

MULTI-USE AND SINGLE-USE DEVICES FOR INJECTOR INTERFACES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to United States Provisional Patent Application Serial No. 63/578,287, titled “Multi-Use and Single-Use Devices for Injector Interfaces” and filed on August 23, 2023, the disclosure of which is incorporated herein in its entirety.

BACKGROUND

Field of the Technology

[0002] The present disclosure relates to connection fittings for use in injector systems or other means of dispersing medicine, such as contrast imaging agents.

Description of Related Art

[0003] In many medical diagnostic and therapeutic procedures, a medical practitioner injects a patient with one or more medical fluids. In recent years, a number of medical fluid delivery systems for pressurized injection of fluids, such as an imaging 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 imaging procedures. In general, these medical fluid delivery systems are designed to deliver a preset amount of fluid at a preset flow rate.

[0004] Connection devices used in injection systems for dispersing various medicines to patients need to be able to be easily assembled and disassembled. This is true in some systems where one part of that system may be used multiple times, such as a multi-use tubing system, and others which are used once per patient, such as a single-use tubing set. Given this arrangement, it is important to know when devices intended for a single use have already been used and the general status of the assembly, including status of the devices intended for multiple uses.

[0005] Thus, there exists a need to sense the positions of different tubing components within injection systems to allow for an administrator to use the systems more effectively and without error. Medical personnel must connect and/or disconnect fluid delivery systems in a relatively short time and under stressed and/or emergency conditions. It is thus desirable to develop connector assemblies that are configured for delivery of medical fluids to a patient that have durable connector interfaces capable of connecting or disconnecting simply and quickly without leaking, breaking, or inadvertently disconnecting.

BRIEF SUMMARY

[0006] A connection system may include an interface having a housing and a sensor disposed within the housing, with the sensor being configured to be displaced between a first position, a second position, and a third position; a multi-use fitting having at least one engaging surface and a slot, with the multi-use fitting being configured to be at least partially secured within the housing so that the at least one engaging surface displaces the sensor between the first position and the second position; and a single-use fitting having a flange, with the single-use fitting being configured to be at least partially secured within the multi-use fitting such that the flange is received within and extends through the slot and displaces the sensor between the second position and the third position. The sensor may be configured to detect displacement between the first position and the second position, thereby sensing at least partial engagement between the multi-use fitting and the interface. The sensor may also be configured to detect displacement between the second position and the third position, thereby sensing at least partial engagement between the single-use fitting and the multi-use fitting.

[0007] A connection system may include an interface, a multi-use fitting, and a single-use fitting. The interface may include: a housing defining a first space and an inlet, and a sensor disposed within the housing and at least partially exposed to the first space. The multi-use fitting may include a body defining a bore and at least a first portion of a slot, the bore defining a first fluid flow path, and at least one engaging surface extending from the body. The single-use fitting may include a body defining an outlet at a first end; a connector extending from a second end of the body opposing the outlet, defining a second fluid flow path in fluid communication with the outlet, and a flange extending from the connector. The multi-use fitting may be configured to be secured within the first space of the housing, such that the at least one engaging surface contacts the sensor. When multi-use fitting is secured to the housing, the first fluid flow path may be in fluid communication with the inlet. The single-use fitting may be configured to be secured to the multi-use fitting, such that the flange extends through the slot and contacts the sensor. When the single-use fitting is secured to the multi-use fitting, the second fluid flow path may be in fluid communication with the first fluid flow path, thereby defining a single fluid flow path from the inlet to the outlet. The sensor may be configured to detect: (1) a lack of contact, corresponding to the multi-use fitting not being secured within the housing; (2) contact by the at least one engaging surface, corresponding to the multi-use fitting being at least partially secured within the housing; and (3) contact by the flange, corresponding to the single-use fitting being at least partially secured within the multi-use fitting.

[0008] A multi-use fitting may include a body defining a fluid flow path and at least a first portion of a slot; and at least one engaging surface extending from the body, the at least one engaging surface configured to displace a sensor.

[0009] A single-use fitting may include a body defining an outlet at a first end; a connector extending from a second end of the body opposing the outlet, the connector defining an inlet, and a flange extending from the connector. A fluid flow path may be defined between the inlet and the outlet, and the flange may be configured to displace a sensor.

[0010] A dust cap may include a body comprising a connector extending in a first direction and a closed end extending in a second direction, opposite the first direction; and a flange extending from the connector, the flange being configured to displace a sensor.

[0011] A connection system may include a multi-use fitting and a single-use fitting. The multi-use fitting may include a body having a bore defining a fluid flow path and at least a first portion of a slot, and at least one engaging surface extending from the body and being configured to displace a sensor. The single-use fitting may include: a body defining an outlet at a first end; a connector extending from a second end of the body opposing the outlet, the connector defining an inlet; a flange extending from the connector and being configured to displace the sensor; and a fluid flow path extending from the first end to the second end. The at least one engaging surface may be configured to displace the sensor a first distance, and the flange may be configured to displace the sensor a second distance beyond the first distance. The connector may be configured to mate with the bore to connect the single-use fitting to the multi-use fitting, thereby connecting the fluid flow path of the multi-use fitting with the fluid flow path of the single-use fitting.

[0012] In some embodiments, the present disclosure may be characterized by one or more of the following numbered clauses:

[0013] Clause 1. A connection system comprising: an interface comprising a housing and a sensor disposed within the housing, the sensor being configured to be displaced between a first position, a second position, and a third position; a multi-use fitting comprising at least one engaging surface and a slot, the multi-use fitting being configured to be at least partially secured within the housing so that the at least one engaging surface displaces the sensor between the first position and the second position; a single-use fitting comprising a flange, the single-use fitting being configured to be at least partially secured within the multi-use fitting such that the flange is received within and extends through the slot and displaces the sensor between the second position and the third position, wherein the sensor is configured to detect displacement between the first position and the second position, thereby sensing at least partial engagement

between the multi-use fitting and the interface, and wherein the sensor is configured to detect displacement between the second position and the third position, thereby sensing at least partial engagement between the single-use fitting and the multi-use fitting.

[0014] Clause 2. The connection system of clause 1, wherein upon being displaced to the second position, the sensor detects full engagement between the multi-use fitting and the interface, and wherein upon being displaced to the third position, the sensor detects full engagement between the single-use fitting and the multi-use fitting.

[0015] Clause 3. The connection system of clause 2, wherein upon being displaced between the first position and the second position, the sensor detects partial engagement between the multi-use fitting and the interface, and wherein upon being displaced between the second position and the third position, the sensor detects partial engagement between the single-use fitting and the multi-use fitting.

[0016] Clause 4. The connection system of any of clauses 1-3, wherein the sensor comprises a lever, an arm, and a spring extending about the arm, wherein the lever is configured to be rotated about the arm by engaging with the at least one engagement surface and the flange, and wherein the spring is configured to bias the lever toward the first position.

[0017] Clause 5. The connection system of clause 4, wherein the sensor further comprises a magnet disposed within the arm and a circuit board located a distance away from the magnet, the circuit board being configured to sense the rotation of the magnet when the lever is rotated about the arm.

[0018] Clause 6. The connection system of any of clauses 1-5, wherein the multi-use fitting comprises a body defining a bore and at least a first portion of the slot, wherein the bore at least partially defines a first fluid flow path, and wherein the at least one engaging surface extends from the body.

[0019] Clause 7. The connection system of clause 6, wherein the at least one engaging surface comprises a flat portion extending from the body and a curved portion extending from the flat portion.

[0020] Clause 8. The connection system of clause 7, wherein the at least one engaging surface comprises a first engaging surface and a second engaging surface, the first and second engaging surfaces defining at least a second portion of the slot therebetween.

[0021] Clause 9. The connection system of any of clauses 6-8, wherein the multi-use fitting further comprises at least one wing extending from the body, wherein the at least one wing is configured to engage with the housing to secure the multi-use fitting to the interface.

[0022] Clause 10. The connection system of clause 9, wherein the at least one wing comprises a tapered leading edge and a retention rib, the tapered leading edge being configured to deform upon engagement and disengagement with the housing, and wherein the housing defines a lip, the lip being configured to contact the retention rib, thereby securing the multi-use fitting to the housing.

[0023] Clause 11. The connection system of any of clauses 6-10, wherein the single-use fitting comprises a body and a connector extending from the body, the connector configured to mate with the bore, wherein the body of the single-use fitting and the connector at least partially define a second fluid flow path configured to be aligned with the first fluid flow path when the connector is mated with the bore, and wherein the flange extends from the connector.

[0024] Clause 12. The connection system of clause 11, wherein the single-use fitting comprises a locking lever extending from the body of the single-use fitting, and the body of the multi-use fitting defines a socket, and wherein the locking lever is configured to engage with the socket, thereby at least partially securing the single-use fitting within the multi-use fitting.

[0025] Clause 13. The connection system of any of clauses 1-12, when the single-use fitting is secured within the multi-use fitting and the multi-use fitting is secured within the housing, the single-use fitting and the multi-use fitting are configured such that the single-use fitting remains secured within the multi-use fitting when the multi-use fitting is removed from the housing.

[0026] Clause 14. A connection system comprising: an interface comprising: a housing defining a first space and an inlet; and a sensor disposed within the housing and at least partially exposed to the first space; a multi-use fitting comprising: a body defining a bore and at least a first portion of a slot, the bore defining a first fluid flow path; and at least one engaging surface extending from the body; a single-use fitting comprising: a body defining an outlet at a first end; a connector extending from a second end of the body opposing the outlet, the connector defining a second fluid flow path in fluid communication with the outlet; and a flange extending from the connector, wherein the multi-use fitting is configured to be secured within the first space of the housing, such that the at least one engaging surface contacts the sensor, wherein, when the multi-use fitting is secured to the housing, the first fluid flow path is in fluid communication with the inlet, wherein the single-use fitting is configured to be secured to the multi-use fitting, such that the flange extends through the slot and contacts the sensor, wherein, when the single-use fitting is secured to the multi-use fitting, the second fluid flow path is in fluid communication with the first fluid flow path, thereby defining a single fluid flow path

from the inlet to the outlet, wherein the sensor is configured to detect: (1) a lack of contact, corresponding to the multi-use fitting not being secured within the housing; (2) contact by the at least one engaging surface, corresponding to the multi-use fitting being at least partially secured within the housing; and (3) contact by the flange, corresponding to the single-use fitting being at least partially secured within the multi-use fitting.

[0027] Clause 15. The connection system of clause 14, wherein the sensor comprises: an arm; a lever extending from the arm and configured to be at least partially exposed within the first space; and a spring extending about the arm, wherein the lever is configured to contact the at least one engaging surface and the flange to rotate the arm in a first direction, and wherein the spring is configured to bias the arm in a second direction, opposite the first direction.

[0028] Clause 16. The connection system of clause 15, wherein the contact between the at least one engagement surface and the lever rotates the arm a first distance in the first direction, and wherein contact between the flange and the lever rotates the arm a second distance in the first direction, the second distance extending beyond the first distance.

[0029] Clause 17. The connection system of clause 16, wherein the sensor further comprises: a magnet disposed within the arm; and a circuit board located a distance away from the magnet, wherein the circuit board is configured to sense the rotation of the magnet when the arm is rotated due to the lever contacting the at least one engagement surface or the flange.

[0030] Clause 18. The connection system of clause 17, wherein the lever, arm, spring, and magnet are disposed in a second space defined within the housing, and the circuit board is disposed in a third space defined within the housing fluidly sealed from the first space.

[0031] Clause 19. The connection system of any of clauses 14-18, wherein the at least one engaging surface comprises a flat portion extending from the body and a curved portion extending from the flat portion.

[0032] Clause 20. The connection system of clause 19, wherein the at least one engaging surface comprises a first engaging surface and a second engaging surface, the first and second engaging surfaces defining at least a second portion of the slot therebetween.

[0033] Clause 21. A multi-use fitting comprising: a body defining a fluid flow path and at least a first portion of a slot; and at least one engaging surface extending from the body, the at least one engaging surface configured to displace a sensor.

[0034] Clause 22. The multi-use fitting of clause 21, wherein the at least one engaging surface comprises a flat surface extending from the body and a curved surface extending from the body along an end of the flat surface.

[0035] Clause 23. The multi-use fitting of clause 22, wherein the curved surface is configured to displace the sensor.

[0036] Clause 24. The multi-use fitting of clause 22 or 23, wherein the at least one engaging surface comprises a first engaging surface and a second engaging surface, the first and second engaging surfaces defining at least a second portion of the slot therebetween.

