality of separate surfaces that together define the top surface 46. The top surface 46 may be planar, segmented, arcuate, curved, or a combination thereof. In some embodiments, the base surface 38, the first and second surfaces 40, 42, and the point 44 define a border or an outline of the lug 34 having a generally arrowhead shape shown in FIGS. 2A-2B.

[0089] With reference to FIGS. 2A-2D, according to one embodiment, the syringe port 16 of the injector 10 (shown in FIG. 1A) has a locking mechanism 35 configured to operatively engage the at least one syringe retaining member 32 of the syringe 12. Referring initially to FIG. 2A, the locking mechanism 35 includes a housing 70 with a central opening 71 configured to receive the proximal end 20 of the syringe 12. The housing 70 may be formed as part of the housing 14 of the injector 10 (shown in FIG. 1A) or as a fitted attachment to the housing 14 of injector 10. A first retaining ring 48 is secured to a distal end of the

housing 70 such that the central opening 71 of the housing 70 is aligned with a central opening 50 of the first retaining ring 48. The first retaining ring 48 has a body 72 having a radially extending flange 74. At least a portion of the body 72 extends away from the flange 74 in a proximal direction. When installed on the housing 70, the flange 74 engages a top portion of the housing 70 and is secured by one or more fasteners (not shown) extending through one or more fastener openings 76. At least a portion of the body 72 of the first retaining ring 48 is inserted into the central opening 71 of the housing 70. In other embodiments, the first retaining ring 48 may be secured to the housing 70 by other mechanical fastening arrangements, such as a clip, screws, adhesives, welding, or snap fit. When installed on the housing 70, a central axis 59 of the first retaining ring 48 is coaxial with a central axis of the housing 70.

[0090] With continuing reference to FIG. 2A, an inner portion of a sidewall 58 within the central opening 50 of the first retaining ring 48 has one or more first recesses 60 that are configured to receive the one or more lugs 34 of the syringe 12 when the insertion section 30 of the syringe 12 is inserted through the central opening 50 of the first retaining ring 48. The one or more first recesses 60 may be evenly spaced about the inner circumference of the sidewall 58. In such embodiments, the first recesses 60 are separated from each other by portions of the sidewall 58 of the first retaining ring 48. Together, each first recess 60 and the sidewall 58 of the first retaining ring 48 on one radially adjacent side (left or right) of the first recess 60 define a clearance space 63 for receiving the syringe retaining member 32 on the syringe 12. The first recess 60 of each clearance space 63 may be configured to receive at least one lug 34 of the syringe retaining member 32, while the sidewall 58 of the first retaining ring 48 may be configured to receive a portion of the outer surface 21 of the barrel 18 when the syringe retaining member 32 is inserted into the clearance space 63. For example, in an embodiment where the first retaining ring 48 has six clearance spaces 63 equally separated about the circumference of the first retaining ring 48, each clearance space 63 is separated 60 degrees apart from the clearance spaces 63 adjacent on either side. In such embodiments, each first recesses 60 may extend over 30 degrees of the circumference of the first retaining ring 48 while the portion of the sidewall 58 of the first retaining ring 48 that defines the remainder of the clearance space 63 extend over the remaining 30 degrees of the circumference. In other embodiments, the first retaining ring 48 may include 1-5 or 7-12 or more clearance spaces 63 wherein each first recess 60 may extend over more than 30 degrees

or less than 30 degrees of the circumference of the sidewall **58** of the first retaining ring **48**. In some embodiments, the number of lugs **34** on the syringe **12** corresponds to the number of first recesses **60** on the retaining ring **48**. In other embodiments, the number of lugs **34** on the syringe **12** is smaller than the number of first recesses **60** on the retaining ring **48**. In such embodiments, the lugs **34** on the syringe **12** are spaced apart along an outer circumference of the syringe barrel **18** such that each lug **34** can be aligned with a corresponding first recess **60** on the retaining ring **48**. In other embodiments, the number of lugs **34** on the syringe **12** is higher than the number of first recesses **60** on the retaining ring **48** such that more than one lug **34** may be received within at least one first recess **60**.

[0091] Each of the one or more first recesses **60** extends radially outward into the inner portion of the sidewall **58** relative to the central axis **59**. The lateral surfaces of each first recess **60** define a travel path for guiding the movement of the lug **34** in and out of the first recess **60** as the insertion section **30** of the syringe **12** is inserted into and out of the first retaining ring **48**. Each first recess **60** extends substantially parallel along a direction of the central axis **59**. In some embodiments, each first recess **60** may have one or more guiding surfaces **62** and **65** that guide the lugs **34** into self-oriented alignment with the first recesses **60** such that the lugs **34** can be inserted into the first recesses **60** and self-align the syringe **12** within syringe port **16** without any guidance or effort of the technician. The guiding surfaces **62** and **65** may be inclined radially and axially toward an opening of the first recess **60** to self-orient and guide the movement of the second surfaces **42** of the lugs **34**. In some embodiments, the guiding surfaces **65** may be pointed axially such that a first portion of the guiding surface **65** is inclined toward one of the first recesses **60** while a second portion of the guiding surface **65** is inclined toward an adjacent first recess **60**. The one or more guiding surfaces **62** and **65** aid in self-orienting the syringe **12** as it is inserted into the syringe port **16** by guiding the one or more lugs **34** of the syringe **12** into the corresponding one or more first recesses **60** on the syringe port **16**. In this manner, a syringe **12** whose longitudinal axis **15** may be axially misaligned with the axis **59** of the syringe port **16** and the one or more lugs **34** which may be initially misaligned with the corresponding one or more first recesses **60** in a rotational direction about the longitudinal axis **15** of the syringe **12** are brought in alignment axially with the syringe port **16** and rotationally with the one or more first recesses **60** by interaction of at least the second surfaces **42** of the lugs **34** and the one or more guiding surfaces **62** and **65**. The one or more first recesses **60** may have a bottom surface **67** that is

substantially perpendicular to the central axis **59**. In some embodiments, the bottom surface **67** may be angled or tapered in a radial direction.

[0092] With continued reference to the embodiment in **FIG. 2A**, the locking mechanism **35** may further include a second retaining ring **78** having a substantially annular shape with an inner sidewall **80**. The second retaining ring **78** is disposed within the central opening **71** of the housing **70** between a proximal end of the body **72** of the first retaining ring **48** and a bottom **82** of the housing **70**. As detailed further herein, the second retaining ring **78** is rotatable relative to the first retaining ring **48** and the housing **70**, which are fixed relative to each other. The second retaining ring **78** may have one or more first locking elements **84** and, optionally, one or more second locking elements **86** disposed on at least a portion of the inner sidewall **80**. The one or more first and second locking elements **84**, **86** may be arranged in an alternating manner such that each first locking element **84** has a second locking element **86** provided on either side of it along the circumference of the inner sidewall **80**. In other embodiments, at least one second locking element **86** is provided for a plurality of first locking elements **84**. In some embodiments, the total number of first and second locking elements **84**, **86** may correspond to the total number of first recesses **60** and/or the at least one syringe retaining member **32** of the syringe **12**. In other embodiments, the total number of first and second locking elements **84**, **86** may correspond to a multiple or fraction of the number of at least one syringe retaining members **32** of the syringe **12**.

[0093] The one or more first and second locking elements **84**, **86** extend radially outward from the inner sidewall **80** of the second retaining ring **78** and are separated by one or more second recesses **88**. The one or more second recesses **88** are configured to receive the one or more lugs **34** of the syringe **12** when the insertion section **30** of the syringe **12** is inserted through the central opening **50** of the first retaining ring **48**. The one or more second recesses **88** are arranged around a circumference of the inner sidewall **80** of the second retaining ring **78** such that the one or more second recesses **88** may be selectively aligned with the one or more first recesses **60** on the first retaining ring **48**. For example, in an embodiment where the first retaining ring **48** has six first recesses **60** equally separated about the housing **70**, the second retaining ring **78** may also have six second recesses **88** equally separated apart (i.e., separated by 60 degrees) from the second recesses **88** adjacent on either side.

[0094] With reference to **FIG. 2B**, the one or more first locking elements **84** have a first inclined surface **90** configured for engaging at least the second surface **42** of the at least one

lug **34**. The first inclined surface **90** may be linear, segmented, curved, or a combination thereof. The one or more first locking elements **84** may have a second inclined surface **92** additionally configured to engage at least one of the point **44**, the first surface **40**, and/or the second surface **42** of the lugs **34**. Similarly, the one or more second locking elements **86** may have a second inclined surface **92** configured to engage at least one of the point **44**, the first surface **40**, and/or the second surface **42** of the lugs **34**. The second inclined surface **92** may be linear, segmented, curved, or a combination thereof. The first inclined surface **90** on the one or more second locking elements **86** may transition to a linear top surface **94** that is substantially parallel to a top surface of the second retaining ring **78**. The angle and profile of the first inclined surface **90** of the one or more first locking elements **84** may be the same as or different than the second inclined surface **92** of the locking elements **84** and **86**. In some embodiments, only a first inclined surface **90** may be provided in linear, segmented, curved, or combination form.

[0095] With continuing reference to **FIGS. 2C-2B**, the one or more first locking elements **84** may extend higher along the inner sidewall **80** relative to the one or more second locking elements **86**. The linear top surface **94** of the one or more second locking elements **86** may be positioned lower relative to the top of the one or more first locking elements **84** in order to accommodate the relative sliding movement of one or more locking tabs **96** extending proximally from the first retaining ring **48**. The one or more locking tabs **96** define a rotational stop surface for one or more lugs **34** once the syringe **12** is inserted into the syringe port **16**. In other embodiments, the one or more locking tabs **96** may be provided separately from the one or more second locking elements **86**. In some embodiments, the one or more locking tabs **96** may be provided on the syringe and/or at least one of the lugs **34**, as described herein.

[0096] With reference to **FIG. 2D**, the second retaining ring **78** is rotatably retained within the housing **70**. At least one guide pin **98** extends in a proximal direction from a bottom surface of the second retaining ring **78**. The at least one guide pin **98** is received inside at least one guide pin slot **101** formed on the bottom **82** of the housing **70**. The at least one guide pin slot **101** may extend over a portion of a circumference of the bottom **82** (see **FIG. 2A**). At least one elastically resilient member **102** (shown in **FIG. 2A**), such as a spring, is connected to or in contact with at least a portion of the second retaining ring **78** and with at least a portion of the housing **70**. In one embodiment, the elastically resilient member **102**

may be connected to or in contact with at one end of the at least one guide pin **98**, while the opposing end of the elastically resilient member **102** may be connected to or in contact with an end of the at least one guide pin slot **101**. The at least one elastically resilient member **102** (shown in **FIG. 2A**) urges the second retaining ring **78** to a first position (see **FIG. 2B**) wherein the one or more first recesses **60** are not aligned with the one or more second recesses **88**. By inserting the syringe **12** into the syringe port **16**, the one or more lugs **34** engage the one or more first and second locking elements **84**, **86** to rotate the second retaining ring **78** to a second position and allow the insertion of the one or more lugs **34** into the one or more second recesses **88**, as described herein.