[0037] Clause 25. The multi-use fitting of any of clauses 21-24, further comprising at least one wing extending from the body, the at least one wing defining at least one retaining rib configured to secure the at least one wing to an interface.

[0038] Clause 26. The multi-use fitting of clause 25, wherein the at least one wing comprises a tapered leading edge, the tapered leading edge being configured to fit within the interface.

[0039] Clause 27. The multi-use fitting of clause 25 or 26, wherein the at least one wing comprises a finger press configured to flex the at least one wing to secure the at least one wing within the interface and to remove the at least one wing from the interface.

[0040] Clause 28. The multi-use fitting of any of clauses 25-27, wherein the at least one wing comprises a first wing and a second wing, and the at least one retaining rib comprises a first retaining rib disposed on the first wing and a second retaining rib disposed on the second wing.

[0041] Clause 29. The multi-use fitting of clause 28, wherein the first retaining rib and the second retaining rib correspond, respectively, to a first retaining lip and a second retaining lip on the interface to secure, respectively, the first wing and the second wing within the interface.

[0042] Clause 30. The multi-use fitting of any of clauses 21-29, wherein the body further defines an inner bore, the inner bore comprising an inlet and an outlet, and wherein the inner bore defines the fluid flow path between the inlet and the outlet.

[0043] Clause 31. The multi-use fitting of clause 30, wherein the inlet is configured to be connected to a tubing, the tubing being configured to provide a medicament through the flow path.

[0044] Clause 32. The multi-use fitting of clause 30 or 31, wherein the outlet is configured to be connected to a single-use fitting.

[0045] Clause 33. The multi-use fitting of clause 32, wherein the single-use fitting is configured to provide the medicament to a patient.

[0046] Clause 34. The multi-use fitting of clause 33, wherein the body further defines a socket configured to engage a portion of the single-use fitting to connect the single-use fitting to the multi-use fitting.

[0047] Clause 35. The multi-use fitting of clause 30-34, wherein the body further defines an outer bore at least partially surrounding the inner bore, the outer bore defining the at least a first portion of the slot.

[0048] Clause 36. A single-use fitting comprising: a body defining an outlet at a first end; a connector extending from a second end of the body opposing the outlet, the connector defining an inlet, and a flange extending from the connector, wherein a fluid flow path is defined between the inlet and the outlet, and wherein the flange is configured to displace a sensor.

[0049] Clause 37. The single-use fitting of clause 36, wherein the flange defines an edge, and the edge comprises a vertical portion extending from the connector and a slanted portion extending from the vertical portion.

[0050] Clause 38. The single-use fitting of clause 37, wherein the slanted portion of the edge is configured to displace the sensor.

[0051] Clause 39. The single-use fitting of clause 36 or 37, wherein the vertical portion of the edge extends from the connector to define an orthogonal angle therebetween, and the slanted portion of the edge extends from the vertical portion at an angle that is not orthogonal relative to the connector.

[0052] Clause 40. The single-use fitting of any of clauses 36-39, further comprising a stop extending from the body.

[0053] Clause 41. The single-use fitting of clause 40, wherein the stop extends a distance from the body beyond the flange.

[0054] Clause 42. The single-use fitting of any of clauses 36-41, further comprising a locking lever configured to connect the single-use fitting to a multi-use fitting.

[0055] Clause 43. The single-use fitting of clause 42, wherein the locking lever comprises a tapered leading edge configured to be secured within a portion of the multi-use fitting.

[0056] Clause 44. The single-use fitting of clause 42 or 43, wherein the locking lever further comprises a finger press configured to flex the locking lever to facilitate the connection to the multi-use fitting.

[0057] Clause 45. The single-use fitting of any of clauses 36-44, wherein the outlet is configured to be connected to a tubing, the tubing being configured to receive a medicament from the fluid flow path.

[0058] Clause 46. The single-use fitting of clause 45, wherein the connector is configured to mate with a bore of a multi-use fitting.

[0059] Clause 47. The single-use fitting of clause 46, wherein the fluid flow path is configured to receive the medicament from the multi-use fitting via the inlet.

[0060] Clause 48. The single-use fitting of any of clauses 36-47, further comprising an outer shell extending around the outlet, the outer shell defining a rear opening.

[0061] Clause 49. The single-use fitting of clause 48, wherein the outer shell further defines a bottom opening.

[0062] Clause 50. A dust cap comprising: a body comprising a connector extending in a first direction and a closed end extending in a second direction, opposite the first direction; and a flange extending from the connector, the flange being configured to displace a sensor.

[0063] Clause 51. The dust cap of clause 50, wherein the flange defines an edge, the edge defining a vertical portion extending from the connector and a slanted portion extending from the front portion.

[0064] Clause 52. The dust cap of clause 51, wherein the slanted portion of the edge is configured to displace the sensor.

[0065] Clause 53. The dust cap of clause 51 or 52, wherein the front portion of the edge comprises a notch.

[0066] Clause 54. The dust cap of any of clauses 51-53, wherein the vertical portion of the edge extends from the connector to define an orthogonal angle therebetween, and the slanted portion of the edge extends from the vertical portion at an angle that is not orthogonal relative to the connector.

[0067] Clause 55. The dust cap of any of clauses 50-54, further comprising a locking lever configured to connect the dust cap to the multi-use fitting.

[0068] Clause 56. The dust cap of clause 55, wherein the locking lever comprises a tapered leading edge configured to be secured within a portion of the multi-use fitting.

[0069] Clause 57. The dust cap of clause 55 or 56, wherein the locking lever further comprises a finger press configured to flex the locking lever to facilitate the connection to the multi-use fitting.

[0070] Clause 58. The dust cap of any of clauses 50-57, wherein the connector is configured to mate with a bore of a multi-use fitting.

[0071] Clause 59. The dust cap of clause 58, wherein the closed end of the dust cap is configured to terminate a fluid flow path defined at least partially by the bore of the multi-use fitting.

[0072] Clause 60. A connection system comprising: a multi-use fitting comprising: a body comprising a bore defining a fluid flow path and at least a first portion of a slot; and at least one engaging surface extending from the body and being configured to displace a sensor; a single-use fitting comprising: a body defining an outlet at a first end; a connector extending

from a second end of the body opposing the outlet, the connector defining an inlet; a flange extending from the connector and being configured to displace the sensor; and a fluid flow path extending from the first end to the second end, wherein the at least one engaging surface is configured to displace the sensor a first distance, and the flange is configured to displace the sensor a second distance beyond the first distance, wherein the connector is configured to mate with the bore to connect the single-use fitting to the multi-use fitting, thereby connecting the fluid flow path of the multi-use fitting with the fluid flow path of the single-use fitting.

[0073] Clause 61. The connection system of clause 60, wherein when the single-use fitting is connected to the multi-use fitting, the flange is configured to extend through the slot to displace the sensor.

[0074] Clause 62. The connection system of clause 60 or 61, wherein the at least one engaging surface comprises a flat surface extending from the body and a curved surface extending from the body along an end of the flat surface.

[0075] Clause 63. The connection system of clause 62, wherein the curved surface is configured to displace the sensor.

[0076] Clause 64. The connection system of any of clauses 60-63, wherein the at least one engaging surface comprises a first engaging surface and a second engaging surface, the first and second engaging surfaces defining at least a second portion of the slot therebetween.

[0077] Clause 65. The connection system of any of clauses 60-64, further comprising at least one wing extending from the body of the multi-use connector, the at least one wing defining at least one retaining rib configured to secure the at least one wing to an interface.

[0078] Clause 66. The connection system of clause 65, wherein the at least one wing comprises a tapered leading edge, the tapered leading edge being configured to fit within the interface.

[0079] Clause 67. The connection system of clause 65 or 66, wherein the at least one wing comprises a finger press configured to flex the at least one wing to secure the at least one wing within the interface and to remove the at least one wing from the interface.

[0080] Clause 68. The connection system of any of clauses 65-67, wherein the at least one wing comprises a first wing and a second wing, and the at least one retaining rib comprises a first retaining rib disposed on the first wing and a second retaining rib disposed on the second wing.

[0081] Clause 69. The connection system of clause 68, wherein the first retaining rib and the second retaining rib correspond, respectively, to a first retaining lip and a second retaining lip on the interface to secure, respectively, the first wing and the second wing within the interface.

[0082] Clause 70. The connection system of any of clauses 60-69, wherein the flange defines an edge, and the edge comprises a vertical portion extending from the connector and a slanted portion extending from the vertical portion.

[0083] Clause 71. The connection system of clause 70, wherein the slanted portion of the edge is configured to displace the sensor.

[0084] Clause 72. The connection system of clause 70 or 71, wherein the vertical portion of the edge extends from the connector to define an orthogonal angle therebetween, and the slanted portion of the edge extends from the vertical portion at an angle that is not orthogonal relative to the connector.

[0085] Clause 73. The connection system of any of clauses 70-72, further comprising a stop extending from the body, the stop being configured to at least partially impede the connection of the single-use fitting to the multi-use fitting.

[0086] Clause 74. The connection system of any of clauses 60-73, wherein the body of the multi-use fitting further defines a socket, and the single-use fitting comprises a locking lever configured to be received within the socket, further connecting the single-use fitting to the multi-use fitting.

[0087] Clause 75. The connection system of any of clauses 60-74, wherein the bore defines an inlet and an outlet, the inlet of the bore being configured to be connected to a first tubing and the outlet of the bore being configured to mate with the connector of the single-use fitting, wherein the outlet of the single-use fitting is configured to be connected to a second tubing, thereby defining a system fluid flow path from the first tubing, through the fluid flow path of the multi-use fitting and the flow path of the single-use fitting, to the second tubing, and wherein the system fluid flow path is configured to receive a medicament and deliver the medicament to a patient downstream of the second tubing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0088] Fig. 1 is a perspective view of a connection system and assembly according to one embodiment of the present disclosure;

[0089] Fig. 2 is an exploded view of the assembly of Fig. 1;

[0090] Fig. 3 is a cross-sectional side view of an interface of the system of Fig. 1;

[0091] Fig. 4 is a perspective view of a sensor arm of the interface of Fig. 3;

[0092] Fig. 5 is a cross-sectional view of the sensor arm of Fig. 4;

[0093] Fig. 6 is a partial perspective view of the interface of Fig. 3;

[0094] Fig. 7 is a perspective view of a lever of the interface of Fig. 3;

[0095] Fig. 8 is a perspective view of a multi-use fitting of the system of Fig. 1;

- [0096] Fig. 9 is rear perspective view of the multi-use fitting of Fig. 8;
- [0097] Fig. 10 is cross-sectional view of the multi-use fitting of Fig. 8;
- [0098] Fig. 11 is a perspective view of a single-use fitting of the system of Fig. 1;
- [0099] Fig. 12 is a cross-sectional view of the single-use fitting of Fig. 11;
- [00100] Fig. 13 is perspective view, showing the multi-use fitting being connected to the interface of Fig. 1;
- [00101] Fig. 14 is a perspective view, showing the single-use fitting being connected to the multi-use fitting engaged within the interface of Fig. 1;
- [00102] Fig. 15 is a cross-sectional view, showing the multi-use fitting being connected into the interface of Fig. 1;
- [00103] Fig. 16 is a cross-sectional view, showing the multi-use fitting engaged with the sensor within the interface of Fig. 1;
- [00104] Fig. 17 is a cross-sectional view, showing the single-use fitting being connected to the multi-use fitting engaged within the interface of Fig. 1;
- [00105] Fig. 18 is a cross-sectional view, showing the single-use fitting connected to the multi-use fitting within the interface of Fig. 1;
- [00106] Fig. 19 is a cross-sectional view, showing the single-use and multi-use fittings being removed from the interface of Fig. 1;
- [00107] Fig. 20 is a perspective view of a connection system and assembly according to one embodiment of the present disclosure;
- [00108] Fig. 21 is an exploded view of the system of Fig. 20;
- [00109] Fig. 22 is a perspective view of the interface of the system of Fig. 20;
- [00110] Fig. 23 is a rear perspective view of the interface of the system of Fig. 20;
- [00111] Fig. 24 is an exploded view of the interface of the system of Fig. 20;
- [00112] Fig. 25 is a perspective view of the sensor assembly of the system of Fig. 20;
- [00113] Fig. 26 is a front perspective view of a multi-use fitting of the system of Fig. 20;
- [00114] Fig. 27 is a rear perspective view of the multi-use fitting of the system of Fig. 20;
- [00115] Fig. 28 is a cross-sectional view of the multi-use fitting of the system of Fig. 20;
- [00116] Fig. 29 is a rear perspective view of a single-use fitting for the system of Fig. 20;
- [00117] Fig. 30 is a front perspective view of a single-use fitting for the system of Fig. 20;
- [00118] Fig. 31 is a cross-sectional view of the single-use fitting of the system of Fig. 20;
- [00119] Fig. 32 is a perspective view of the multi-use fitting being connected to the interface of the system of Fig. 20;

[00120] Fig. 33 is a cross-sectional view of the multi-use fitting being connected to the interface of the system of Fig. 20;

[00121] Fig. 34 is a cross-section view of the multi-use fitting being connected to the interface of the system of Fig. 20;

[00122] Fig. 35 is a cross-sectional view of the multi-use fitting connected to and engaged with the sensor of the interface of the system of Fig. 20;

[00123] Fig. 36 is a perspective, cross-sectional view of the multi-use fitting connected to and engaged with the sensor of the interface of the system of Fig. 20;

[00124] Fig. 37 is a perspective view of the single-use fitting being connected to the multi-use fitting engaged within the interface of the system of Fig. 20;

[00125] Fig. 38 is a perspective view of the single-use fitting connected to the multi-use fitting engaged within the interface of the system of Fig. 20;

[00126] Fig. 39 is a cross-sectional view of the single-use fitting being connected to the multi-use fitting engaged within the interface of the system of Fig. 20;

[00127] Fig. 40 is a cross-sectional view of the single-use fitting connected to the multi-use fitting engaged within and engaged with the sensor of the interface of the system of Fig. 20;

[00128] Fig. 41 is a cross-sectional view of the interface of the system of Fig. 20;

[00129] Fig. 42 is a perspective view of a dust cap that can be used with the multi-use fitting and the interface of the system of Fig. 20;

[00130] Fig. 43 is another perspective view of the dust cap of Fig. 42;

[00131] Fig. 44 is a cross-sectional view of the dust cap of Fig. 42;

[00132] Fig. 45 is a cross-sectional view of the dust cap being engaged with the interface and the sensor of the system of Fig. 20;

[00133] Fig. 46 is a cross-sectional view of the dust cap connected to the interface and the sensor of the system of Fig. 20; and

[00134] Fig. 47 is a perspective view of the dust cap and multi-use fitting being engaged with or removed from the interface and the sensor of the system of Fig. 20.

DETAILED DESCRIPTION

[00135] As used herein, the singular form of “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise. Spatial or directional terms, such as “left”, “right”, “inner”, “outer”, “above”, “below”, and the like, relate to the disclosure as shown in the drawing figures and are not to be considered as limiting as the disclosure can assume various alternative orientations. All numbers and ranges used in the specification and claims are to be understood as being modified in all instances by the term “about”. By “about” is meant plus or

minus twenty-five percent of the stated value. However, this should not be considered as limiting to any analysis of the values under the doctrine of equivalents.

[00136] Unless otherwise indicated, all ranges or ratios disclosed herein are to be understood to encompass the beginning and ending values and any and all subranges or subratios subsumed therein. For example, a stated range or ratio of “1 to 10” should be considered to include any and all subranges or subratios between (and inclusive of) the minimum value of 1 and the maximum value of 10; that is, all subranges or subratios beginning with a minimum value of 1 or more and ending with a maximum value of 10 or less. The ranges and/or ratios disclosed herein represent the average values over the specified range and/or ratio.

[00137] The terms “first”, “second”, and the like are not intended to refer to any particular order or chronology, but refer to different conditions, properties, or elements. The term “at least” is synonymous with “greater than or equal to”. The term “includes” is synonymous with “comprises”.

[00138] As used herein, the terms “parallel” or “substantially parallel” mean a relative angle as between two objects (if extended to theoretical intersection), such as elongated objects and including reference lines, that is from 0° to 5°, or from 0° to 3°, or from 0° to 2°, or from 0° to 1°, or from 0° to 0.5°, or from 0° to 0.25°, or from 0° to 0.1°, inclusive of the recited values. As used herein, the terms “perpendicular” or “substantially perpendicular” mean a relative angle as between two objects at their real or theoretical intersection is from 85° to 90°, or from 87° to 90°, or from 88° to 90°, or from 89° to 90°, or from 89.5° to 90°, or from 89.75° to 90°, or from 89.9° to 90°, inclusive of the recited values.

[00139] There is a need for a fluid injector system for delivery of multiple fluid doses to multiple patients using one or more multi-dose containers. The assembly should be configured to retain sterility of the fluid path through the single-use and multi-use portions of the assembly and, particularly, should maintain sterility of portions of the assembly which are reusable. Furthermore, the system should be arranged to allow the fluid injector system to recognize when a multi-use fluid path section has been attached and when a new single-use fluid path section has been connected to the multi-use fluid path set, indicating that the system and fluid path sets are ready to be primed and prepared for the next fluid injection procedure. The system may include features for ensuring patient safety, for example, by preventing cross-contamination of the multi-use tubing set, preventing re-use of the single-use tubing set between injection procedures, and/or for automatically priming the properly connected fluid path set to ensure that any air is removed from the fluid path of the multi- and single-use tubing sets to prevent inadvertent injection of air into a patient.

[00140] 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 embodiments of a multi-patient fluid medical injector/injection system (hereinafter “fluid injector system”) having a multi-use disposable fluid path set for delivering fluid to patients over a plurality of fluid injection procedures, having features for preventing cross-contamination between patients and designed for connection with a single-use disposable fluid path set connector that is used for a single injection procedure and replaced prior to the next injection procedure. The multi-use disposable fluid path set and the single-use disposable fluid path set connector interact and connect with the fluid injector by means of an injector interface. The fluid injector system includes multiple other components, for example, as described in U.S. Patent No. 5,383,858; U.S. Patent No. 7,553,294; U.S. Patent No. 7,666,169; U.S. Patent No. 8,945,051; U.S. Patent No. 10,022,493; U.S. Patent No. 10,507,319; International Patent Application No. PCT/US2012/037491; International Patent Application No. PCT/US2022/017812; and U.S. Application Publication No. 2014/0027009, the disclosures of which are hereby incorporated by reference in their entireties. Generally, the fluid injector system has a powered injector administrator or device and a fluid delivery set intended to be associated with the injector to deliver one or more fluids from one or more multi-dose containers under pressure into a patient.

[00141] While the systems and apparatuses described herein are with reference to computed tomography (CT) contrast injection systems, angiography (CV) contrast injection systems, positron emission tomography (PET) contrast injection systems, and magnetic resonance imaging (MRI) contrast injection systems, other pressurized injection protocols may also incorporate the various embodiments described herein for securing a syringe plunger to a piston of the fluid injector.

[00142] Various embodiments of the connector systems including the multi-use tubing set, the single-use tubing set, and the injector interface of the present disclosure may include connection systems 10, 110 for use in injection systems for dispersing medicaments to patients. While connector systems 10 and 110 are exemplary embodiments, they should not be considered limiting and modifications and changes to connector systems 10 and 110 which do not impact the scope of features of the system should also be considered to be within the scope of the present disclosure. Both systems 10, 110 are designed to sense different connections between the different features. This sensing can help an administrator with the dispersal of the medicament and the replacement of the different parts of the system 10, 110.

[00143] Embodiments of the present disclosure are directed to a connection system including an interface comprising a housing. The housing may include a sensor disposed therein, where the sensor is configured to reversibly move between a first position, a second position, and a third position. The first position may generally be associated with a state when the interface is not attached to either the multi-use fluid path set or the single-fluid path set. When the connector fitting on multi-use fluid path set is installed into the interface, at least a portion of the multi-use fluid path, the sensor is moved to the second position, indicating to a controller on the fluid injector system that the multi-use fluid path set has been installed. Reversible connection of connector fitting of the single-use fluid path set with the connector fitting of the multi-use fluid path set within the interface moves the sensor to the third position, indicating to the controller that the single-use tubing set and the multi-use tubing set have been fluidly connected and are ready for a priming operation to remove any air from the fluid path formed by the single-use tubing set and the multi-use tubing set. The controller of the fluid injector system may then automatically initiate a priming operation or, alternative, indicate to a user that the fluid injector system is ready for priming. In certain embodiments, when the single-use tubing set has not been correctly engaged with the multi-use tubing set, for example, as indicated by a signal sent from the sensor, the controller may not initiate a priming operation and indicate to a user that a safe fluid connection between the single-use tubing set and the multi-use tubing set has not been achieved and that the user should examine and/or correct the connection between the single-use tubing set and the multi-use tubing set. In such a case, the controller will not initiate or allow a priming operation until the single-use tubing set and the multi-use tubing set are correctly connected.

[00144] With reference to Figs. 1-19, a first connection system 10 according to embodiments of the present disclosure is shown. The system 10 includes an interface 12 which may be located on a housing of the fluid injector, a multi-use tubing set fluidly connected at its proximal end to one or more fluid reservoirs, such as one or more syringes such as in a fluid injector configuration illustrated in International Patent Application No. PCT/US2022/017812, and having a multi-use fitting 14 at its distal end that fits within and connects to the interface 12, and a single-use fitting 16 of a single-use fluid path set that fits within and connects to the multi-use fitting 14. Generally, the multi-use fitting 14 can be used multiple times over several fluid injection procedures. The single-use fitting 16 is intended to be used once, in a single fluid injection procedure, and is replaced within the system 10 after that use. The interface 12 is connected to an injector system, from which a medical fluid, such as a contrast agent or saline, can be dispensed to a patient. The interface 12 includes a sensor 21 to sense the status

of the connection system, such as the position of the multi-use fitting 14 and the single-use fitting 16 and whether they are correctly installed into interface 12 and whether fluid communication exists between multi-use fitting 14 and single-use fitting 16. The parts of the system 10 may be made of plastic or other suitable medical grade material that supports the functionality described in this application. The plastic may be clear to allow an administrator to visibly see the different engagements described here as well. The interface 12 may also be mechanically and/or electrically connected to electronic systems that provide outputs to a controller or an administrator indicating different stages of assembly and use of the system 10.

[00145] With reference to Figs. 1-7, various features of the interface 12 are shown. The interface 12 holds the sensor 21 that senses the engagement of the multi-use fitting 14 and the single-use fitting 16 within the interface 12. How those fittings 14, 16 are connected to the interface 12 will be described herein. The interface 12 includes a housing 22 that holds the sensor 21. According to certain embodiments, as shown in Figs. 3-5, the sensor 21 may have a sensor arm 20 that includes a rib 24, a boss 25, a pivot arm 26, and a spring 28 or other biasing member extending around the pivot arm 26. The sensor 21 may also include at least one magnet 30 configured to interact with a circuit board 32, for example to indicate which position the sensor is in. The rib 24 may be arranged within the housing 22 to contact the single-use fitting 16 as described herein. The boss 25 extends from the rib 24 and is arranged within the housing 22 to contact the multi-use fitting 14 as described below. The rib 24 can be defined along the edge of the sensor arm 20, and it terminates with the boss 25. As shown, the boss 25 may be generally cylindrical and extends generally perpendicular to the edge. The rib 24 and the boss 25 may have different widths relative to one another to facilitate their respective contacts with the single-use fitting 16 and multi-use fitting 14. The pivot arm 26 is located a distance away from the rib 24 and is arranged so that the sensor arm 20 rotates about the pivot arm 26 within the housing 22 between at least the first position, the second position, and the third position. As shown in Figs. 3-5, the pivot arm 26 extends perpendicular to the part of the rib 24 extending along the edge of the sensor arm 20 and parallel to axis of the boss 25. On one end, the pivot arm 26 may have a cross-section having a cross shape, and on an opposing end, the pivot arm 26 may be cylindrical. Other configurations and shapes may be appreciated, so long as the sensor arm 20 fits within the housing 22 and operates properly in the system 10 as described herein. A spring 28 or other biasing element may fit around one end of the pivot arm 26, which is shown as the cross-shaped end in the figures. The spring 28 biases the pivot arm 26 in one direction within the housing 22, urging the sensor arm 20 to rotate in that direction. When fully biased by the spring 28, the sensor arm 20 can be considered to be in a first position. In other

words, when the boss 25 and rib 24 are not contacted by the multi-use fitting 14 and/or the single-use fitting 16, the sensor 21 is in the first position. When the boss 25 and rib 24 are in contact with their respective features on the multi-use fitting 14 and/or single-use fitting 16, the sensor 21 can be considered to be at a second position and/or a third position, respectively.