[0097] To insert the syringe **12** into the syringe port **16**, the insertion section **30** of the syringe **12** is urged into contact with the first retaining ring **48**. If the lugs **34** are initially misaligned relative to the first recesses **60**, guiding surfaces, for example the point **44** and/or at least one first surface **40** and/or at least one second surface **42** on the one or more lugs **34** and the guiding surfaces **62**, **65** on the locking mechanism **35**, guide the lugs **34** toward self-alignment with the first recesses **60** as the insertion section **30** is moved proximally relative to the retaining ring **48**. Continued proximal movement of the syringe **12** relative to the first retaining ring **48** causes the lugs **34** to be guided into the first recesses **60** until at least a portion of one or more of the lugs **34** is brought into contact with the one or more first and second locking elements **84**, **86** of the second retaining ring **78**. The first and second inclined surfaces **90**, **92** are configured for engaging at least one of the lug **34** surfaces **40**, **42**, or the point **44**. Continued proximal movement of the syringe **12** relative the first retaining ring **48** causes the lugs **34** to exert a proximally directed force on the first and/or second inclined surfaces **90**, **92** and thus on second retaining ring **78**. As the second retaining ring **78** is prevented from moving proximally by the housing **70** and because of the slope or taper on the first and second inclined surfaces **90**, **92** and/or the point **44** and/or at least one first surface **40** and/or at least one second surface **42** on the lug **34**, the proximal movement creates a force which has a component in the rotational direction which acts against the restoring force of the at least one elastically resilient member **102** to rotate the second retaining ring **78** from the first position shown in **FIG. 2B** to a second position where the one or more first recesses **60** are aligned with the one or more second recesses **88**. In this embodiment, the point **44** and/or at least one first surface **40** and/or at least one second surface **42** on the lug **34** are the opening surfaces which force open the locking or attachment mechanism **35**. The one or

more lugs 34 may cause the second retaining ring 78 to rotate in the first direction, such as a clockwise or a counterclockwise direction. As the second retaining ring 78 is rotated during a proximal movement of the syringe 12 within the syringe port 16, the one or more lugs 34 are guided into the corresponding one or more second recesses 88 until the point 44 of the lugs 34 engages a bottom or stop surface of the one or more second recesses 88. As the operator releases the syringe 12, under the restoring action of the elastically resilient member 102, the second retaining ring 78 is rotated in the second direction, which is opposite to the first direction, from the second position back to the first position. According to certain embodiments, rotation of the second retaining ring 78 relative to the housing 70 causes the syringe 12 to rotate therewith until the one or more lugs 34 are secured behind one or more retention surfaces 64 of the first retaining ring 48 and engage the one or more locking tabs 96. In this example embodiment, the first surface 40 is the rotational stop surface which interacts with locking tab 96. In some embodiments, movement of the second retaining ring 78 may be limited by the position of the one or more guide pins 98 within the one or more guide pin slots 101. Alternatively, one or more first and second locking elements 84, 86 of the second retaining ring 78 could interact with one or more elements on first retaining ring 48, for example an extension of one or more locking tabs 96 to limit the rotation of the second retaining ring 78. As the second retaining ring 78, along with the syringe 12, is rotated to the first position, the one or more second recesses 88 are offset relative to the one or more first recesses 60 such that removal of the syringe 12 in the distal direction is prevented by one or more retention surfaces 64 of the first retaining ring 48 interacting with one or more base surfaces 38 of one or more lugs 34.

[0098] In another embodiment, the elastically resilient member 102 continues to exert a torque to close or hold the lug 34 against locking tab 96. In some embodiments, second inclined surface 92 continues to be urged against the second surface 42 of the lug 34. In such embodiments, because the syringe 12 can rotate no further, the force between the two surfaces urges the syringe 12 distally, pushing the one or more base surfaces 38 against the one or more retention surfaces 64. This has the benefit of taking up the mechanical slack, slop, or clearances that are needed to allow free motion of the syringe 12 during installation and removal. The strength of the torque, the slopes/tapers of the surfaces, and the friction involved can be adjusted to lock the syringe 12 tightly enough that minimal reverse or proximal motion will happen during the filling of a syringe 12. An audible and/or tactile

feedback may be provided when the syringe 12 is seated and locked within the syringe port 16. The audible and/or tactile feedback may be generated by an interaction of any surface on the syringe 12 with a corresponding surface on the syringe port 16 when the syringe 12 is in the locked position. For example, audible and/or tactile feedback may be generated by an interaction of at least one surface on the lug 34, such as the point 44 and/or at least one first surface 40 and/or at least one second surface 42, with at least a portion of the locking mechanism 35. The rotation of the syringe 12 due to the force of the elastically resilient member 102 during engagement may produce a tactile feedback.

[0099] To unlock and remove the syringe 12 from the syringe port 16, the syringe 12 is rotated relative to the first retaining ring 48 about the central axis 59 against the restoring force of the elastically resilient member 102. For example, if the syringe 12 is locked within the syringe port 16 by rotating the syringe 12 in a clockwise direction, the syringe 12 may be unlocked by rotating the syringe 12 in a counterclockwise direction. Rotation of the syringe 12 aligns the second recesses 88 with the first recesses 60. The syringe 12 can then be removed/ejected from the syringe port 16 by movement of the syringe 12 in a distal direction. In the process of turning the syringe 12 and thus rotating the second retaining ring 78 against the force of the elastically resilient member 102, the at least one second surface 42 or the point 44 on the syringe 12 and the first and/or second inclined surface 90, 92 on the second retaining ring 78 interact to create a distally directed force on the syringe 12 to eject/urge the syringe 12 out of syringe port 16. When a syringe 12 is released, unlatched, or disengaged, the syringe 12 is free to be removed or pulled from the syringe port 16 by the user. In some embodiments of the present disclosure, when the syringe 12 is released from the syringe port 16, there is an axial force ejecting, pushing, urging or moving the syringe 12 distally out of the syringe port 16 without any guidance or effort by the technician. In certain embodiments, this force or motion may not necessarily be sufficient to fully eject the syringe 12 all the way out of the syringe port 16, however, the force or motion may be sufficient so that the user has a tactile indication or feedback that the rotation is sufficient for release and the syringe 12 may be more readily removed from the syringe port 16. For example, rotation of the syringe barrel 18 may cause the point 44 on the lug 34 to slide along the surface in a distal direction along the surface of the first and/or second inclined surface 90, 92 on the second retaining ring 78. When the base surface 38 of the one or more lugs 34 clears the corresponding one or more retention surfaces 64 on the second retaining ring 78, the distally directed force causes

the syringe 12 to be urged distally and, if allowed, be ejected to a first position out of the syringe port 16, indicating to the operator that the syringe 12 has been fully released and can be removed from the syringe port 16. As the syringe 12 is removed from the syringe port 16, the restoring force of the elastically resilient member 102 causes the second retaining ring 78 to return to the first position for a subsequent insertion of the new syringe 12. In the embodiment shown in FIGS 2A-2D, the syringe 12 may be rotated 30 degrees or less about the longitudinal axis 15 to disengage the syringe 12 for removal from the syringe port 16.

[00100] The operation of the locking mechanism 35 can be further explained through the interaction of the retention surfaces of the syringe 12 and syringe port 16 that cooperate to retain the syringe 12 in the syringe port 16 once one or more of the base surfaces 38 of the syringe 12 is engaged with the one or more retention surfaces 64 of the first retaining ring 48. The guiding surfaces of the syringe 12 and syringe port 16 that cooperate to self-align or automatically rotationally align the syringe 12 and the syringe port 16 for self-oriented installation of the syringe 12 include the one or more second surfaces 42 and/or point 44 of the syringe 12 and the one or more guiding surfaces 65 of the syringe port 16. The opening surfaces of the syringe 12 and syringe port 16 that cooperate to open the syringe port 16 for the installation of the syringe 12 include the one or more second surfaces 42 of the syringe 12 and one or more of the first and/or second inclined surfaces 90, 92 of the syringe port 16. The tightening surfaces of the syringe 12 and syringe port 16 that cooperate to take up the mechanical slack or tolerances include one or more surfaces 38, 40, 42 of the syringe 12 and/or surfaces 64, 96, 90, 92 of syringe port 16. The detachment surfaces of the syringe 12 and syringe port 16 that cooperate to disengage or remove the syringe 12 from the syringe port 16 include surfaces 42 of the syringe 12 and surfaces 90, 92 of the syringe port 16. The ejection surfaces of the syringe 12 and syringe port 16 that cooperate to create a distally directed force to urge ejection of the syringe 12 from syringe port 16 include the second surfaces 42 of the syringe 12 and second inclined surfaces 92 of the syringe port 16. The rotational stop surfaces of the syringe 12 and syringe port 16 that cooperate to prevent rotation as a luer connector is screwed onto the syringe 12 include the one or more first surfaces 40 of the syringe 12 and the one or more locking tabs 96 of the syringe port 16, as well as any frictional force between the one or more base surfaces 38 of the syringe 12 and the one or more retention surfaces 64 of the syringe port 16. The syringe clearance surface(s), which allow the syringe to fit into the syringe port 16, include outer surface 21 of

the barrel **18** on one radially adjacent side (left or right) of the lug **34** which clear the sidewall **58** of the first retaining ring **48**.

[00101] With reference to **FIGS. 3A-3B**, a connection interface **100** for loading and removing the at least one syringe **12** from the at least one syringe port **16** of the injector **10** is shown in accordance with another embodiment. The syringe **12** and the injector **10** include the connection interface **100** having at least one syringe retaining member **32** provided on the syringe **12** and a corresponding locking mechanism **35** provided on the syringe port **16** of the injector **10**.

[00102] With reference to **FIGS. 3A-3B**, the syringe **12** generally has a cylindrical syringe barrel **18** formed from glass or a suitable medical-grade plastic. The barrel **18** has a proximal end **20** and a distal end **24**, with a substantially cylindrical sidewall **19** (shown in **FIG. 3B**) extending therebetween along a length of a longitudinal axis **15** extending through a center of the barrel **18**. A nozzle **22** extends from the distal end **24** of the barrel **18**. The barrel **18** has an outer surface **21** and an inner surface **23** (shown in **FIG. 3B**) that defines an interior volume **25** (shown in **FIG. 3B**) configured for receiving a medical fluid therein.