[00146] The end of the pivot arm 26 that does not feature the spring 28 is hollow and holds the at least one magnet 30 therein. The circuit board 32 may be positioned adjacent from the magnet 30 and pivot arm 26, some distance away from both features, for example, in vicinity to detect changes in the magnetic field produced by the at least one magnet 30. The circuit board 32 contains electronics to sense the rotation or other movement of the magnet 30. This can be done by detecting the changes in the magnetic field created by the magnet 30 when it moves or rotates between at least the first, second, and third positions. The rotation of the magnet 30 is detected by the circuit board 32, for example, via the hall effect and is provided as an output of the system 10 to the controller to indicate the status of the system 10. While in the present embodiment, the magnet 30 is located within the pivot arm 26, it is contemplated that the magnet 30 and circuit board may be positioned in other locations on the sensor while still retaining the ability to sense change between at least the first, second, and third positions.

[00147] Referring to Fig. 3, the portion of the sensor 21 having the sensor arm 20, spring, 28, and magnet 30 may be located within a first space 34 within the housing 22. The portion of the sensor 21 having the circuit board 32 interacting with the magnet 30 and sensor arm 20 may be located in a second space 36. These spaces 34, 36 are fluidly isolated from each other to prevent damage to one or both sides of the sensor 32 in the case fluid leaks into the housing 22. In particular, this fluid isolation may protect the circuit board 32 from damage, as the fluid being injected by the injection system travels through the housing 22 in close proximity to the sensor arm 21 and circuit board 32. Because the circuit board 32 detects the changes in the magnetic field created by the magnet 30, the circuit board 32 and the magnet 30 do not need to be visible to one another or otherwise have an unobstructed path between them. Both spaces 34, 36 can take any shape so long as the sensor 21 is supported within the housing 22 and may freely move therein. In some embodiments, the sensor 21 may be located entirely within one space defined within the housing 22. To further protect the sensor 21, a cap 38 may be applied to the top of the sensor 21, surrounding the top portions of the rib 24, boss 25, and pivot arm 26, and the entirety of the spring 28. The cap 38 can take any shape so long as it provides some protection to the sensor arm 20. The cap 38 may also act as a rotational support for the pivot arm 26, allowing the pivot arm 26 to rotate within the housing 22.

[00148] As illustrated in Figs. 3, 6, and 7, in certain embodiments, a latch 40 may be disposed within the housing 22. The latch 40 may include a body 42 that defines a ramp 44 and a latch lip 48. Latch 40 is configured to engage and releasably lock the multi-use fitting 14 within interface 10. As shown in Fig. 6, the body 42 has a plate-like structure, with cylindrical ends that are affixed to corresponding ports within the housing 22. A spring 46 (Fig. 16) may be disposed within the housing 22 and extend generally perpendicular to at least a portion of the plate-like surface of body 42 in order to bias the body 42 in one direction. The body may also include a button 47. The button 47 is used to release the latch 40 and acts against the spring 46 to disengage the multi-use fitting 14 from the interface 10. Although shown in the drawings, it is to be understood that the latch 40 may not include the button 47 to configure a releasing of the latch 40. The latch 40 is disposed within another space 49 within the housing 22 that is separated from the other spaces 34, 36. With reference to Fig. 6 and 15, the housing 22 may include a clearance slot 23 that allows for tubing T that provides fluid communication between the one or more fluid reservoirs (not shown) the multi-use fitting 14, to also extend at least partially through the housing 22. The clearance slot 23 will align with other features in the multi-use fitting 14 and the single-use fitting 16 to disperse medical fluids as described herein.

[00149] With reference to Figs. 8-10, a multi-use fitting 14 according to certain embodiments is shown. The multi-use fitting 14 has an inlet 52 in fluid communication with a valve 54 that also at least partially define the fluid flow path FP (shown in Fig. 10) with the passage(s) in the housing 22. The valve 54 shown may be a swabable valve, which means that the valve 54 can be swabbed and cleaned with an alcohol pad or with other means prior to making any other connections. In other embodiments, the valve 54 may include at least one one-way valve or check valve allowing unidirectional fluid flow from the fluid reservoirs through the inlet 52 and exiting to the single-use tubing set through the at least one one-way valve when the single-use fitting 16 is engaged with the multi-use fitting 14. In certain embodiments, valve 54 may have threads so that a mating piece, such as the single-use fitting 16, can be releasably screwed into place about the valve to create a fluid-tight connection between the valve 54 and that mating piece. When not connected to another mating piece, the valve 54 may include a polymeric plug (e.g., the swabable cover having a silicon cover with a resealable slit) that seals the flow path defined by the valve to prevent the ingress of pathogens from the surrounding environment. Other valves and valve configurations known to those having skill in the art may also be used. A body 56 extends around the valve 54 to define a receiving space 58 with the valve 54. The body 56 may be arranged such that the inlet 52 extends in a proximal direction away from the body 56, and the valve 54 extends in a direction

opposite that of the inlet 52 within the body 56. It is to be understood that the inlet 52 and the valve 54 may extend in different directions at different angles relative to each other, so long as the functionality of the multi-use fitting 14 remains intact. As shown in Figs. 8 and 9, the body 56 may be cylindrical or any other complimentary shapes and defines receiving slots 60 at opposing points along the circumference of the cylindrical shape for receiving the multi-use fitting 14 into the interface 12. Next to the receiving slots 60 are engaging surfaces 62 for engaging with a corresponding feature on the interface 12, which may be flat relative to the rest of the body 56, as shown. The engaging surfaces 62 may be located on an outer surface of the body 56 opposing the inner surface that faces the valve 54. In other words, the engaging surfaces 62 may be considered to be on an outside surface of the body 56, while the valve 54 is located inside the body 56. Extending from the body 56, perpendicular to the inlet 52 and the valve 54, is a mounting flange including a mounting face 64. In certain embodiments, the mounting face 64 may be substantially flat and extends in a rectangular shape about the valve 54. Although shown as having a rectangular shape, the mounting face 64 may also take other shapes, such as a, circular, square, diamond with tapered ends, etc. The mounting face 64 may terminate with a mounting lip 66 extending about at least a portion of the perimeter of the mounting face 64. The mounting lip 66 may substantially correspond in shape with the latch lip 48 to secure the multi-use connector 14 to the interface 12 as described herein. The receiving slots 60, engaging surfaces 62, mounting face 64, and mounting lip 66 may be arranged symmetrically relative to the body 56 to allow for easier use of the multi-use fitting 14. In particular, the symmetrical nature of these features allows the multi-use fitting 14 to be oriented and applied to the housing 22 easily and in two or more different ways. In other embodiments, for example, if the mounting face 64 is substantially circular, the symmetry of the multi-use fitting may allow the fitting to be installed without concern of the orientation (e.g., orientation-free) of the multi-use fitting 14 relative to the interface 12. The shape of the mounting face 54 may be chosen with this symmetrical arrangement in mind, meaning that different shapes of the mounting face 54 may be used so long as those shapes provide for some symmetry about the body 56. The symmetry allows for a user to easily orient the multi-use fitting 14 relative to the housing 22.

[00150] With reference to Figs. 11 and 12, an embodiment of a single-use fitting 16 is shown. The single-use fitting 16 may include a shroud 72, which is cylindrical in shape and extends about a connector 74. The shroud 72 may serve to prevent inadvertent contact with the fluid connector 74, for example preventing touching of connector 74 while preparing the system for a fluid injection procedure. In certain embodiments, the shroud 72 may engage and

activate sensor 21 moving it to the third position when attached to the multi-use fitting 14 and interface 12. The connector 74 is configured to fluidly and releasably connect to the valve 54 of the multi-use connector 14 and is an example of the mating piece discussed above. Thus, the connector 74 may include complementary connecting means, such as corresponding threads to those on the valve 54. The shroud 72 is located a distance away from the connector 74, which defines a space 76 with the connector 74. The space 76 may be sized to prevent insertion of a fingertip or other potential contamination element into the space 76. An outlet 78 extends from the shroud 72 in a direction opposite that of the connector 74. The outlet 78 is configured to fluidly connect to a patient tubing interface, such as a tubing and distal connector for connecting to a catheter inserted into the patient's vasculature system for directing the medicament to the patient. The connector 74 and outlet 78 may also at least partially define the fluid flow path that is in line with the fluid flow paths in the multi-use fitting 14, multi-use tubing set, and housing 22. Within the fluid flow path, may be at least one check valve 77 that is provided to prevent reverse flow from the single-use tubing into the multi-use tubing and contamination of the multi-use set 14 with bodily fluids of the patient. In some embodiments, check valve 77 may include two check valves 77.

[00151] With reference to Figs. 13-19, the assembly and disassembly of the connection system 10 and the sensing of these actions will now be described. The multi-use fitting 14 slides into and releasably connects with the latch 40 in the housing 22 of the interface 12 as shown in Figs. 13-15. According to these embodiments, the mounting face 64 of multi-use fitting 14 slides in the direction of the arrows as shown in Fig. 13 into receiving space 49 of interface 12 to engage latch 40. Once the multi-use fitting 14 is installed and sensed by the sensor 21 of the interface 12, the single-use fitting 16 is then engaged to the multi-use fitting 14, moving in a linear direction that is perpendicular to the sliding direction of the multi-use fitting. In embodiments where the connection mechanism includes threading, the single-use fitting 16 is engaged using a corkscrew motion, having some rotational and some linear movement. The linear movement of the single-use fitting 16 is shown by the arrows in Fig. 17.

[00152] More specifically, as shown in Figs. 13-16, the multi-use fitting 14 slides into the housing 22, such that one end of the mounting face 64 and its corresponding mounting lip 66 enter the space 49 within the housing 22 that holds the latch 40. The mounting lip 66 is arranged along the end of the mounting face 64, such that part of the mounting lip 66 will slide up the ramp 44 of latch 40 and eventually engage with and lock into place against the latch lip 48 as the multi-use fitting 14 slides within the housing 22. In certain embodiments, the engagement between the mounting lip 66 and the latch lip 48 may provide audible or tactile feedback to a

user to signal a secure connection. In other embodiments, the engagement between the mounting lip 66 and the latch lip 48 may activate sensor 21, moving sensor arm 20 from the first position to the second position, causing the sensor 21 to send a signal to the controller that the multi-use fitting 14 is engaged with the interface 12. The controller may then indicate to the user, for example by a pop-up window on a screen (GUI) associated with the fluid injector, change in lighting, or other audible or visual indication, that the multi-use fitting 14 is engaged. As this movement is occurring, the other elements of the multi-use fitting 14 are being received within the housing 22. In particular, the body 56 moves within the housing 22, so that the engaging surface 62 contacts the boss 25 of the sensor arm 20. This contact moves the sensor arm 20 from the first position toward the second position. The contact also occurs prior to the mounting lip 66 engaging with the latch lip 48. As the mounting lip 66 continues to move up the ramp 44, the engaging surface 62 pushes against the boss 25, rotating the sensor arm 20 about the pivot arm 26. This action rotates the magnet 30, and the circuit board 32 senses that movement of magnet 30 to indicate movement from the first position towards and, ultimately, into the second position. This sensing can then be outputted to the controller to indicate some engagement between the multi-use fitting 14 and the interface 12 as indicated. When the mounting lip 66 is fully engaged with the latch lip 48, the engaging surface 62 remains in contact with the boss 25, but rotation of the sensor 21 stops. At this point, the sensor 21 has rotated a defined number of degrees in a direction against the biasing force of the spring 28, and the sensor arm 20 is in the second position. In one embodiment, the rotation may be any suitable arc, for example from 5-9°. This rotation is sensed by the rotation of the magnet 30 relative to the circuit board 32, and this sensing that the sensor arm 20 is fully in the second position can then be outputted to the controller to indicate that the multi-use fitting 14 is fully engaged with the interface 12. The sensor 21 can also sense when multi-use fitting 14 is only partially engaged with interface 12, which can also be outputted to the controller, which may then notify the user by a signal, for example by a pop-up window on a screen (GUI) associated with the fluid injector, change in lighting, or other audible or visual indication. This allows user of system 10 to know when multi-use fitting 14 is not fully engaged with interface 12.

[00153] Next, as shown in Figs. 17 and 18, the single-use fitting 16 is moved to connect with the multi-use fitting 14 and the interface 12. The single-use fitting 16 is aligned so that the connector 74 can mate with the valve 54, for example, by threadable connection. This places the shroud 72 within the space 58 formed between the body and the valve 54. The shroud 72 may also rotate as the connector 74 rotatably connected with the valve 54. The shroud 72 may be shaped such that it extends through the space 58 and receiving slots 60 formed in the body

56 when the connector 74 is connected to the valve 54. The extension of the shroud 72 into the receiving slots 60 and the placement of the receiving slots 60 next to the engaging surfaces 58 means that the end of the shroud 72 contacts the rib 24 of the sensor arm 20 of the sensor 21, indicating that the single-use fitting 16 is being installed by moving the sensor arm 20 from the second position towards the third position. As the connector 74 is completely connected with the valve 54 and a fluid-tight connection is formed, the shroud 72 extends further into the receiving slots 60, where it contacts and pushes the rib 24 off of the engaging surface 62. This contact moves the sensor arm 20 from the second position to the third position. This rotates the sensor 21 further about the arm 26 compared to rotation caused by the multi-use fitting 14 and results in additional sensing that the connection assembly is fully engaged and fluidly connected. As shown in Fig. 18, the sensor 21 has rotated an additional number of degrees against the biasing force of the spring 28 and has moved an additional distance within the housing 22 to the third position. In one embodiment, the rotation can be an additional 5-9° beyond the rotation already occurred by installation of the multi-use fitting 14. When the connector 74 is fully mated with the valve 54, the shroud 72 will have moved the sensor 21 arm, so that the sensor arm 21 is in the third position. The sensor 21 can provide an output to the controller, for example by a pop-up window on a screen (GUI) associated with the fluid injector, change in lighting, or other audible or visual indication, indicating that the single-use fitting 16 is fluidly connected to the multi-use fitting 14 within the interface 12. The sensor 21 may also provide an output, for example by a pop-up window on a screen (GUI) associated with the fluid injector, change in lighting, or other audible or visual indication, to indicate that the single-use fitting 16 is in the process of being connected to the multi-use fitting 14 before the connector 74 is fully mated with the valve 54 or if the single-use fitting 16 is incorrectly connected to the multi-use fitting 14. When the controller receives a signal from sensor 21 that the single-use fitting 16 and the multi-use fitting 14 are correctly and fluidly connected, the controller may, in certain embodiments, initiate an auto-priming sequence to prime the tubing set and remove substantially all the air from the tubing set or, in other embodiments, indicate to the user that the system is ready for a priming operation. When the controller receives a signal from sensor 21 that the single-use fitting 16 and the multi-use fitting 14 are not correctly connected, the controller may signal the user that a setup fault has occurred, and the fluid injector system is not ready for priming and that the user must correct the fault before proceeding with the injection protocol.

[00154] It is further contemplated that different kinds of single-use fittings 16 can be mated to the multi-use fitting 14. To detect the different types of single-use fittings 16, each type of

single-use fitting 16 may include a shroud 72 with a uniquely sized outer diameter. According to these embodiments, the differently sized shrouds 72 will push the rib 24 different amounts, and this will cause the rib 24 to rotate different amounts of degrees within the housing 22. The circuit board 32 can detect these differences in rotation of the magnet 30 to identify the specific single-use fitting 16 in use. These features are described in greater detail with the embodiment described in connection with Figs. 32-41 and 45-47. One having ordinary skill in the art will appreciate that those disclosures can also be applied similarly to this embodiment with multi-use fitting 14 and different single-use fittings 16.

[00155] As illustrated in Fig. 19, withdrawing the fittings 14, 16 from the interface 12 can be done by, in one embodiment, simply pulling the multi-use fitting 14 from the housing 22 or, in another embodiment, pressing the button 47 to release the latch 44, which disengages the mounting lip 66 from the latch lip 48 and pulling the multi-use fitting 14 from the housing 22. This allows the multi-use fitting 14 to be pulled out of the housing 22 in the opposite direction from which it entered. The single-use fitting 16 may remain engaged with the multi-use fitting 14 during this disassembly, although this is not required, as throughout a series of injection procedures, the single-use fitting 16 of several single-use fittings 16 will be engaged and disengaged from the multi-use fitting 14. As the multi-use fitting 14 is pulled out of the housing 22, the shroud 72 and the engaging surface 62 pull away from the rib 24. This allows the spring 28 to act on the sensor 21 and rotate the sensor 21 back in the direction of the first position within the housing 22. The circuit board 32 also detects this rotation of the magnet 30. This allows for an output, telling an administrator that the multi-use fitting 14 and the single-use fitting 16 have been removed from the interface 12. The single-use fitting 16 may also be removed on its own by disengaging the connector 74 with the valve 54, which is also detected by the sensor 21. When the single-use fitting 16 is removed, the shroud 72 is moved away from the rib 24, allowing the spring 28 to bias the rotating the rib 24 back into the second position from the third position. This rotation is also detected by the circuit board 32 given its position relative to the magnet 30 and a signal is sent to the controller indicating that the system 10 is ready for attachment of the next single-use connector fitting 16.

[00156] The different sensor outputs allow an administrator to take an appropriate action to the interface 12 such as allowing or preventing the next step in the injection procedure. Such an action may be to replace the single-use fitting 16. For example, after the system 10 is used in an injection, the injector system may be prevented from dispensing additional medicament until the sensor 21 senses that the used single-use fitting 16 has been removed and replaced with a new single-use fitting 16. The injector may also have certain indicators, telling an

administrator that the fluid injector is prepared to perform an injection procedure when a single-use fitting 16 is detected as being connected to the multi-use fitting 14 with an injection having yet to be made with that single-use fitting 16. The injection system may also have control over the dispersal of the medicament such that dispersal is prevented when the single-use fitting 16 and/or multi-use fitting 14 are not detected within the interface 12.

[00157] With reference to Figs. 20-47, another embodiment of a connector system according to the present disclosure, including connection system 110 is shown. Various similar features of this embodiment and the embodiment illustrated in Figs. 1-19 and described herein, may not be discussed in detail and it will be understood that the previous descriptions of the similar feature may apply when appropriate. This connection system 110 includes an interface 112, a multi-use fitting 114, and a single-use fitting 116 that are used in a similar manner to the system 10 previously described. The multi-use fitting 114 can be used for multiple injection procedures before being replaced, whereas the single-use fitting 116 is intended to be used once and is replaced within the system 110 after a single injection procedure. A dust cap 216 may also be used in this system 110 and in various embodiments of system 10, which will be described herein. The dust cap 216 can also be used multiple times, for example, the dust cap 216 may be attached to the multi-use fitting 114 between injection procedures to limit contact between atmospheric contaminants and the inner bore 142 of the multi-use fitting 114. As described herein, the interface 112 holds a sensor 127 that can detect when the multi-use fitting 114, single-use fitting 116, and dust cap 216 are properly connected to each other and interface 112.

[00158] With reference to Figs. 20-25, the interface 112 and its various associated features are shown. The interface 112 includes a housing 120 shaped to receive one or more of the multi-use fitting 114, the single-use fitting 116, the sensor 127, and the dust cap 216. The housing 120 includes a first portion 120A and a second portion 120A that, as shown in Fig. 24, are separate parts connected with fasteners F via apertures A (only some labeled for clarity). In some embodiments, the housing 120 may be made of a single part capable of defining the receiving spaces discussed below and holding the relevant parts of the multi-use fitting 114, single-use fitting 115, sensor 127, and dust cap 216, which are also discussed below. With reference to Fig. 21, the housing 120 defines a first receiving space 121 for holding at least a portion of the multi-use fitting 114 and at least a portion of the single-use fitting 116. The first portion 120A of the housing 120 defines the majority of the first receiving space 121. With reference to Fig. 22, the first receiving space 121 may be understood to be a front receiving space given its arrangement at the front of the interface 112. The first receiving space 121 is delineated with a backwall 122. The backwall 122 includes a first portion 122A that is defined

by the first portion 120A of the housing 120 and a second portion 122B that is defined by a second portion 120B of the housing 120. The first portion of the backwall 122A defines an opening 123 through which at least a part of the sensor 127 extends and is exposed within the first receiving space 121. The backwall 122 and the first portion of the housing 120A both partially define a first depression 124 and a second depression 125 at opposing ends of the receiving space 121. The first depression 124 and the second depression 125 are arranged to, respectively, receive or partially surround parts of the single-use fitting 116 and the multi-use fitting 114. The first depression 124 and the second depression 125 may also be arranged to receive parts that are connected to single-use fitting 116 and multi-use fitting 114, such as tubing T or other features arranged to deliver medical fluid through connection system 110.

[00159] With reference to Fig. 24, the housing 120 also defines a second receiving space 126 shaped to hold the sensor 127. As shown, the second receiving space 126 is defined within the second portion of the housing 120B. The second receiving space 126 is located on a side of the first portion of the housing 120A opposing the first receiving space 121. In some embodiments, the first portion of the housing 120A may also partially define the second receiving space 126. Because of this, the second receiving space 126 may be understood to be a first rear receiving space. As shown in Fig. 25, an embodiment of the sensor 127 includes a lever 128, a pivot arm 130, and a biasing member, such as spring 132. An end of the lever 128 extends into the front receiving space 121 via the opening 123 in backwall 122. The lever 128 is arranged to at least partially engage with portions of one or more of the multi-use fitting 114, the single use fitting 116, and the dust cap 216 via the opening 123. This engagement rotates the lever 128 about the pivot arm 130 between at least a first position, a second position, a third position, and a fourth position, and the sensor 127 is configured to detect this rotation to determine various engagements between the interface 112, the multi-use fitting 114, the single-use fitting 116, and/or the dust cap 216, which will be discussed herein. The spring 132 may be wrapped around a portion of the lever 128 to bias the lever 128 against the direction of engagement so that in the absence of an engaging force, the lever 128 is biased to the first position. The movement of the lever 128 between the different positions signifies engagement, or lack of engagement, with one or more of the multi-use fitting 114, single-use fitting 116, and/or the dust cap 216. In the first position, the lever 128 is not engaged by any other element and is fully biased by the spring 132, so that it fully protrudes through the opening 123 and into the first space 121.

[00160] With reference to Fig. 23, the housing 120 further defines a third receiving space 134 shaped to hold additional parts of the sensor 127, such as a circuit board or other electronics

136 (referred to herein as only the “circuit board 136”). The third receiving space 134 is located on a side of the housing 120 opposing the first side receiving space 121. Because of this, the third receiving space 134 may be understood to be a second rear receiving space. In other words, when the first portion of the housing 120A, and the second portion of the housing 120B are connected via fasteners F, the third receiving space 134 is on the side that opposes the first receiving space 121. The third receiving space 134 may be a space defined within the second portion of the housing 122B, similar to the second receiving space 126, or the third receiving space 134 may be defined by alignment parts 135 as shown in Fig. 23. Alignment parts 135 are shaped to hold parts of the circuit board 136 therein, so that fasteners F can be used to secure the circuit board 136 to the second portion of the housing 120B. This is shown in Figs. 23 and 24. As shown in Fig. 23, third receiving space 134 may also be considered a receiving area.

[00161] The third receiving space 134 is fluidically sealed from the first receiving space 121 and the second receiving space 126. Various sidewalls, sealants, or other features in the rear side of the interface 112 can be used to fluidly seal the third receiving space 134. As shown, the second portion of the housing 120B maintains the fluid separation between the third receiving space 134/circuit board 136 and the second receiving space 126/sensor 127. The circuit board 136 is arranged to interact with a magnetic field of magnet 138 that is disposed within the pivot arm 130. As shown in Fig. 25, the magnet 138 is disposed in an end of the pivot arm 130, but in other embodiments, the magnet 138 may be arranged elsewhere within the sensor 127, so long as it can interact with the circuit board 136 in such a way to indicate the various positions (e.g., first, second, third, and fourth positions). The circuit board 136 is disposed a distance away from the magnet 138, for example, in vicinity to detect changes in the magnetic field produced by the magnet 138, and it is arranged to sense the rotation or other movement of the magnet 138 via the changes in the magnetic field created by the magnet 138. The rotation of the pivot arm 130 created by rotation of the lever 128 also rotates the magnet 138 between at least the first, second, third, and fourth positions. This rotation changes the magnetic field of the magnet 138, which interacts with the circuit board 136, for example via the hall effect, is sensed by the circuit board and signals are sent to a controller indicated the extent of the rotational change in the magnetic field of magnet 138, corresponding to positional movement of the system 110 between at least the first position, the second position, the third position, and the fourth position. In other words, the magnet 138 creates a magnetic field, and the circuit board 136 includes electronics that can sense the change in that magnetic field that occurs during rotation of the magnet 138 that is caused by rotation of the lever 128. This sensing can then be outputted to an administrator via the controller of the injection system to know the

status of the system 110. Because the circuit board 136 detects the changes in the magnetic field created by the magnet 138, the circuit board 136 and magnet 138 do not need to be visible to one another or otherwise have an unobstructed path between them.