[00103] A drip flange **36** may optionally extend radially outward from the outer surface **21** of the syringe barrel **18** relative to the longitudinal axis **15**. The drip flange **36** may extend around at least a portion of the outer circumference of the barrel **18**. In one embodiment, the drip flange **36** is positioned distally along the longitudinal axis **15** relative to the syringe retaining member **32**. The drip flange **36** may be configured to prevent fluid that drips from the nozzle **22** from entering the syringe port **16** on the injector **10**. In this manner, the drip flange **36** helps reduce the amount of fluid that may enter the syringe port **16** and jam or interfere with the connection interface **100** and/or the interior mechanics and electronics of the injector **10** (shown in **FIG. 1A**). In some embodiments, the drip flange **36** defines a stop surface that delimits the insertion section **30** of the syringe **12**. The drip flange **36** may be formed integrally with the barrel **18** or it may be affixed or otherwise secured to the outer surface **21** of the barrel **18** using, for example, a frictional fit and/or an adhesive. In other embodiments, the drip flange **36** may be formed on the outer surface **21** of the barrel **18** by etching, laser cutting, machining, or molding.

[00104] With continued reference to **FIGS. 3A-3B**, the proximal end **20** of the syringe **12** is sized and adapted to be inserted in the syringe port **16** of the injector **10** (shown in **FIG. 1A**). In some embodiments, the proximal end **20** of the syringe **12** defines an insertion

section 30 that is configured to be removably inserted into the syringe port 16 of the injector 10 while the remaining portion of the syringe 12 remains outside of the syringe port 16. One or more syringe retaining members 32 are provided on or near the proximal end 20 of the syringe barrel 18 as described herein, for forming a locking engagement with a corresponding locking mechanism 35 in the syringe port 16 according to the embodiment shown in FIGS. 3A-3B. For example, the one or more syringe retaining member 32 may be provided on an outer surface 21 of the syringe barrel 18. The syringe retaining member 32 may be formed integrally with the barrel 18 or it may be affixed or otherwise secured to the outer surface 21 of the barrel 18 using, for example, a frictional fit, welding, and/or an adhesive. In other embodiments, the syringe retaining member 32 may be formed on the outer surface 21 of the barrel 18 by etching, laser cutting, machining, or molding. The combination of the syringe 12 having the one or more syringe retaining members 32 and the locking mechanism 35 of the injector 10 (shown in FIG. 1A) defines a connection interface for loading and unloading of the syringe 12 to and from the injector 10. In some embodiments, the one or more syringe retaining members 32 cooperate with at least a portion of the locking mechanism 35 to self-orient the syringe 12 relative to the syringe port 16 such that the syringe 12 may be releasably locked with the syringe port 16.

[00105] In the embodiment shown in FIGS. 3A-3B, the at least one syringe retaining member 32 is formed as one or more first lugs 34 and optionally one or more second lugs 37 that protrude radially outwardly from the outer surface 21 of the syringe barrel 18 relative to the longitudinal axis 15. The one or more first lugs 34 and/or one or more second lugs 37 protrude radially outwardly from the outer surface 21 of the barrel 18 in a direction substantially perpendicular to the outer surface 21. In embodiments where more than two first and/or second lugs 34, 37 are provided, the first and second lugs 34, 37 may be evenly or unevenly spaced apart in a radial direction about an outer circumference of the barrel 18. In such embodiments, the first and second lugs 34, 37 are separated from each other by portions of the outer surface 21 of the barrel 18. Together, each first or second lug 34, 37 and the outer surface 21 of the barrel 18 on one radially adjacent side (left or right) of the first or second lug 34, 37 define the syringe retaining member 32. In some embodiments, a plurality of first and/or second lugs 34, 37 may be clustered and separated radially about the circumference of the barrel 18 from one or more adjacent clusters of first or second lugs 34, 37. For example, in an embodiment with six syringe retaining members 32 having equal

angular separation therebetween, each syringe retaining member **32** extends over 60 degrees and is therefore separated by 60 degrees from the syringe retaining member **32** adjacent on either side. In such an embodiment, each first or second lug **34**, **37** may extend over 30 degrees of the circumference of the barrel **18**, while the portion of the outer surface **21** of the barrel **18** that defines the remainder of the syringe retaining member **32** extends over the remaining 30 degrees of the circumference. In other embodiments, each first or second lug **34**, **37** may extend over more than 30 degrees or less than 30 degrees of the circumference of the barrel **18**. In some embodiments, the syringe retaining members **32** may have unequal angular extension and/or unequal angular spacing between the syringe retaining members **32** about the outer circumference of the barrel **18**. The one or more first lugs **34** are offset longitudinally along the longitudinal axis **15** relative to the one or more second lugs **37**. In one embodiment, the one or more first lugs **34** are positioned closer to the proximal end **20** than the one or more second lugs **37**. In other embodiments, one or more first lugs **34** are aligned longitudinally with the one or more second lugs **37** along the longitudinal axis **15** such that at least a portion of the one or more first lugs **34** is at a same longitudinal distance from the proximal end **20** as at least a portion of the one or more second lugs **37**. In an embodiment in which one or more lugs **34** or **37** are absent, the corresponding retaining member **32** may be defined as the clearance surface(s), which is the outer surface **21** of the barrel **18** between adjacent lugs **34**, **37**. While embodiments having each syringe retaining member **32** extending over 60 degrees are exemplified in the attached drawings, syringes with retaining members **32** having other angles of separation, for example $360/x$ degrees where x is value from 1 and 36, are also within the scope of the present disclosure.

[00106] With continuing reference to **FIG. 3A**, each of the one or more first lugs **34** may have a generally triangular, polygonal, or arrowhead shape or alternatively may be shaped according to **FIGS. 5A-Z** or **10A-H**. Each of the one or more first lugs **34** has a base surface **38** that may be substantially perpendicular to the longitudinal axis **15** of the barrel **18**. In some embodiments, the base surface **38** may be angled relative to the direction of the longitudinal axis **15** in a radial cross-sectional plane. In other embodiments, the base surface **38** may be angled relative to the direction of the longitudinal axis **15** as it extends around the outer circumference of the barrel **18** in a radial cross-sectional plane. The base surface **38** may be planar, segmented, arcuate, curved, or a combination thereof. In some embodiments, the base surface **38** may have a plurality of individual sections that together define the base

surface **38**. The plurality of individual sections of the base surface **38** may define a surface that may be planar, segmented, arcuate, curved, or a combination thereof.

[00107] In certain embodiments, at least one first surface **40** may extend on one end of the base surface **38** in a direction substantially parallel to the longitudinal axis **15**. In some embodiments, at least one first surface **40** may be tapered axially relative to the longitudinal axis **15** in a proximal or a distal direction of the longitudinal axis **15**. The axial tapering of the at least one first surface **40** relative to the longitudinal axis **15** may be defined as an angle of inclination of the first surface **40** in a cylindrical plan projection view in a direction from the distal end **24** toward the proximal end **20**. The at least one first surface **40** may be directly connected with the base surface **38**. In some embodiments, at least one first surface **40** may be disconnected from the base surface **38**. The at least one first surface **40** may be planar, segmented, arcuate, curved, or a combination thereof. In some embodiments, the at least one first surface **40** may have a plurality of individual sections that together define the at least one first surface **40**. The plurality of individual sections of the at least one first surface **40** may define a surface that may be planar, segmented, arcuate, curved, or a combination thereof.

[00108] At least one second surface **40'** may extend on one end of the base surface **38** opposite the first surface **40** in a direction substantially parallel to the longitudinal axis **15**. In some embodiments, at least one second surface **40'** may be tapered axially relative to the longitudinal axis **15** in a proximal or a distal direction of the longitudinal axis **15**. The axial tapering of the at least one second surface **40'** relative to the longitudinal axis **15** may be defined as an angle of inclination of the first surface **40** in a cylindrical plan projection view in a direction from the distal end **24** toward the proximal end **20**. The at least one second surface **40'** may be directly connected with the base surface **38**. In some embodiments, at least one second surface **40'** may be disconnected from the base surface **38**. The at least one second surface **40'** may be planar, segmented, arcuate, curved, or a combination thereof. In some embodiments, the at least one second surface **40'** may have a plurality of individual sections that together define the at least one second surface **40'**. The plurality of individual sections of the at least one second surface **40'** may define a surface that may be planar, segmented, arcuate, curved, or a combination thereof.

[00109] In some embodiments, at least one third surface **42** extends from one end of the second surface **40'** to the end of the first surface **40**. The at least one third surface **42** may be

tapered axially relative to the longitudinal axis **15** in a proximal or a distal direction of the longitudinal axis **15**. In some embodiments, at least one third surface **42** may be tapered axially relative to the longitudinal axis **15** in a proximal direction. The axial tapering of the at least one third surface **42** relative to the longitudinal axis **15** may be defined as an angle of inclination of the at least one third surface **42** in a cylindrical plan projection view in a direction from the distal end **24** toward the proximal end **20**. The at least one third surface **42** and the at least one first surface **40** may join together at a rounded or a sharp point **44**. The at least one third surface **42** may be directly connected with at least one of the first surfaces **40** at the point **44**. In some embodiments, at least one third surface **42** may be disconnected from at least one of the first surfaces **40** at the point **44**. In some embodiments, the point **44** may be disconnected from the at least one third surface **42** and the first surface **40**. The at least one third surface **42** may be planar, segmented, arcuate, curved, or a combination thereof. In some embodiments, the at least one third surface **42** may have a plurality of individual sections that together define the at least one third surface **42**. The plurality of individual sections of the at least one third surface **42** may define a surface that may be planar, segmented, arcuate, curved, or a combination thereof.

[00110] The base surface **38** and the first, second, and third surfaces **40**, **40'**, **42** define a top surface **46** of each of the one or more first lugs **34**. In some embodiments, the top surface **46** may be shaped to correspond to the curvature of the syringe barrel **18**. In other embodiments, the top surface **46** of one or more of the lugs **34** may be angled relative to the outer surface **21** of the syringe barrel **18** such that a first end of the top surface **46** is higher than a second end of the top surface **46** relative to the syringe barrel **18**. The top surface **46** may be continuous and uninterrupted, or it may be comprised of a plurality of separate surfaces that together define the top surface **46**. The top surface **46** may be planar, segmented, arcuate, curved, or a combination thereof.