[00162] Figs. 26-28 show the multi-use fitting 114 according to various embodiments. The multi-use fitting 114 includes a body 140, and the body 140 defines an inner bore 142 and an outer bore 143 surrounding the inner bore 132. At least a portion of the outer bore 143 defines opposing outer edges 147 that at least partially define a slot 146 between those edges 148. Opposing flat surfaces of outer edges 148 extends from the body 140 and also at least partially define the slot 146. Opposing curved surfaces 149 extend, respectively, from the opposing flat surfaces 148 to further define the slot 146. The curved surfaces 149 are arranged to contact the lever 128 of sensor 127 when the multi-use fitting 114 is being secured within the first space 121 of the interface 112. The curved surfaces 149 cause the lever 128 to be moved from the first position towards the second position as the multi-use fitting 114 is engaged with the interface 112. The second position signifies the connection between the multi-use fitting 114 and the interface 112 has been correctly achieved. As the multi-use fitting 114 is in the process of connecting with the interface 112, the lever 128 moves between the first position and the second position, and the sensor can detect the partial engagement of the multi-use fitting 114 with the interface 112 by partial movement of the lever 128 towards the second position. The flat surfaces 148 are arranged relative to the curved surfaces 149 to ensure that the multi-use fitting 114 fits easily within the housing 120 of the interface 112. The flat surfaces 148 ensure that the multi-use fitting 114 is properly aligned within the first receiving space 121, so that the curved surfaces engage with the lever 128. The alignment also ensures that retaining ribs 153, located on wings 150, which are both discussed below, are properly received within the first receiving space 151 and aligned with retaining lips 154, which are also discussed below. The extension of the flat surfaces 148 from the body 140 and into the receiving space 121 also prevents rotation of the multi-use fitting 114 relative to the interface 112. In other words, the flat surfaces 148 extend into the receiving space 121, so that they are held within parts of the backwall 122 that prevent rotation of the multi-use fitting 114. This ensures that the curved surfaces 149 are always properly aligned to be engaged with the lever 128 and that forces applied to the multi-use fitting 114 and interface 112 do not interfere with the engagement between the curved surfaces 149 and the lever 128. This allows for an easier and more efficiently engagement between the curved surfaces 149 and the lever 128. The sensor 127 may then send a signal to the controller once the lever 128 is in the second position to indicate that the multi-use fitting 114 is fully engaged with the interface 112. If the sensor 127 detects

incomplete movement towards the second position, the sensor 127 may then send a signal to the controller to indicate that the multi-use fitting 114 is not fully engaged with the interface 112 and the controller may warn the user to check the connection between the multi-use fitting 114 and the interface 112.

[00163] With reference to Fig. 28, the inner bore 142 defines a fluid flow path FP to receive the medical fluid from the injection system provided via tubing T. The tubing T may at least partially fit within the second depression 125 (see Fig. 22) defined by the interface 112. With reference to Figs. 26 and 27, the body 140 of the multi-use fitting 114 includes flexible wings 150 extending from the outer bore 143. The flexible wings 150 are configured to releasably secure the multi-use fitting 114 to the interface 112. The flexible wings 150 include tapered leading edges 152 that can flex and fit within the first space 121 of the housing 120 as the multi-use fitting 114 is inserted into the first space 121. The tapered leading edge 152 of flexible wing 150 includes retention rib 153 to secure the multi-use fitting 114 within the housing 120. The housing 120 includes retaining lips 154 that are complementary to the retaining ribs 153. The retaining lips 154 are profiled to engage the retaining ribs 153 as the flexible wings 150 are flexibly biased during insertion into first space 121 to keep the flexible wings 150 within the interface 112, so that the multi-use fitting 114 can be secured within the interface 112. The retaining ribs 153 are also arranged to be properly engaged with the retaining lips 154 due to the alignment provided by the flat surfaces 148 within the first receiving space 121. Finger presses 155 are located proximate the ends of the wings 150 opposite the tapered leading edges 152. The finger presses 155 allow for a user to press the ends of the wings 150 together, so that the wings 150 can be bent to fit into the first receiving space 121. When the finger presses 155 are disengaged by the user, when the multi-use interface 114 is fully placed within the first receiving space 121, the flexible wings 150 are biased outward engaging the retaining ribs 153 against the retaining lips 154. This action aligns the retaining ribs 153 with the retaining lips 154 and the retaining lips 154 prevent the multi-use fitting 114 from being removed from the first space 121 without the user flexing the flexible wings 150 towards each other to disengage the retaining ribs 153 from the retaining lips 154 of first space 121. With reference to Fig. 26, a flat finger press 156 is also present on the body 140 to allow a user to push the multi-use fitting 114 into the housing 112 to further facilitate the engagement between the two features. Next to the finger press 156 is a socket 156 for receiving locking lever 182 of the single-use fitting 116, so that the single-use fitting 116 can be connected and releasably secured to the multi-use fitting 114.

[00164] With reference to Figs. 29-31, embodiments of a single-use fitting 116 according to the present disclosure is shown. The single-use fitting 116 includes a body 160 having a connector 162 extending in the proximal direction and an outlet 164 extending in the distal direction. The outlet 164 is located within an outer shell 166 of the body 160 where the outer shell is configured for easy gripping by the user. The connector 162 is configured to mate with the multi-use fitting 114, described herein to define the fluid flow path FP with the outlet 164. The fluid flow path FP of the single-use fitting 116 extends through the connector 162, the body 160, and outlet 164. The outlet 164 may be connected to a single-use tubing component T that provides fluid communication with a distal connector element that connects to a needle or catheter to provide fluid communication with a patient's vasculature system. The connector 162 is shaped to fit between the inner bore 142 and the outer bore 143, surrounding the inner bore 142 of the multi-use fitting 114 and fluidly connect the single-use fitting 116 with the multi-use fitting 114. The inner bore 142 and connector 162 may have corresponding locking and sealing elements, such as one or more o-rings 163 (shown in Fig. 31) to facilitate this connection and provide a fluid tight seal. In one embodiment, the inner bore 142 of the multi-use fitting 114 may act as a male fitting, and the connector 162 of the single-use fitting 116 may act as a female fitting. In another embodiment, the inner bore 142 of the multi-use fitting 114 may act as the female fitting, and the connector 162 of the single-use fitting 116 may act as the male fitting. The arrangement of these features may take any form, so long as the functionality of interface 112, multi-use fitting 114, and single-use fitting 116 remains. Outer shell 166 may also define a bottom opening 170 and a rear opening 172 that allow for a user to grab and interact with single-use fitting 116 and allow access to different features on body 160.

[00165] With reference to Figs. 30 and 31, a flange 174 extends from the bottom of the connector 162 and extends along the connector 162 such that it is parallel to the longitudinal axis L of the connector 162. The flange 174 has an edge 176 that includes a vertical portion 178 that extends perpendicular to the longitudinal axis L of the connector 162 and a slanted portion 180 that extends from the vertical portion 178 at a non-orthogonal angle relative to the longitudinal axis L. As shown in Fig. 31, the fluid flow path FP defined by the single-use fitting 116 also extends along the longitudinal axis L. However, other arrangements are contemplated, such as a fluid flow path within the single-use fitting 116 that has a path that extends around, above, or below the longitudinal axis L. The edge 176 is arranged to engage with the lever 128 of the sensor 127 and displace the lever 128 as the single-use fitting 114 is engaged with the multi-use fitting 114 and the interface 112, which causes the sensor 127 to detect this engagement by movement of the lever 128 from the second position toward the third position

via the methods described herein. In some embodiments, the slanted portion 180 is arranged to displace the lever 128, and in other embodiments, the vertical portion 178 may be arranged to displace the lever 128. In additional embodiments, both portions 178, 180 may displace the lever 128. With reference to Fig. 30, a flexible locking lever 182 extends from the body 160 and includes a bent shape to releasably engage and lock the tapered leading edge 184 within the socket 156 of the multi-use fitting 114. The flexible locking lever 182 may flex downward and then snap into socket 156 to lock the single-use fitting 116 with the multi-use fitting 114. To disengage the single-use fitting 116 from the multi-use fitting 114, a user may press down on a top surface or a finger press 186 of the flexible locking lever 182 to disengage the tapered leading edge 184 from the socket 156 and allow removal of the single-use fitting 116 from the multi-use fitting 114. With reference to Figs. 29 and 31, a stop 181 extends downward from the body 160 proximate the bottom opening 170. The stop 181 extends away from the body 160 beyond the flange 174 and is arranged to act against the interface 112 when the single-use fitting 116 is engaged in the system 110, so that the single-use fitting 116 only extends a certain distance into the multi-use fitting 114 and interface 112 during engagement and use. A portion of the flange 174 may be connected to the stop 181. In certain embodiments, the locking lever 182 may operate similarly to the wings 150, having a retaining rib that engages with a corresponding retaining lip within the socket 156. Other methods of securing the locking lever 182 within the socket 156 may also be used.

[00166] With reference to Figs. 32-41, the assembly and disassembly of the connection system 110 is illustrated and described. Generally, the multi-use fitting 114 is pressed into and connects with the housing 120 of the interface 112, as shown in Figs. 32-36. The multi-use fitting 114 is pressed into the housing 120 in the direction of the arrows shown in Figs. 32 and 33. In certain embodiments, the user may apply a pinching force to the flexible wings 150 to assist engagement with interface 112. Single-use fitting 116 is then pressed into place within multi-use fitting 114, with the locking lever 182 being engaged with the socket 156, moving in a direction that is perpendicular to the movement of multi-use fitting 114 when it connects with housing 120. Movement of single-use fitting 116 is shown by the arrows in Figs. 37-39.

[00167] More specifically with reference to Figs. 32-36, the multi-use fitting 114 is aligned with and pushed into the first receiving space 121 of the housing 120. The first receiving space 121 is shaped to receive the flexible wings 150 as described herein; however, the shape is such that the wings 150 must be inwardly flexed to be secured within the opening 138. In other words, the wings 150 must be bent, which is facilitated by the tapered leading edges 152 and finger presses 154. A user presses down on the finger presses of the wings and inwardly flexing

the flexible wings 150 so that the body 140 of the multi-use fitting 114 fits within the opening 138. The flexible wings 150 and the first receiving space 121 are shaped, so that when the flexible wings 150 are released, the retention ribs 153 are aligned with the retention lips 155 of the housing 120. A restoring force on the flexed wings 150 cause the retention ribs 153 to engage with the retention lips 155 to releasably secure the multi-use fitting 114 within the housing 120. The release of the wings 150 may also provide audible and tactile feedback when the retention ribs 153 are engaged with the retention lips 155. The user may also align the multi-use fitting 114 within the housing 120 and then press on the flat finger press 158 until the multi-use fitting 114 snaps into place within the housing 120. Audible and tactile feedback may again signal the engagement of the multi-use fitting 114 with the housing 120.

[00168] The body 140 is arranged such that when the multi-use fitting 114 is pushed into the housing, the curved surfaces 149 are aligned with the portion of the lever 128 of the sensor 127 exposed within the first opening 121. The pushing of the multi-use fitting 114 into the opening 121 leads to contact between at least one of the curved surfaces 149 of the multi-use fitting 114 and the lever 128 of the sensor 127. This contact rotates the lever 128 about the pivot arm 130 from the first position toward the second position, causing the circuit board 136 to detect the rotation of the magnet 138. A certain amount of contact leads to a certain degree of rotation of the lever 128 against the spring 132. This degree of rotation can correlate to a partial or full engagement of the multi-use fitting 114 with the interface 122. In one embodiment, the lever 128 may rotate 5-7°. As noted above, the lever 128, when disengaged from any part of the multi-use fitting 114, can be considered to be in a first position due to the biasing force of spring 132. When the lever 128 is fully engaged with the curved surfaces 149 of the multi-use fitting, the lever 128 is moved into a second position that is detected by the sensor 127. When the lever 128 is only partially engaged with the curved surfaces 149 of the multi-use fitting, the lever 128 is between the first position and the second position, indicating that multi-use fitting 114 is not fully engaged with the interface 112. Corresponding signals related to the position of lever 128 and the state of the system are communicated by sensor 127 to the controller.