[00111] Each of the one or more second lugs **37** may be formed as a projection that extends radially outward from the outer surface **21** of the barrel **18**. The one or more second lugs **37** optionally have an inclined release member **104** that extends from the outer surface **21** of the barrel **18** to the top surface **106** of the at least one second lug **37** in a direction of the circumference of the barrel **18**. If present, the inclined release member **104** may facilitate the molding of the syringe **12** in a simple two part mold. In some embodiments, the top surface **106** may be shaped to correspond to the curvature of the syringe barrel **18**. In other

embodiments, the top surface **106** may be angled relative to the outer surface **21** of the syringe barrel **18**. The top surface **106** may be continuous and uninterrupted, or it may be comprised of a plurality of separate surfaces that together define the top surface **106**. The top surface **106** may be planar, segmented, arcuate, curved, or a combination thereof. The release member **104** may be configured to engage a third retaining ring **108** to release the syringe **12** from the syringe port **16**, as described herein.

[00112] With continuing reference to **FIG. 3A**, the at least one syringe port **16** of the injector **10** (shown in **FIG. 1A**) has a locking mechanism **35** configured to operatively engage the at least one syringe retaining member **32** of the syringe **12**. The locking mechanism **35** includes a housing **70** having a substantially circular shape with a central opening **71** configured to receive the proximal end **20** of the syringe **12**. The housing **70** may be formed as part of the housing **14** of the injector **10** (shown in **FIG. 1A**) or as a fitted attachment of the housing **14** of the injector **10**. A first retaining ring **48** is secured to a distal end of the housing **70** such that the central opening **71** of the housing **70** is aligned with a central opening **50** of the first retaining ring **48**. The first retaining ring **48** has a body **72** having a radially extending flange **74**. At least a portion of the body **72** extends away from the flange **74** in a proximal direction. When installed on the housing **70**, the flange **74** engages a top portion of the housing **70** and is secured by one or more fasteners (not shown) extending through one or more fastener openings **76**. At least a portion of the body **72** of the first retaining ring **48** is inserted into the central opening **71** of the housing **70**. In other embodiments, the first retaining ring **48** may be secured to the housing **70** by other mechanical fastening arrangement, such as a clip or snap fit. When installed on the housing **70**, the central axis **59** of the first retaining ring **48** is coaxial with a central axis of the housing **70**.

[00113] With continuing reference to **FIG. 3A**, an inner portion of a sidewall **58** within the central opening **50** of the first retaining ring **48** has one or more first recesses **60** that are configured to receive the one or more first lugs **34** of the syringe **12** when the insertion section **30** of the syringe **12** is inserted through the central opening **50** of the first retaining ring **48**. The one or more first recesses **60** may be evenly spaced about the inner circumference of the sidewall **58**. In such embodiments, the first recesses **60** are separated from each other by portions of the sidewall **58** of the first retaining ring **48**. Together, each first recess **60** and the sidewall **58** of the first retaining ring **48** on one radially adjacent side

(left or right) of the first recess 60 define a clearance space 63 for receiving the syringe retaining member 32 on the syringe 12. The first recess 60 of each clearance space 63 may be configured to receive at least one first lug 34 or the second lug 37 of the syringe retaining member 32, while the sidewall 58 of the first retaining ring 48 may be configured to receive a portion of the sidewall 19 of the barrel 18 when the syringe retaining member 32 is inserted into the clearance space 63. For example, in an embodiment where the first retaining ring 48 has six clearance spaces 63 equally separated about the circumference of the first retaining ring 48, each clearance space 63 is separated 60 degrees apart from the clearance spaces 63 adjacent on either side. In such embodiments, each first recesses 60 may extend over 30 degrees of the circumference of the first retaining ring 48 while the portion of the sidewall 58 of the first retaining ring 48 that defines the remainder of the clearance space 63 extends over the remaining 30 degrees of the circumference. In other embodiments, the first retaining ring 48 may include 1-5 or 7-12 or more clearance spaces 63 wherein each first recess 60 may extend over more than 30 degrees or less than 30 degrees of the circumference of the sidewall 58 of the first retaining ring 48. In some embodiments, the number of first and second lugs 34, 37 on the syringe 12 corresponds to the number of first recesses 60 on the retaining ring 48. In other embodiments, the number of first and second lugs 34, 37 on the syringe 12 is smaller than the number of first recesses 60 on the retaining ring 48. In such embodiments, the first and second lugs 34, 37 on the syringe 12 are spaced apart along an outer circumference of the syringe barrel 18 such that each first or second lug 34, 37 can be aligned with a corresponding first recess 60 on the retaining ring 48. In other embodiments, the number of first and second lugs 34, 37 on the syringe 12 is higher than the number of first recesses 60 on the retaining ring 48 such that more than one first and second lugs 34, 37 may be received within at least one first recess 60. For example, the first or second lug 34, 37 may be formed as a collection of lugs, either in one lug position or spread over two or more lug positions which operate together to perform one or more of the functions herein attributed to the first or second lugs 34, 37 or any surface thereof.

[00114] Each of the one or more first recesses 60 extends radially outward into the inner portion of the sidewall 58 relative to the central axis 59. The lateral surfaces of each first recess 60 define a travel path for guiding the movement of the first and second lugs 34, 37 in and out of the first recess 60 as the insertion section 30 of the syringe 12 is inserted into and out of the first retaining ring 48. Each first recess 60 extends substantially parallel along a

direction of the central axis **59**. In some embodiments, each first recess **60** may have one or more guiding surfaces **62** that guide the first and second lugs **34, 37** into self-alignment with the first recesses **60** such that the first and second lugs **34, 37** can be inserted into the first recesses **60** and self-align the syringe **12** within syringe port **16** without any guidance or effort by the technician. The guiding surfaces **62** may be inclined to toward an opening of the first recess **60** to guide the movement of the first and second lugs **34, 37**. In this manner, the one or more first and second lugs **34, 37** which may be initially misaligned relative to the corresponding one or more recesses **60** are brought in self-alignment with the one or more recesses **60** by the one or more guiding surfaces **62**.

[00115] With continued reference to the embodiment in **FIG. 3A**, the locking mechanism **35** further includes a second retaining ring **78** having a substantially annular shape with an inner sidewall **80**. The second retaining ring **78** is disposed within the central opening **71** of the housing **70** between a proximal end of the body **72** of the first retaining ring **48** and a bottom **82** of the housing **70**. As detailed further herein, the second retaining ring **78** is rotationally movable and axially fixed relative to the first retaining ring **48** and the housing **70**. The second retaining ring **78** has one or more second recesses **88**. The one or more second recesses **88** are configured to receive the one or more first and second lugs **34, 37** of the syringe **12** when the insertion section **30** of the syringe **12** is inserted through the central opening **50** of the first retaining ring **48**. The one or more second recesses **88** are arranged around a circumference of the inner sidewall **80** of the second retaining ring **78** such that the one or more second recesses **88** are aligned with the one or more first recesses **60** on the first retaining ring **48**. For example, in an embodiment where the first retaining ring **48** has six first recesses **60**, the second retaining ring **78** may also have six second recesses **88** separated 60 degrees apart each other. The rotational movement of the second retaining ring **48** may be guided and constrained by one or more proximal pins **98'** and/or one or more elastically resilient members **102'** housed in one or more slots in housing **70**.

[00116] With continued reference to **FIG. 3A**, the locking mechanism **35** may further include a third retaining ring **108** having a substantially annular shape with an inner sidewall **110**. The third retaining ring **108** is disposed within the central opening **71** of the housing **70** between the first retaining ring **48** and the second retaining ring **78**. As detailed further herein, the third retaining ring **108** is rotatable relative to the first retaining ring **48**, the second retaining ring **78**, and the housing **70**, which are all fixed relative to each other. The

third retaining ring **108** has one or more locking elements **112** disposed on at least a portion of the inner sidewall **110**. The one or more locking elements **112** extend radially outward relative to the inner sidewall **110** and are arranged in an alternating manner such that each locking element **112** is separated by a third recess **114**.

[00117] The one or more locking elements **112** have an inclined surface **116** configured for selectively engaging the third surface **42** of the one or more first lugs **34**. The inclined surface **116** may be linear, segmented, curved, or a combination thereof.

[00118] With continued reference to **FIG. 3A**, the third retaining ring **108** is rotatably retained within the housing **70**. At least one guide pin **98** extends from the third retaining ring **108** and is received inside at least one guide pin slot **101** (not shown) formed on one or both of the first and second retaining rings **48, 78**. At least one elastically resilient member **102**, such as a spring, is connected at one end to at least a portion of the third retaining ring **108** and to at least a portion of one or both of the first and second retaining rings **48, 78**. In one embodiment, the elastically resilient member **102** may be connected at one end to the at least one guide pin **98**, while the opposing end of the elastically resilient member **102** may be connected to the at least one guide pin slot **101**. The at least one elastically resilient member **102** urges the third retaining ring **108** to a first position. By inserting the syringe **12** into the syringe port **16** in a proximal direction, the opening surface, in this embodiment the third surface **42** of one or more lugs **34**, engages the one or more locking elements **112** to rotate the third retaining ring **108** to a second position where the at least one third recess **114** is aligned with at least one first recess **60** and at least one second **88**. Once the second surface **40'** on the first lug **34** clears the inclined surface **116** of the locking element **112**, the third retaining ring **108** rotates in the opposite direction back to its initial first position and locks the syringe **12** within the syringe port **16** where base surface **38** is retained proximal to locking element **112**, as described herein. An audible and/or tactile feedback may be provided when the syringe **12** is locked within the syringe port **16**, for example by the movement of the third retaining ring **108** to the first position.

[00119] To insert the syringe **12** into the syringe port **16**, the insertion section **30** of the syringe **12** is urged into contact with the first retaining ring **48**, such as shown in **FIG. 3D**. If the first and second lugs **34, 37** are initially misaligned relative the first recesses **60**, the guiding surfaces **65** guide the first and second lugs **34, 37** toward self-alignment with the first recesses **60** as the insertion section **30** is moved proximally relative to the first retaining ring

48. Continued proximal movement of the syringe 12 relative the first retaining ring 48 causes the first and second lugs 34, 37 to be guided within the first recesses 60 until at least a portion of the third surface 40' of one or more of the first lugs 34 is brought into contact with the inclined surface 116 of the one or more locking elements 112 of the third retaining ring 108. The inclined surface 116 is configured for engaging the second surface 40' of the first lugs 34. As shown in FIG. 3D, continued proximal movement of the syringe 12 relative the first retaining ring 48 causes the first lugs 34 to act against the restoring force of the at least one elastically resilient member 102 to rotate the third retaining ring 108 from the first position shown in FIG. 3D to a second position shown in FIG. 3E. The one or more first lugs 34 may cause the third retaining ring 108 to rotate in a first direction, such as a clockwise or a counterclockwise direction. As the third retaining ring 108 is rotated during a proximal movement of the syringe 12 within the syringe port 16, the one or more first lugs 34 and second lugs 37 are guided into the corresponding one or more second recesses 88 until the base surface 38 of all the first and second lugs 34, 37 clear the bottom portion of the third retaining ring 108. Under the restoring action of the elastically resilient member 102, the third retaining ring 108 is rotated in a second direction which is opposite to the first direction. Rotation of the third retaining ring 108 relative to the housing 70 causes the locking elements 112 to be positioned over the one or more first and second lugs 34, 37 such that removal of the syringe 12 in the distal direction is prevented.

[00120] To unlock the syringe 12 from the syringe port 16, the syringe 12 is rotated in a first direction around the longitudinal axis 15, as shown in FIG. 3F. The rotational movement of the syringe 12 causes the third surface 42 of the first lugs 34 to bear against the first inclined surface 90 of the second retaining ring 78 and rotate the second retaining ring 78 against the force of its resilient member 102' (shown in FIG. 2A). After a rotation, for example of approximately 30 degrees, the guide pin 98 on the second retaining ring 78 engages the third retaining ring 108 to cause it to also rotate in the first direction. After additional rotation, for example approximately another 30 degrees of rotation, the first and second lugs 34, 37 line up with the first recesses 60 of the first retaining ring 48, and the locking elements 112 on the third retaining ring 108 move away to clear the space proximal to the first recesses 60 such that the at least one first recesses 60 are aligned with the at least one third 114, as shown in FIG. 3G. At this point, the distally directed force component created by the rotational movement of the third surface 42 of the first lugs 34 against the first

inclined surface **90** causes the syringe **12** to move distally and eject from the syringe port **16**, as shown in **FIG. 3H**. As the syringe **12** is ejected from the syringe port **16**, the restoring force of the elastically resilient members **102** and **102'** cause the third retaining ring **108** and the second retaining ring **78** to return to their respective first positions by rotating in a second direction in preparation for a subsequent insertion of a new syringe **12**.

[00121] The operation of the locking mechanism **35** can be further discussed with reference to the retention surfaces of the syringe **12** and syringe port **16** that cooperate to retain the syringe **12** in the syringe port **16** once it is engaged are one or more base surfaces **38** and top surfaces **106** of the syringe **12** and the one or more surfaces of the locking elements **112** of the syringe port **16**. The guiding surfaces of the syringe **12** and syringe port **16** that cooperate to self-align or automatically rotationally align the syringe **12** and the syringe port **16** for installation are the one or more points **44** and/or third surfaces **42** of the syringe **12** and the one or more guiding surfaces **65** of the syringe port **16**. The opening surfaces of the syringe **12** and syringe port **16** that cooperate to open the syringe port **16** for the installation of the syringe **12** are the one or more third surfaces **42** of the syringe **12** and one or more of the inclined surfaces **116** of the syringe port **16**. The detachment surfaces of the syringe **12** and syringe port **16** that cooperate to disengage or remove the syringe **12** from the syringe port **16** are the third surfaces **42** of the syringe **16** and inclined surface **90** of the syringe port **16**. The ejection surfaces of the syringe **12** and syringe port **16** that cooperate to create a distally directed force to urge ejection of the syringe **12** from syringe port **16** are the third surfaces **42** of the syringe **16** and inclined surfaces **90** of the syringe port **16**. The rotational stop surfaces of the syringe **12** and syringe port **16** that cooperate to prevent rotation as a luer connector is screwed onto the syringe **12** are the one or more first surfaces **40** and/or second surfaces **40'** of the syringe **12** and the one or more second recesses **88** of the syringe port **16**, as well as any frictional force between the one or more base surfaces **38** of the syringe **12** and the one or more locking elements **112** of syringe port **16**. The syringe clearance surface(s), which allow the syringe to fit into the syringe port **16**, are outer surface **21** of the barrel **18** on one radially adjacent side (left or right) of the lug **34** which clear the sidewall **58** of the first retaining ring **48**.

[00122] The embodiment of the syringe port **16** of **FIGS. 3A–3H** has been described from the perspective that there are first recesses **60** cut into the sidewall **58** of the first retaining ring **48**. In another embodiment, the sidewall **58** can be considered to project from the

cylindrical surface defined by the first recesses **60** of the first retaining ring **48**. Each of these two configurations may be used to describe or be embodied in a single embodiment.

[00123] While **FIGS. 2A-3G** illustrate several non-limiting embodiment of the at least one syringe retaining member **32**, various other shapes are also contemplated. For example, the one or more first lugs **34** and/or second lugs **37** of the at least one syringe retaining member **32** may have a generally circular, square, rectangular, pentagonal, or any other polygonal shape. Various features may be provided on the at least one syringe retaining member **32** to help self-orient the syringe **12** relative to the syringe port **16** or to releasably lock the syringe **12** with the syringe port **16**. In each embodiment, the at least one syringe retaining member **32** is configured for forming a reversible locking engagement with a corresponding locking mechanism in the syringe port **16** of the injector **10** for retaining the syringe **12** in the syringe port **16**. Various other shapes for one or more lugs **34** of the at least one syringe retaining member **32** are discussed herein with reference to **FIGS. 4A-5Z** and **10A-10H**.

[00124] **FIGS. 4A-4L** show cylindrical plan projection views of various embodiments of the proximal end **20** of the at least one syringe **12** and a corresponding at least one syringe port **16** for receiving the proximal end **20** of the syringe **12**. With reference to **FIG. 4A**, an embodiment of the proximal end **20** of the syringe **12**, as generally illustrated in **FIG. 2A**, is rotationally aligned as shown by the dotted lines for insertion of the syringe **12** into the distal end of the syringe port **16**. From this perspective, when self-aligned, the syringe retaining members **32**, including the lugs **34** and the outer surface **21** of the barrel **18** located between the lugs **34** are configured to be received within the clearance space **63** of the syringe port **16** to allow insertion of the syringe **12** into the syringe port **16**. Similarly, the outer surface **21** of the syringe barrel **18** clears the sidewall **58** of the first retaining ring **48**. One way to measure or express the relationship between these elements is through the angle which they subtend on the outside of the syringe **12** and the inside of the syringe port **16**. For example, in an embodiment with the six fold symmetry of the syringe retaining members **32**, each lug **34** subtends a nominal angle of 30 degrees and each first recess **60** similarly subtends 30 degrees, of course with an allowance for clearance and tolerance so that the lug **34** can slide within the first recess **60**. Because the one or more locking tabs **96** extend over a finite angular extent, the base surface **38** of the lug **34** may not be positionable fully under the retention surface **64**. For example, if the lugs **34** and the first recesses **60** are both 30 degrees and locking tab **96** occupies an angle of 4 degrees, then the base surface **38** of the lug **34** will

overlap with the locking tab **96** over a surface of 26 degrees. To maximize the overlap, the lug **34** can be reduced to 28 degrees and the recess **60** can be increased in width to 32 degrees, including the 4 degrees of the locking tab **96**. Upon insertion, the entire width of the lug **34** may be positioned under the retention surface **64** adjacent the locking tab **96**. Each lug **34** is configured for being received within the first recess **60** on the first retaining ring **48**. The second surface **42** of each lug **34** may be self-guided into alignment with the first recess **60** along the guiding surface **65** to enable the insertion of the lug **34** into the first recess **60**. With reference to **FIG. 4K**, the second retaining ring **78** has first locking elements **84** and second locking elements **86** having a substantially rectangular shape with a recess **91** provided in one of the upper corners. The recess **91** is configured for guiding the second surface **42** of the lugs **34** into the second recess **88** as the lugs **34** are inserted into the syringe port **16**.

[00125] **FIG. 4B** shows another embodiment in which the number of lugs **34** is smaller than the number of recesses **60** on the syringe port **16**. If one or more lugs **34** are absent, the missing area is taken up by a larger area of the outer surface **21** of the syringe **12**. In some embodiments, at least two lugs **34** are provided, adjacent to each other, spaced around the barrel **18**, or on opposite sides of the barrel **18**, so that one of the lugs **34** will rotate against the corresponding locking tabs **96** for proper engagement of the syringe **12** within the syringe port **16**. Each lug **34** is configured for being received within the first recess **60** on the first retaining ring **48**. The second surface **42** of each lug **34** may be guided into alignment with the first recess **60** along the guiding surface **65** to enable the insertion of the lug **34** into the first recess **60**.

[00126] **FIG. 4C** shows another embodiment in which the one or more locking tabs **96** are formed on the top surface **38** of at least one of the lugs **34**. In other embodiments, the one or more locking tabs **96** may be formed separately from the lugs **34**. In other embodiments, locking tabs **96** may be provided on both the at least one lugs **34** of syringe **12** and at least one retaining member **58** of the syringe port **16**.

[00127] **FIG. 4D** shows a cylindrical plan projection view of an embodiment of the syringe **12** and syringe port **16** shown in **FIGS. 3A-3E**. **FIG. 4E** shows a further embodiment in which some, but not all, of the first and second lugs **34**, **37** have been removed. In **FIG. 4J**, the locking elements **112** on the third retaining ring **108** do not have the inclined surface **116** shown in **FIGS. 4D-4E**. Instead, a space **SS** is provided between

the locking elements 112 and the sidewall 58 for inserting the point 44 of the first lugs 34. In each of these embodiments, at least one first lug 34 is provided.

[00128] FIG. 4F shows another embodiment with eight fold symmetry. A benefit of higher symmetry arrangements is that a lower rotational angle of the syringe 12 is necessary for installation and removal. For example, with eight fold symmetry, the rotation of the syringe 12 for removal and ejection can be 22.5 degrees or less. The additional lugs also spread the holding or restraining force more evenly around the syringe barrel 18. In other embodiments, the connection between the syringe 12 and the syringe port 16 may have 8-fold, 10-fold, 12-fold, 16-fold, or any other symmetry.

[00129] With reference to FIG. 4G, the lugs 34 have a generally triangular shape with a pair of second surfaces 42 tapering axially to a point 44. The second surfaces 42 are configured to engage the guiding surfaces 65 on the first retaining ring 48 to self-guide the lugs 34 into the first recess 60. The second retaining ring 78 has second recesses 88 shaped correspondingly to receive the lugs 34. At least some of the first locking elements 84 have a ramp 89 to guide the lugs 34 toward the second recess 88 as the syringe 12 is inserted proximally within the syringe port 16. In FIG. 4H, the lugs 34 have a triangular shape with at least one surface that is substantially parallel to the longitudinal axis 15 (shown in FIG. 3A). The second retaining ring 78 has second recesses 88 shaped correspondingly to receive the lugs 34. In FIG. 4I, the lugs 34 have an integral locking tab 96.