[00169] As shown in Figs. 37-40, the single-use fitting 116 can then be aligned with the multi-use fitting 114 and inserted into place. To do this, the connector 162 is aligned with the inner bore 142, and the locking lever 168 is aligned with the socket 156. The flange 174 is arranged on the connector 162, so that when the connector 162 and bore 142 and the locking lever 168 and socket 156 are aligned, the flange 174 of the single-use fitting 116 will be received within the slot 146 between the flat surfaces 148 and curved surfaces 149 of multi-use fitting 114. When the single-use fitting 116 is inserted into the multi-use fitting 114, the

connector 162 mates with the bore 142, and the flexible locking lever 182 of the single-use fitting 116 is flexed to fit into the socket 156 of the multi-use fitting 114. The locking lever 182 has a shoulder 188 and/or a lip 189 that engage with part of the socket 156 to releasably lock the locking lever 168 in the socket 156, thereby locking the single-use fitting 116 with the multi-use fitting 114. There may also be audible or tactile feedback when the socket 156 receives the locking lever 168 to signal a connection. The inserting of the single-use fitting 116 into the multi-use fitting 114 pushes the flange 174 through the slot 146 of the multi-use fitting 114. Because the slot 146 is arranged between the curved surfaces 149, the flange 174 extends through the slot 146 to engage with the lever 128 of sensor 127. This engagement occurs throughout the connection process and displaces the lever 128 farther away from the curved surfaces 149 and rotates the lever 128 about the arm 126 from the second position to the third position, an additional degree beyond the rotation already created by the curved surfaces 149 of the multi-use fitting 114. This additional rotation rotates the magnet 130, which the circuit board 132 detects. When the single-use fitting 116 is fully connected to the multi-use fitting 114, the flange 174 moves the lever 128 from the second position completely to the third position. The rotation can then be output to the controller, for example by a pop-up window on a screen (GUI) associated with the fluid injector, change in lighting, or other audible or visual indication, indicating that the single-use fitting 116 is fluidly connected to the multi-use fitting 114 within the interface 112 in ways already discussed herein. When the single-use fitting 116 is in the process of being connected to the multi-use fitting 114, the rotation of the lever between the second position and the third position can also be output to an administrator, signaling that the single-use fitting 116 is only partially connected to the multi-use fitting 114 or if the single-use fitting 116 is incorrectly connected to the multi-use fitting 114. When the controller receives a signal from sensor 127 that the single-use fitting 116 and the multi-use fitting 114 are correctly and fluidly connected, the controller may, in certain embodiments, initiate an auto-priming sequence to prime the tubing set and remove substantially all the air from the tubing set or, in other embodiments, indicate to the user that the system is ready for a priming operation. When the controller receives a signal from sensor 127 that the single-use fitting 116 and the multi-use fitting 114 are not correctly connected, the controller may signal the user that a setup fault has occurred and the fluid injector system is not ready for priming and that the user must correct the fault before proceeding with the injection protocol.

[00170] Upon completion of an injection procedure, the single-use fitting 116 may be removed from the multi-use fitting 114 and interface 112 by pressing on the flexible locking lever 182 of the single-use fitting 116 in the socket 156 of the multi-use fitting 114 to disengage

the shoulders 188 or lip 189 from the socket 156 to unlock the locking lever 168 from the socket 156, thereby unlocking the single-use fitting 116 with the multi-use fitting 114. The single-use fitting 116 may then be removed from the multi-use fitting 114 by pulling the single-use fitting 116 out of the multi-use fitting 114/interface 112 assembly. As the single-use fitting 116 is removed, the lever 128 of sensor 127 is biased by the spring 132 back to the first position, indicating to the controller that the fluid injector system is ready to begin the connection set up for the next injection procedure.

[00171] Withdrawal of both fittings 114, 116 from the interface 112 may be done by removing the multi-use fitting 114, as shown in Fig. 41. Removal of the multi-use fitting 114 occurs by inwardly flexing the flexible wings 150 to disengage the retention ribs 153 from the retention lips 155, so that the multi-use fitting 114 can be removed from the first receiving space 121 in the housing 120. Here, the single-use fitting 116 may still remain engaged with the multi-use fitting 114 and is also removed from the interface 112. The single-use fitting 116 can then be removed by deforming the locking lever 168 and pulling the single-use fitting 116 out of the multi-use fitting 114, disconnecting the connector 162 from the bore 142. Alternatively, the connected assembly of fittings 114 and 116 may be discarded into the waste in the assembled state. The biasing of the spring 132 will move the lever 128 back into its previous positions during disassembly of the system 110, whether that disassembly involves both the multi-use fitting 114 and single-use fitting 116 being removed at once, or only the single-use fitting 116 being removed from the multi-use fitting 114.

[00172] With reference to Figs. 42-44, certain embodiments including a dust cap 216 for the multi-use fitting 114 are shown. The dust cap 216 can also connect to the multi-use fitting 114 to provide contamination protection in between injection procedures, so that the multi-use fitting 114 can be reused within the system 110 with multiple different single-use fittings 116. The dust cap 216 includes a body 262 having a connector 264 extending in a first direction and a closed end 266 extending in a second direction opposite that of the connector 264. A divider 268 extends within the interior of the body 262 to isolate the connector 264 from the closed end 266. The connector 264 is configured to mate with the bore 142 of the multi-use fitting 114 to cover the multi-use fitting 114 and prevent the bore 142 from being accessed or otherwise contaminated by any environmental factors when not connected to a single-use fitting 116. Instead of defining a fluid flow path, like single-use fitting 116, the dust cap 216 acts as a cap on the multi-use fitting 114, with the divider 268 serving as an end to any fluid flow path FP that is defined in the multi-use connector 114 (see, Fig. 46).

[00173] A flange 270 extends from the connector 264 and extends along the connector 264 such that it is parallel to the longitudinal axis of the connector 264. The flange 270 has an edge 272 that includes a vertical portion 274 that extends perpendicular to the longitudinal axis L' of the connector 264 and an angled portion 276 that extends from the vertical portion 274 at a non-orthogonal angle relative to the longitudinal axis L'. The vertical portion 274 includes a notch 275. The edge 272 is arranged to engage with the lever 128 of sensor 127 and displace the lever 128, which causes the sensor 127 to detect this engagement via the methods described herein. The notch 275 also engages with the lever 128. In some embodiments, the angled portion 276 is arranged to displace the lever 128, and in other embodiments, the vertical portion 276 may be arranged to displace the lever 128. In additional embodiments, both portions 274, 276 may displace the lever 128. The flange 270 extends forward a length away from the connector 264 that is different from the length flange 174 extends from connector 162 on the single-use fitting 114. The difference in these lengths allows for the sensor 127 to differentiate between the single-use fitting 116 and the dust cap 216 when they are connected to the multi-use fitting 114. For example, the flange 270 engages the lever 128 of the sensor 127 and displaces the lever from the second position (due to the multi-use fitting 114 being engaged with the sensor 127) to a fourth position, beyond the third position. The sensor 127 may then send a signal to the controller to indicate that the lever 128 is in the fourth position and therefore, the dust cap 216 is attached to the multi-use portion 114 in the interface 112. As shown, the flange 270 is larger than flange 174, which means the engagement caused by the flange 270 will displace the lever 128 a greater distance than flange 174 and so the fourth position is beyond the third position (e.g., the lever 128 rotates even farther). In other embodiments, flange 270 may be smaller than flange 174 such that the fourth position is intermediate of the second position and the third position. In certain embodiments, notch 175 may also be used to move lever 128, further differentiating between the two flanges 174, 270.

[00174] According to certain embodiments, a flexible locking lever 278, similar to flexible locking lever 182 of the single-use fitting 116, extends from the body 262 and includes a bent shape to engage with the socket 156 of the multi-use fitting 114. The locking lever 278 may operate similarly to locking lever 182 and releasably lock the cap 216 to the multi-use fitting 114. Both locking levers 182, 278 discussed herein are shown as having specific shapes in the drawings. The locking levers 182, 278 may take these shapes or others that still allow for the locking levers 182, 278 to engage with the socket 156. In other embodiments, dust cap 216 may removably engage with multi-use fitting 114 by a friction fit.

[00175] As shown in Figs. 45 and 46, the dust cap 216 can be aligned with the multi-use fitting 114 and inserted into place. When the dust cap 216 is inserted onto the multi-use fitting 114, the connector 264 of the dust cap 216 mates with the bore 142 of the multi-use fitting 114, and the locking lever 278 is deformed to fit into the socket 156. The locking lever 278 has a tapered leading edge 282 that engages with part of the socket 156 to retain the locking lever 278 in the socket 156. There may also be audible or tactile feedback when the socket 156 receives the locking lever 278 to signal a connection. The pushing of the dust cap 216 into the multi-use fitting 114 pushes the flange 270 through the slot 146. Because the slot 146 is arranged between the curved surfaces 149, the flange 270 extends through the slot 146 to engage with the lever 128 of the sensor 127. This engagement occurs throughout the connection process and pushes the lever 128 away from the curved surface 149 and rotates the lever 128 about the pivot arm 130 an additional amount beyond the rotation already created by the curved surfaces 149. This additional rotation rotates the magnet 138, which circuit board 136 detects. The rotation can then be output to an administrator and used in ways already discussed above.

[00176] Additional single-use fittings and/or dust caps not described here can also be applied in similar ways to the multi-use fitting 114, allowing for those additional single-use fittings to be detected as well, like single-use fitting 116 and dust cap 216. The features of these different fittings may be sized differently than those described herein, causing the lever 128 to rotate different degrees around the pivot arm 130 to allow the sensor 127 to detect a unique device being connected to the multi-use fitting 114 and interface 112.

[00177] While the various embodiments of connector assemblies 10 and 110 have been described using a mechanical sensor 21 and 127 that utilize movement of sensor arm 20 and lever 128, respectively, other mechanical sensors, optical sensors, or electrical sensors may be utilized to determine whether the connector assembly 10 and 110 are in the first position, the second position, the third position, the fourth position, or somewhere in between any of the positions, thereby determining the status of the connector assembly 10 or 110 and transmitting a signal indicating the status to the controller. For example, in one embodiment, the sensor 21 or 127 may be an optical sensor including at least one light source and at least one light detector configured to measure reflection intensity or transmission intensity. The at least one light source may, for example, measure the intensity of reflection/transmission of light passing through a system having only the interface 12, 112 without either the multi-use fitting 14, 114, and the single-use fitting 16, 116 in the light path (e.g., the “first position”); only a section of the multi-use fitting 14, 114 in the light path (the “second position”); both the multi-use fitting 14, 114, and the single-use fitting 16, 116 in the light path (the “third position”); or the multi-

use fitting 14, 114 and the dust cap 216 (the “fourth position”) and, based on the intensity of the reflection/transmission, the sensor 21, 127 may send a signal to the controller indicating the status of the connector assembly 10, 110. According to this embodiment, the surfaces and material of the multi-use fitting 14, 114; the single-use fitting 16, 116; and the dust cap 216 may have different optical properties (e.g., different reflective/transmission properties). For example, the material of the component within the light path may be made of a different material (different medical grade polymers, degree of opaqueness, color, degree of light refraction, etc.), have different surface properties (surface roughness, surface opaqueness, surface reflective properties, surface color, etc.), have different reflectivity/transmission property when fittings surfaces are stacked (e.g., light shining on/through only the multi-use fitting 14, 114 (“second position”) will have a different reflection/transmission compared to light shining on/through both the multi-use fitting 14, 114 and the single-use fitting 16, 116 (“third position”) or light shining on/through both multi-use fitting 14, 114 and dust cap 216 (“fourth position”).

[00178] In another embodiment, the optical sensor may include multiple light sources configured to detect the absence or presence of the multi-use fitting 14, 114; the single-use fitting 16, 116; and/or the dust cap 216 at different locations. For example, a first light source may be located to detect the presence or absence of the multi-use fitting 14, 114 in the interface 12, 112 (e.g., when the multi-use fitting 14, 114 is installed, at least a portion of the multi-use fitting 14, 114 is in the path of the light from the first light source, indicating that the connector assembly 10, 110 is in the second position); a second light source may be located to detect the presence or absence of the single-use fitting 16, 116 in the interface 12, 112 (e.g., the single-use fitting 16, 116 is connected to the multi-use fitting 14, 116 within the interface 12, 112 and at least a portion of the single-use fitting 16, 116 may be in the path of the light from the second light source, indicating that the connector assembly 10, 110 is in the third position); and in certain embodiments, a third light source may be located to detect the presence or absence of the dust cap 216 in the multi-use fitting 14, 114 within the interface 12, 112 (e.g., the dust cap 216 is connected to the multi-use fitting 14, 116 within the interface 12, 112 and at least a portion of the dust cap 216 may be in the path of the light from the third light source, indicating that the connector assembly 10, 110 is in the fourth position). Other embodiments of the optical sensor may utilize combinations of multiple light sources and differences in reflection/transmission of light.