[00130] FIGS. 5A-5Z illustrate various embodiments of the lug 34. FIG. 5A shows an example lug 34 having the configuration described herein with reference to FIGS. 2A-2D, while FIG. 5B illustrates an outline of the lug 34 with a dotted line indicating each of the surfaces of the lug 34.

[00131] FIG. 5C shows an example of a lug 34c in which the center section 612 is hollow and the lug 34c is defined by perimeter surfaces. In some embodiments, the center section 612 may have a thickness that corresponds to the thickness of the syringe barrel 18 (shown in FIG. 2A). In other embodiments, the center section 612 may have a thickness that is greater or less than the thickness of the syringe barrel 18 (shown in FIG. 2A). In some embodiments, the hollow center section 612 extends only through a portion of the sidewall thickness of the syringe barrel 18. The perimeter surfaces may be connected together or have one or more gap therebetween. One benefit of having a hollow center section 612 is that sinking of the plastic material can be reduced or eliminated as the material cools during

molding. With reference to **FIG. 5D**, one or more reinforcing members **614** may be provided in the center section **612**. The one or more reinforcing members **614** may be connected to or separated from the perimeter surfaces of the lug **34D**. In cases where the retention force needs to be high and thus there is significant stress on the surface of the lug **34D**, the presence of additional material or reinforcing members, for example one or more reinforcing members **614**, can allow the lug **34D** to operate under such higher forces. **FIG. 5E** shows a lug **34E** in which a plurality of voids **612''** are provided. In some embodiments, the voids **612''** may have a substantially circular shape; however, various other shapes may be readily implemented.

[00132] **FIG. 5F** illustrates a lug **34F** in which the second surfaces **42** are not physical surfaces but are virtual surfaces defined by the dashed lines extending between points **620** and **622**. These virtual surfaces taper axially in a manner described herein with reference to the first and second surfaces **40, 42** on the lug **34** shown in **FIGS. 2A** and **3A**.

[00133] According to certain embodiments, lug **34** may be a combination of a plurality of lugs that together form the surfaces of lug **34** which can be a combination of physical surfaces and/or virtual surfaces. **FIG. 5G** shows an embodiment where the lug **34G** is an assembly of a plurality of lugs **34G-1** to **34G-5**. As shown with the dotted lines in **FIG. 5G**, the functional surfaces of the lug **34G** are defined by the interaction of two or more of the lugs **34G-1** to **34G-5**. The second surfaces **42** are not physical surfaces but are virtual surfaces defined by the dashed lines extending between **34G-1** and **34G-2** and between **34G-4** and **34G-5**. These virtual surfaces taper axially in a manner described herein with reference to the first and second surfaces **40, 42** on the lug **34** shown in **FIG. 2A**.

[00134] **FIG. 5H** shows a lug **34H** having a pair of lugs **34H-1** and **34H-4**. In the embodiment of **FIG. 5H**, the base surface **38** and the first surfaces **40** are formed on the lug **34H-1**, while point **44** is a surface of lug **34H-2**. The second surfaces **42** are virtual surfaces formed between the two lugs **34H-1** and **34H-2**. These virtual surfaces taper axially in a manner described herein with reference to the first and second surfaces **40, 42** on the lug **34** shown in **FIG. 2A**.

[00135] **FIG. 5I** shows a lug **34I** having four lugs **34I-1** to **34I-2**. In the embodiment of **FIG. 5I**, the base surface **38** is formed on the lug **34I-1**, while point **44** is a surface of lug **34I-3**. The first surfaces **40** are virtual surfaces formed between **34I-1** and **34I-2**, and between **34I-2** and **34I-4**. The second surfaces **42** are virtual surfaces formed between **34I-2**

and 34I-3, and between 34I-3 and 34I-4. These virtual surfaces taper axially in a manner described herein with reference to the first and second surfaces 40, 42 on the lug 34 shown in FIG. 2A.

[00136] FIG. 5J shows a lug 34J having a T-shaped central lug 34J-1 and a pair of lateral lugs 34J-2 and 34J-3. In the embodiment of FIG. 5J, the base surface 38 is formed on the top surface of the lug 34J-1, while point 44 is on the bottom surface of the lug 34J-1. The first surfaces 40 are virtual surfaces formed between a top portion of 34J-1 and 34J-2, and between the top portion of 34J-1 and 34J-3. The second surfaces 42 are virtual surfaces formed between a bottom portion of 34J-1 and 34J-2, and between the bottom portion of 34J-1 and 34J-3. FIG. 5W shows a T-shaped lug 34W without the pair of lateral lugs shown in FIG. 5J. In FIG. 5W, the second surfaces 42 are virtual surfaces formed between the top portion of lug 34W and the bottom portion at the point 44. These virtual surfaces taper axially in a manner described herein with reference to the first and second surfaces 40, 42 on the lug 34 shown in FIG. 2A.

[00137] FIG. 5K shows a lug 34K having an upper lug 34K-1 and a lower lug 34K-2. In the embodiment of FIG. 5K, the base surface 38 is formed on the top surface of the lug 34K-1, while point 44 is represented by the lug 34K-2. A pair of first surfaces 40 extends along lateral portions of 34K-1 and 34K-2. The second surfaces 42 are virtual surfaces formed between a terminal portion of the first surfaces 40 and 34K-2. These virtual surfaces taper axially in a manner described herein with reference to the first and second surfaces 40, 42 on the lug 34 shown in FIG. 2A.

[00138] FIG. 5L shows a lug 34L having a shape similar to the shape of lug 34C described herein with reference to FIG. 5C. Lug 34L further has an integrated locking tab 96a extending from a portion of the base surface 38.

[00139] FIG. 5M shows a lug 34M having a substantially linear base surface 38 and curved first and second surfaces 40, 42. The first and second surfaces 40, 42 may be curved to have a substantially elliptical form. The first and second surfaces 40, 42 taper axially in a curvilinear form to point 44. FIG. 5N shows a lug 34N having a shape similar to that of lug 34M shown in FIG. 5M. The lug 34N is formed from an upper lug 34N-1 and a lower lug 34N-2. The upper lug 34N-1 defines a substantially linear base surface 38, while the lower lug 34N-2 is spaced apart from the upper lug 34N-1 by a gap and has a substantially curved shape that tapers axially inwardly along the second surfaces 42.

[00140] FIGS. 5O-5P show lugs 34O, 34P having a shape similar to the shape of lug 34C described herein with reference to FIG. 5C. Lugs 34O, 34P have at least one of the first or second surfaces 40, 42 removed such that lugs 34O, 34P have a discontinuous outline with at least one virtual second surface 42O extending between the point 44 and the first surface 40. This virtual second surface 42O tapers axially in a manner described herein with reference to the first and second surfaces 40, 42 on the lug 34 shown in FIG. 2A.

[00141] FIGS. 5Q shows a lug 34Q formed from three circular lugs 34Q-1 to 34Q-3. The circular lugs 34Q-1 to 34Q-3 are positioned such that virtual surfaces are defined therebetween. In particular, a pair of second virtual surfaces is defined by the pair of upper circular lugs 34Q-2 and 34Q-3 and the lower circular lug 34Q-1. The lugs 34Q-1 to 34Q-3 may have any other shape, such as oval, square, triangular, rhomboid, or other polygonal shape. Each virtual second surface 42 tapers axially in a manner described herein with reference to the first and second surfaces 40, 42 on the lug 34 shown in FIG. 2A. FIG. 5R shows a lug 34R having a shape formed from two circular lugs 34R-1 to 34R-2 with a single virtual second surface 42 defined therebetween. The lugs 34R-1 to 34R-2 may have any other shape, such as oval, square, triangular, rhomboid, or other polygonal shape. FIG. 5Y shows a lug 34Y formed from three circular lugs 34Y-1 to 34Y-3 where the upper pair of lugs 34Y-1 and 34Y-2 is closer axially to the lower lug 34Y-3 than in the lug embodiment 34Q described with reference to FIG. 5Q. In FIG. 5Z, the lower lug 34Z-3 of lug 34Z is represented as a rectangular element rather than a circular element.

[00142] With reference to FIGS. 5S(1)-5S(3), a pair of lugs 34SA and 34SB is provided on separate lugs 34 separated by the outer surface 21 of the barrel 18. On the first lug 34SA, a single lug 34S-1 is provided in an upper corner, for example the upper right corner of the outline of lug 34 where a virtual base surface 38 is joined with a virtual first surface 40. The first lug 34SA is configured to engage the locking tab 96 provided on the first retaining ring 48 of the locking mechanism 35 when the syringe 12 is inserted into the syringe port 16 (as shown in cylindrical plan projection FIG. 5S(3)). The second lug 34SB is formed as a single lug 34S-2 located at the point 44. The second lug 34SB is configured to self-orient and guide the syringe 12 into the syringe port 16 by engaging the guiding surface 65 on the first retaining ring 48. The lugs 34S-1 and 34S-2 may have a circular, oval, triangular, square, rectangular, or other polygonal shape.

[00143] With reference to **FIG. 5T**, the lug **34T** is formed as a rectangular second surface **42** that tapers axially from the base surface **38** to the point **44**. This second surface **42** tapers axially in a manner described herein with reference to the first and second surfaces **40**, **42** on the lug **34** shown in **FIG. 2A**.

[00144] With reference to **FIG. 5U**, the lug **34U** is shaped as a square lug having two sides aligned along the direction of tapered second surfaces **42**. **FIG. 5V** shows a triangular lug **34V** having two sides aligned along the direction of tapered second surfaces **42**. In other embodiments, lug **34V** may include at least one second lug defining the base surface **38**. The second surfaces **42** in **FIGS. 5T-5V** taper axially in a manner described herein with reference to the first and second surfaces **40**, **42** on the lug **34** shown in **FIG. 2A**.

[00145] **FIG. 5X** shows a lug **34X** having a plurality of parallel elements spaced apart horizontally relative to a vertical axis. A virtual second surface **42** is defined between at least two adjacent parallel elements. The second surface **42** in **FIG. 5X** tapers axially in a manner described herein with reference to the first and second surfaces **40**, **42** on the lug **34** shown in **FIG. 2A**. Some embodiments of syringe **12** may include various combinations of any of lugs **34A** through **34X** and/or **10A** through **10H** in the at least one syringe retaining members **32**.

[00146] With reference to **FIG. 6A**, a coupling **130**, including a mounting member therefor, can be fabricated to be separate from and attachable to the syringe barrel **18**. The coupling **130** can, for example, be configured to accept the syringe **12** having at least one syringe retaining member **32** described herein and to adapt the syringe **12** for use with a fluid injector having a syringe port with a locking mechanism not configured to receive the at least one syringe retaining member **32**. For example, the coupling **130** can adapt the syringe **12** for use with the fluid injector described in United States Patent No. 5,383,858 or United States Patent No. 6,652,489, or any other fluid injector. In some embodiments, the coupling **130** is releasably connectable to the injector. In other embodiments, the coupling **130** may be inserted into and retained in a locking mechanism of the fluid injector. The coupling **130** may also be releasably connected or attached to the syringe **12** independently of the attachment of the coupling to the injector.

[00147] With reference to **FIG. 6A**, the coupling **130** has a first portion **132** configured for receiving a syringe **12** having at least one syringe retaining member **32**, according to an embodiment described herein, and a second portion **134** configured for loading into an injector having a syringe port which is not configured to receive the syringe **12** having at least

one syringe retaining member **32** according to an embodiment described herein. The first portion **132** may be directly connected and monolithically formed with the second portion **134**. In some embodiments, the first portion **132** may be releasably connected to the second portion **134** such that various second portions (shown in **FIGS. 7A-7B**) may be used with the first portion **132**. With continued reference to **FIG. 6A**, the first portion **132** has a locking mechanism **35** described herein with reference to **FIGS. 2A-2D**. In other embodiments, the first portion **132** may have a locking mechanism **35** described with reference to **FIGS. 3A-3H**. In various embodiments, the first portion **132** of the coupling **130** is configured for releasably receiving the syringe **12** having a corresponding at least one syringe retaining member **32**, as described herein. With reference to **FIGS. 7A-7B**, the second portion **134** of the coupling **130** may have a connection interface configured for connecting with an injector that would otherwise not be capable of receiving the syringe **12** having a syringe retaining member **32** described herein. **FIG. 7A** shows the second portion **134** configured for use with an engagement mechanism of the injector described in United States Patent No. 5,383,858, while **FIG. 7B** shows the second portion **134** configured for use with an engagement mechanism of the injector described in United States Patent No. 6,652,489. The second portion **134** may be configured to interface with various other injectors not expressly described herein. In some embodiments, the coupling **130** may have a separate mechanism for engaging and disengaging the coupling **130** to and from a locking mechanism of the injector.

[00148] With reference to **FIG. 6B**, an adapter **230** may be configured to receive a syringe **S** not having one or more syringe retaining members **32** described herein for removably connecting with an injector having the locking mechanism **35** in accordance with one of the embodiments described herein. In various embodiments, the adapter **230** may be configured for connecting to a syringe **S** for subsequent installation on an injector. For example, the adapter **230** may be connected to the non-compatible syringe **S** releasably or permanently. Such an adapter **230** may have a connection interface having at least one engagement member **32** in accordance with embodiments described herein. The adapter **230** may be configured for being releasably connectable with an injector having a locking mechanism **35** described herein. The adapter **230** and the syringe **S** may be connected prior to connecting to the injector, or the adapter **230** may be connected to the injector before the syringe **S** is connected to the adapter **230**. The adapter **230** and syringe **S** may be removed from the

injector after use, with the adapter **230** being disposed of with the syringe **S**, or being removed from the used syringe **S** and saved for subsequent use with a different syringe **S**.

[00149] In one embodiment, a first portion **232** of the adapter **230** may be configured for permanently or releasably receiving the syringe **S**, which is not compatible for use with any of the locking mechanisms **35** described herein. In some embodiments, the syringe **S** may be the syringe described in United States Patent No. 5,383,858 or United States Patent No. 6,652,489, or any other syringe type. The adapter **230** allows the non-compatible syringe **S** to engage and be retained by the locking mechanisms **35** described herein. In some embodiments, the adapter **230** may have a separate mechanism for engaging and disengaging the syringe **S** while the adapter **230** remains connected to the locking mechanism **35** of the injector **10**. The first portion **232** may also be a cradle or sleeve to hold or retain other syringes **S**, for example hand held syringes or syringes having different retention mechanisms or features and allowing them to engage and be retained by locking mechanisms **35**. A second portion **234** of the adapter **230** may have at least one syringe retaining member **32** in accordance with embodiments described herein. In some embodiments, the at least one syringe retaining member **32** may have one or more lugs **34** described herein with reference to **FIGS. 2A-5Z** and **10A-10H**. The second portion **234** of the adapter **230** may be configured for being releasably connectable with an injector having a locking mechanism **35** described herein. In this manner, various non-compatible syringes **S** may be used with an injector having a locking mechanism **35** described herein. In various embodiments, the adapter **230** may be configured for connecting a pressure jacket (not shown) to the injector for use in injection procedures requiring high pressure. For example, the adapter **230** having the pressure jacket may be configured for being releasably connectable with an injector. Such an adapter **230** may have a connection interface having at least one syringe retaining member **32** in accordance with one of the embodiments described herein or alternatively have a connection interface that allows non-compatible syringes to be used with the injector. The adapter **230** may be configured for being releasably, permanently, or semi-permanently connectable with an injector having a locking mechanism **35** described herein and allowing syringes **S** having alternate retaining mechanisms to be used with the injector. Once connected with the injector, the syringe **S** may be loaded into the adapter **230** or the pressure jacket and be retained therein at its proximal or distal end.

[00150] In various embodiments, an adapter 230 may be configured for connecting a syringe 12 having some but not all of the features necessary for subsequent installation into an injector 10 described herein. For example, with reference to FIG. 4L, an adapter 320 may be a ring 300 that provides surfaces 42 and 44 and mates with a syringe that has one or more lugs with at least a base surface 38 for retention within locking mechanism 35. According to this embodiment, the ring 300 may be inserted in syringe port 16 and remain therein for use with subsequent syringes. The adapter 320 allows a syringe which could not by itself mate or function fully with the syringe port 16 to mate and at least perform the retention function with the locking mechanism 35. FIG. 4M shows another embodiment of an adapter 320 having a ring with prominences 340 that extend distally out of the syringe port 16. These prominences 340 can be combined or connected, for example to form a ring extending radially outward from the syringe port 16. By rotating the adapter 320, the syringe 12 and the adapter 320 may be released from the syringe port 16. Similarly upon insertion, to the adapter 320 may be pushed proximally for engagement with the syringe 12.

[00151] FIG. 8A is an illustration of a generalized free body diagram of forces present during ejection of the syringe 12 from the syringe port 16. A normal force N_1 and a frictional force F_1 of the lug 34 act against the first locking element 84, and a normal force N_2 and a frictional force F_2 of the lug 34 act on the retention surface of sidewall 58 as well as the force T applied by the user to rotate the syringe 12 and any force D urging the syringe 12 distally provided by the drip flange or other means. In some embodiments, the syringe 12 may be made from a polyethylene terephthalate (PET) material, while the first locking element 84 may be made from a polyoxymethylene (POM) material, such as DELRINTM. The coefficient of friction μ of DELRINTM on another DELRINTM surface is approximately 0.4. Using this value, a practical limit of the angle A to enable ejection is approximately 20 degrees relative to a direction of the longitudinal axis 15 of the syringe 12. Thus for angles greater than 20 degrees, there will be slip and upon sufficient motion for the lugs 34 to clear the projections, the syringe 12 will be ejected and pop distally in the syringe port (FIG. 8B). FIG. 8C shows that the ratio of the force T to rotate the syringe 12 to the restoring force S of the resilient member 102 increases as the angle A increases. The ratio remains substantially constant as the angle increases for low angle values, but then increases significantly at higher angles. In some examples, an angle of at least 30 degrees and less than approximately 60 degrees may be used.

[00152] FIG. 9A is an illustration of a generalized free body diagram of forces acting at the interface during the insertion of the syringe 12 into the syringe port 16. The one or more lugs 34 interact with the one or more first locking elements 84 due to a lateral force **P** provided by the user. During the rotation, the one or more lugs 34 are in sliding contact with the sidewall 58. In addition, the second retaining ring (not shown) slides over the bottom surface 82 of the housing. Performing a static force analysis on this generalized interaction provides an estimate of the force for insertion as a function of the angle **A** of the interaction of the two surfaces for various coefficients of friction μ between the surfaces, as shown in FIG. 9B.

[00153] FIGS. 10A–10H, illustrate various embodiments of the lug 34 for use with various embodiments of the locking mechanisms 35 described herein. FIG. 10A shows an example lug 34AA having the configuration described herein with reference to FIGS. 3A–3H, while FIG. 10B illustrates an outline of the lug 34BB with a dotted line indicating each of the surfaces of the lug 34. FIG. 10C shows an example of a lug 34CC in which the center section 612 is hollow and the lug 34CC is defined by perimeter surfaces. In some embodiments, the center section 612 may have a thickness that corresponds to the thickness of the syringe barrel 18 (shown in FIG. 3A). In other embodiments, the center section 612 may have a thickness that is greater or less than the thickness of the syringe barrel 18 (shown in FIG. 3A). The perimeter surfaces may be connected together or have one or more gap therebetween. One benefit of having a hollow center section 612 is that sinking of the plastic material can be reduced or eliminated as the material cools during molding. With reference to FIG. 10D, one or more reinforcing members 614 may be provided in the center section 612, which has two peripheral gaps as mentioned above. The one or more reinforcing members 614 may be connected to or separated from the perimeter surfaces of the lug 34DD. In cases where the retention force needs to be high and thus there is significant stress on the surface of the lug 34DD, the presence of additional material or reinforcing members, for example one or more reinforcing members 614, can allow the lug 34EE to operate under such higher forces. FIG. 10E shows a lug 34EE having a single vertical or longitudinal member, for example defining surface 40, point 44, and base surface 38. FIG. 10F shows a lug 34FF having two generally rounded lugs, for example defining surface 40, point 44, and base surface 38. FIG. 10G shows a lug 34GG having one rounded lug. The bottom of lug 34GG defines the point 44 and the top defines the base surface 38. FIG. 10H shows a lug 34HH assembled from

three generally vertical and parallel lugs with an even top surface which form the base surface **38** and tapered bottom surface. It should be noted that one or more variations of the lugs **34** shown in **FIGS. 5** and **10** or other variations are within the scope of this disclosure can operate with one or more variations of the syringe ports **16** that are within the scope of this disclosure.

[00154] With reference to **FIG. 1B**, a system may be provided to transmit information from the syringe **12** to the injector **10** (shown in **FIG. 1A**). In one embodiment, the syringe **12** may be provided with one or more encoding devices **49** for example, on one or more of the syringe retaining members **32**. In other embodiments, the one or more encoding devices **49** may be provided on the outer surface **21** (shown in **FIG. 1B**), the inner surface **23** (shown in **FIG. 1B**), within at least a portion of the sidewall **19** (shown in **FIG. 1B**) of the proximal end **20** of the syringe **12**, or on the plunger **26**. In some embodiments, the encoding device **49** may be an optically readable member, such as a barcode, while in other embodiments, the encoding device **49** may be an RFID tag, near-field communication device, or any other suitable encoding device. A plurality of encoding devices **49** may be disposed around an inner or outer circumference of the syringe **12** and/or the plunger **26**. At least one sensor **51** (shown in **FIG. 2A**) may be provided on the syringe port **16** to read the encoding device **49**. In some embodiments, the at least one sensor **51** may be provided on at least one second recess **88**. Examples of information which could be encoded on encoding device **49** include, without limitation, dimensions of syringe **12**, volume of syringe **12**, content of the syringe **12** (in the case of a pre-filled syringe), manufacturing information such as lot numbers, dates and tool cavity number, recommended contrast media flow rates and pressures, and/or loading/injection sequences. In one embodiment, the presence, absence, or shape of one or more syringe retaining members **32** may serve as the encoding device. For example, one absent syringe retaining members **32** may represent a first code. Two or more adjacent absent syringe retaining members **32** may represent a second code. Two or more non-adjacent absent syringe retaining members **32** may represent a third code. Various other combinations of present/absent or differently shaped syringe retaining members **32** may represent various other codes. The presence or absence of individual syringe retaining members **32** can be determined by the injector using mechanical switches, electrical material sensors, optically, visually, or by other means known in the sensing art. This syringe encoding

information is communicated to the injector control for communication to the operator and for subsequent use in correctly programming and controlling the injector.

[00155] In some embodiments, at least a portion of the injector **10** (shown in **FIG. 1A**), such as the base **70** of the locking mechanism **35** shown in **FIGS. 2A** and **3A**, may have an inner support ring (not shown) that protrudes into at least a portion of the interior volume **25** of the proximal end **20** of the syringe **12**. Such a support ring may be removably extendable into at least a portion of the interior volume **25**. The support ring may provide radial and axial support to at least a portion of one or more syringe retaining members **32** and/or the inner sidewall **23** (shown in **FIG. 1B**) of the syringe **12** when the syringe **12** is inserted into the locking mechanism **35**. In embodiments where at least one sensor **51** is provided on the syringe port **16**, such as shown in **FIG. 2A**, the support ring may provide a contrasting surface for detecting the presence or absence of the at least one encoding device **49** on syringe **12**. For example, the support ring may provide a contrasting opaque surface against a translucent or transparent sidewall **19** of the syringe **12** to facilitate the detection of the at least one encoding device **49**.

[00156] Although the disclosure has been described in detail for the purpose of illustration based on what is currently considered to be the most practical and preferred embodiments, it is to be understood that such detail is solely for that purpose and that the disclosure is not limited to the disclosed embodiments, but, on the contrary, is intended to cover modifications and equivalent arrangements. For example, it is to be understood that the present disclosure contemplates that, to the extent possible, one or more features of any embodiment can be combined with one or more features of any other embodiment.

CLAIMS

1. A syringe comprising:
a barrel having a proximal end, a distal end, and a sidewall extending substantially circumferentially between the proximal end and the distal end along a longitudinal axis; and
at least one syringe retaining member having at least one lug protruding radially outwardly relative to an outer surface of the sidewall, the at least one lug tapering axially along the outer surface of the sidewall in a direction from the distal end toward the proximal end,
wherein the at least one lug is configured for engagement with a locking mechanism on a fluid injector to releasably lock the syringe with the fluid injector, and
wherein a taper of the at least one lug rotationally guides the syringe into self-orienting alignment with the locking mechanism and axially ejects the syringe upon rotation of the syringe.
2. The syringe of claim 1, wherein the at least one lug comprises a first surface tapered axially along the outer surface of the sidewall in the direction from the distal end toward the proximal end.
3. The syringe of claim 2, wherein the at least one lug further comprises a second surface tapered axially along the outer surface of the sidewall in a direction opposite the first surface.
4. The syringe of claim 3, wherein the at least one lug further comprises a base surface arranged substantially perpendicularly relative to the longitudinal axis.

5. The syringe of claim 4, wherein the at least one lug further comprises at least one surface connecting the first surface and the second surface to the base surface.

6. The syringe of claim 4, wherein at least one of the first surface, the second surface, and the base surface has a shape selected from the group consisting of linear, curved, continuous, discontinuous, and planar.

7. The syringe of claim 1, wherein a plurality of lugs is spaced around at least a portion of the outer surface of the sidewall with equal or unequal angular intervals around the outer surface of the sidewall.

8. The syringe of claim 7, wherein the plurality of lugs is aligned longitudinally at or near the proximal end relative to the longitudinal axis.

9. The syringe of claim 7, wherein at least one of the plurality of lugs is offset toward the proximal end or the distal end of the barrel.

10. The syringe of claim 1, wherein the at least one lug comprises at least one first lug and at least one second lug, and wherein the at least one second lug is same as or different from the at least one first lug.

11. The syringe of claim 10, wherein at least one of the at least one first lug and the at least one second lug comprises an inclined release member protruding from the outer surface of the sidewall to a top surface of the at least one of the at least one first lug and the at least one second lug.

12. The syringe of claim 1, wherein at least one of the at least one lug comprises one or more locking tabs having at least one stop surface for preventing a rotation of the syringe within the locking mechanism.

13. The syringe of claim 1, wherein the at least one of the at least one lug comprises at least one radially inwardly recessed hollow portion.

14. The syringe of claim 1, further comprising at least one flange protruding radially outwardly from the outer surface of the sidewall relative to the longitudinal axis and extending circumferentially around at least a portion of the outer surface of the sidewall.

15. The syringe of claim 14, further comprising a longitudinal stop surface on the at least one flange for limiting a length of a longitudinal insertion of the syringe into the locking mechanism.

16. The syringe of claim 1, wherein the at least one lug has a shape having a triangle-shaped, arrowhead-shaped, rectangular, or rounded outline.

17. A syringe comprising:

a barrel having a proximal end, a distal end, and a sidewall extending substantially circumferentially between the proximal end and the distal end along a longitudinal axis; and

at least one lug protruding radially outwardly relative to an outer surface of the sidewall, the at least one lug having at least one surface tapering axially along the outer surface of the sidewall in a direction from the distal end toward the proximal end,

wherein the at least one lug is configured for engagement with a locking mechanism on a fluid injector to releasably lock the syringe with the fluid injector, and

wherein the at least one surface rotationally guides the syringe into self-orienting alignment with the locking mechanism and wherein the at least one surface axially ejects the syringe upon rotation of the syringe.

18. A syringe comprising:

a barrel having a proximal end, a distal end, and a sidewall extending substantially circumferentially between the proximal end and the distal end along a longitudinal axis; and

a plurality of lugs protruding radially outwardly relative to an outer surface of the sidewall and spaced around at least a portion of the outer surface of the sidewall, at least one of the plurality of lugs comprising:

a first surface tapered axially along the outer surface of the sidewall in a direction from the distal end toward the proximal end;

a second surface tapered axially along the outer surface of the sidewall in a direction opposite the first surface;

a base surface arranged substantially perpendicularly relative to the longitudinal axis; and

at least one surface connecting the first surface and the second surface to the base surface,

wherein at least one of the plurality of lugs is configured for engagement with a locking mechanism on a fluid injector to releasably lock the syringe with the fluid injector, and

wherein at least one of the first surface and the second surface rotationally guides the syringe into self-orienting alignment with the locking mechanism, and

wherein at least one of the first surface and the second surface axially ejects the syringe upon rotation of the syringe.

19. A fluid injection apparatus, comprising:
at least one syringe comprising a cylindrical barrel with a distal end, a proximal end, a sidewall, and a longitudinal axis extending between the distal end and the proximal end, the barrel having at least one lug protruding radially outwardly from an outer surface of the sidewall, the at least one lug having a surface tapered axially in a direction toward the proximal end;
an injector comprising an injector housing defining at least one syringe port for receiving the at least one syringe;
and
a locking mechanism associated with the at least one syringe port for securing the at least one syringe within the at least one syringe port, the locking mechanism configured for engaging the at least one lug of the at least one syringe to releasably lock the at least one syringe within the at least one syringe port,
wherein the tapered surface of the at least one lug rotationally guides the at least one syringe into self-orienting alignment with the locking mechanism and axially ejects the at least one syringe upon rotation of the at least one syringe.

20. The fluid injection apparatus of claim 19, wherein the locking mechanism comprises:

- a housing having a proximal end, a distal end, and a central opening extending therebetween;
- a first retaining ring at the distal end of the housing; and
- a second retaining ring within the central opening of the housing between the proximal end of the housing and the first retaining ring,

wherein the second retaining ring is selectively rotatable relative to the first retaining ring to operatively engage the at least one lug of the at least one syringe.

21. The fluid injection apparatus of claim 20, wherein the first retaining ring has at least one first recess configured to receive the at least one lug of the at least one syringe when the proximal end of the at least one syringe is inserted into the at least one syringe port.

22. The fluid injection apparatus of claim 21, wherein the at least one first recess has at least one guide surface for guiding the at least one lug of the at least one syringe into the at least one first recess, and wherein at least one lateral surface of the at least one first recess defines a guide path for guiding a movement of the at least one lug within the at least one first recess.

23. The fluid injection apparatus of claim 22, wherein the at least one guide surface is radially angled or curved relative to the longitudinal axis in a direction from the distal end toward the proximal end of the first retaining ring.

24. The fluid injection apparatus of claim 20, wherein a plurality of lugs is spaced around at least a portion of the outer surface of the sidewall of the at least one syringe, and

wherein a plurality of first recesses is spaced apart around at least a portion of an inner surface of the first retaining ring.

25. The fluid injection apparatus of claim 20, wherein the second retaining ring has one or more locking elements on at least a portion of an inner sidewall of the second retaining ring.

26. The fluid injection apparatus of claim 25, wherein the one or more locking elements are separated by one or more second recesses.

27. The fluid injection apparatus of claim 26, wherein at least one of the one or more second recesses is configured to receive the at least one lug of the at least one syringe when the proximal end of the at least one syringe is inserted through the first retaining ring.

28. The fluid injection apparatus of claim 20, wherein the first retaining ring comprises one or more first recesses and the second retaining ring comprises one or more second recesses configured for receiving the at least one lug upon rotation of the second retaining ring into selective alignment with the one or more first recesses.

29. The fluid injection apparatus of claim 20, further comprising a third retaining ring between the first retaining ring and the second retaining ring.

30. The fluid injection apparatus of claim 20, wherein at least one elastically resilient member is coupled with the second retaining ring.