[00179] In certain embodiments, systems 10 and 110 may also include a reader or other detector within the interface 12 configured to detect and read indicia on one or more of the

single-use fitting 16 and the multi-use fitting 14. For example, the system 10 may have a reader capable of reading a barcode or QR-code to read one or more parameters or information from one or more of the single-use fitting 16 and the multi-use fitting 14. According to certain embodiments, the reader may be used to determine whether the multi-use fitting 14 is at the end of its use life and/or if a single-use fitting 16 has been priorly used. Signals may then be sent to the controller to notify the user that it is time to change the multi-use connector and/or to use a new single-use connector. Other data and parameters may also be read from the indicia to allow the controller to adjust the injection protocol or monitor the injections performed by the fluid injector system.

[00180] Although embodiments or aspects have been described in detail for the purpose of illustration and description, it is to be understood that such detail is solely for that purpose and that embodiments or aspects are not limited to the disclosed embodiments or aspects, but, on the contrary, are intended to cover modifications and equivalent arrangements that are within the spirit and scope of the appended claims. For example, it is to be understood that the present disclosure contemplates that, to the extent possible, one or more features of any embodiment or aspect can be combined with one or more features of any other embodiment or aspect. In fact, many of these features can be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one claim, the disclosure of possible implementations includes each dependent claim in combination with every other claim in the claim set.

CLAIMS

We Claim:

1. A connection system comprising:
 - an interface comprising a housing and a sensor disposed within the housing, the sensor being configured to be displaced between a first position, a second position, and a third position;
 - a multi-use fitting comprising at least one engaging surface and a slot, the multi-use fitting being configured to be at least partially secured within the housing so that the at least one engaging surface displaces the sensor between the first position and the second position;
 - a single-use fitting comprising a flange, the single-use fitting being configured to be at least partially secured within the multi-use fitting such that the flange is received within and extends through the slot and displaces the sensor between the second position and the third position,
 - wherein the sensor is configured to detect displacement between the first position and the second position, thereby sensing at least partial engagement between the multi-use fitting and the interface, and
 - wherein the sensor is configured to detect displacement between the second position and the third position, thereby sensing at least partial engagement between the single-use fitting and the multi-use fitting.
2. The connection system of claim 1, wherein upon being displaced to the second position, the sensor detects full engagement between the multi-use fitting and the interface and wherein upon being displaced to the third position, the sensor detects full engagement between the single-use fitting and the multi-use fitting.
3. The connection system of claim 2, wherein upon being displaced between the first position and the second position, the sensor detects partial engagement between the multi-use fitting and the interface and wherein upon being displaced between the second position and the third position, the sensor detects partial engagement between the single-use fitting and the multi-use fitting.

4. The connection system of claims 1-3, wherein the sensor comprises a lever, an arm, and a spring extending about the arm, wherein the lever is configured to be rotated about the arm by engaging with the at least one engagement surface and the flange, and wherein the spring is configured to bias the lever toward the first position.
5. The connection system of claim 4, wherein the sensor further comprises a magnet disposed within the arm and a circuit board located a distance away from the magnet, the circuit board being configured to sense the rotation of the magnet when the lever is rotated about the arm.
6. The connection system of claim 1-5, wherein the multi-use fitting comprises a body defining a bore and at least a first portion of the slot, wherein the bore at least partially defines a first fluid flow path, and wherein the at least one engaging surface extends from the body.
7. The connection system of claim 6, wherein the at least one engaging surface comprises a flat portion extending from the body and a curved portion extending from the flat portion.
8. The connection system of claim 7, wherein the at least one engaging surface comprises a first engaging surface and a second engaging surface, the first and second engaging surfaces defining at least a second portion of the slot therebetween.
9. The connection system of claims 6-8, wherein the multi-use fitting further comprises at least one wing extending from the body and wherein the at least one wing is configured to engage with the housing to secure the multi-use fitting to the interface.
10. The connection system of claim 9, wherein the at least one wing comprises a tapered leading edge and a retention rib, the tapered leading edge being configured to deform upon engagement and disengagement with the housing, and wherein the housing defines a lip, the lip being configured to contact the retention rib, thereby securing the multi-use fitting to the housing.
11. The connection system of claims 6-10, wherein the single-use fitting comprises a body and a connector extending from the body, the connector configured to mate with the bore and wherein the body of the single-use fitting and the connector at least partially define a second

fluid flow path configured to be aligned with the first fluid flow path when the connector is mated with the bore, and wherein the flange extends from the connector.

12. The connection system of claim 11, wherein the single-use fitting comprises a locking lever extending from the body of the single-use fitting, and the body of the multi-use fitting defines a socket, and wherein the locking lever is configured to engage with the socket, thereby at least partially securing the single-use fitting within the multi-use fitting.

13. The connection system of claims 1-12, when the single-use fitting is secured within the multi-use fitting and the multi-use fitting is secured within the housing, the single-use fitting, and the multi-use fitting are configured such that the single-use fitting remains secured within the multi-use fitting when the multi-use fitting is removed from the housing.

14. A connection system comprising:
an interface comprising:
a housing defining a first space and an inlet; and
a sensor disposed within the housing and at least partially exposed to the first space;
a multi-use fitting comprising:
a body defining a bore and at least a first portion of a slot, the bore defining a first fluid flow path; and
at least one engaging surface extending from the body;
a single-use fitting comprising:
a body defining an outlet at a first end;
a connector extending from a second end of the body opposing the outlet, the connector defining a second fluid flow path in fluid communication with the outlet; and
a flange extending from the connector,
wherein the multi-use fitting is configured to be secured within the first space of the housing, such that the at least one engaging surface contacts the sensor,
wherein, when the multi-use fitting is secured to the housing, the first fluid flow path is in fluid communication with the inlet,
wherein the single-use fitting is configured to be secured to the multi-use fitting, such that the flange extends through the slot and contacts the sensor,

wherein, when the single-use fitting is secured to the multi-use fitting, the second fluid flow path is in fluid communication with the first fluid flow path, thereby defining a single fluid flow path from the inlet to the outlet, and

wherein the sensor is configured to detect: (1) a lack of contact, corresponding to the multi-use fitting not being secured within the housing; (2) contact by the at least one engaging surface, corresponding to the multi-use fitting being at least partially secured within the housing; and (3) contact by the flange, corresponding to the single-use fitting being at least partially secured within the multi-use fitting.

15. The connection system of claim 14, wherein the sensor comprises:

an arm;

a lever extending from the arm and configured to be at least partially exposed within the first space; and

a spring extending about the arm,

wherein the lever is configured to contact the at least one engaging surface and the flange to rotate the arm in a first direction, and

wherein the spring is configured to bias the arm in a second direction, opposite the first direction.

16. The connection system of claim 15, wherein the contact between the at least one engagement surface and the lever rotates the arm a first distance in the first direction and wherein contact between the flange and the lever rotates the arm a second distance in the first direction, the second distance extending beyond the first distance.

17. The connection system of claim 16, wherein the sensor further comprises:

a magnet disposed within the arm; and

a circuit board located a distance away from the magnet,

wherein the circuit board is configured to sense the rotation of the magnet when the arm is rotated due to the lever contacting the at least one engagement surface or the flange.

18. The connection system of claim 17, wherein the lever, arm, spring, and magnet are disposed in a second space defined within the housing, and the circuit board is disposed in a third space defined within the housing fluidly sealed from the first space.

19. The connection system of claims 14-18, wherein the at least one engaging surface comprises a flat portion extending from the body and a curved portion extending from the flat portion.
20. The connection system of claim 19, wherein the at least one engaging surface comprises a first engaging surface and a second engaging surface, the first and second engaging surfaces defining at least a second portion of the slot therebetween.
21. A multi-use fitting comprising:
a body defining a fluid flow path and at least a first portion of a slot; and
at least one engaging surface extending from the body, the at least one engaging surface configured to displace a sensor.
22. The multi-use fitting of claim 21, wherein the at least one engaging surface comprises a flat surface extending from the body and a curved surface extending from the body along an end of the flat surface.
23. The multi-use fitting of claim 22, wherein the curved surface is configured to displace the sensor.
24. The multi-use fitting of claim 22 or 23, wherein the at least one engaging surface comprises a first engaging surface and a second engaging surface, the first and second engaging surfaces defining at least a second portion of the slot therebetween.
25. The multi-use fitting of claims 21-24, further comprising at least one wing extending from the body, the at least one wing defining at least one retaining rib configured to secure the at least one wing to an interface.
26. The multi-use fitting of claim 25, wherein the at least one wing comprises a tapered leading edge, the tapered leading edge being configured to fit within the interface.
27. The multi-use fitting of claim 25 or 26, wherein the at least one wing comprises a finger press configured to flex the at least one wing to secure the at least one wing within the interface and to remove the at least one wing from the interface.

28. The multi-use fitting of claims 25-27, wherein the at least one wing comprises a first wing and a second wing, and the at least one retaining rib comprises a first retaining rib disposed on the first wing and a second retaining rib disposed on the second wing.

29. The multi-use fitting claim 28, wherein the first retaining rib and the second retaining rib correspond, respectively, to a first retaining lip and a second retaining lip on the interface to secure, respectively, the first wing and the second wing within the interface.

30. The multi-use fitting of claims 21-29, wherein the body further defines an inner bore, the inner bore comprising an inlet and an outlet and wherein the inner bore defines the fluid flow path between the inlet and the outlet.

31. The multi-use fitting of claim 30, wherein the inlet is configured to be connected to a tubing, the tubing being configured to provide a medicament through the flow path.

32. The multi-use fitting of claim 30 or 31, wherein the outlet is configured to be connected to a single-use fitting.

33. The multi-use fitting of claim 32, wherein the single-use fitting is configured to provide the medicament to a patient.

34. The multi-use fitting of claim 33, wherein the body further defines a socket configured to engage a portion of the single-use fitting to connect the single-use fitting to the multi-use fitting.

35. The multi-use fitting of claims 30-34, wherein the body further defines an outer bore at least partially surrounding the inner bore, the outer bore defining the at least a first portion of the slot.

36. A single-use fitting comprising:
a body defining an outlet at a first end;
a connector extending from a second end of the body opposing the outlet, the connector defining an inlet, and

a flange extending from the connector,

wherein a fluid flow path is defined between the inlet and the outlet and wherein the flange is configured to displace a sensor.

37. The single-use fitting of claim 36, wherein the flange defines an edge, and the edge comprises a vertical portion extending from the connector and a slanted portion extending from the vertical portion.

38. The single-use fitting of claim 37 wherein the slanted portion of the edge is configured to displace the sensor.

39. The single-use fitting of claim 36 or 37, wherein the vertical portion of the edge extends from the connector to define an orthogonal angle therebetween, and the slanted portion of the edge extends from the vertical portion at an angle that is not orthogonal relative to the connector.

40. The single-use fitting of claims 36-39, further comprising a stop extending from the body.

41. The single-use fitting of claim 40, wherein the stop extends a distance from the body beyond the flange.

42. The single-use fitting of any of claims 36-41, further comprising a locking lever configured to connect the single-use fitting to a multi-use fitting.

43. The single-use fitting of claim 42, wherein the locking lever comprises a tapered leading edge configured to be secured within a portion of the multi-use fitting.

44. The single-use fitting of claim 42 or 43, wherein the locking lever further comprises a finger press configured to flex the locking lever to facilitate the connection to the multi-use fitting.

45. The single-use fitting of claims 36-44, wherein the outlet is configured to be connected to a tubing, the tubing being configured to receive a medicament from the fluid flow path.

46. The single-use fitting of claim 45, wherein the connector is configured to mate with a bore of a multi-use fitting.
47. The single-use fitting of claim 46, wherein the fluid flow path is configured to receive the medicament from the multi-use fitting via the inlet.
48. The single-use fitting of claims 36-47, further comprising an outer shell extending around the outlet, the outer shell defining a rear opening.
49. The single-use fitting of claim 48, wherein the outer shell further defines a bottom opening.
50. A dust cap comprising:
a body comprising a connector extending in a first direction and a closed end extending in a second direction, opposite the first direction; and
a flange extending from the connector, the flange being configured to displace a sensor.
51. The dust cap of claim 50, wherein the flange defines an edge, the edge defining a vertical portion extending from the connector and a slanted portion extending from the front portion.
52. The dust cap of claim 51, wherein the slanted portion of the edge is configured to displace the sensor.
53. The dust cap of claim 51 or 52, wherein the front portion of the edge comprises a notch.
54. The dust cap of any of claims 51-53, wherein the vertical portion of the edge extends from the connector to define an orthogonal angle therebetween, and the slanted portion of the edge extends from the vertical portion at an angle that is not orthogonal relative to the connector.
55. The dust cap of claims 50-54, further comprising a locking lever configured to connect the dust cap to the multi-use fitting.

56. The dust cap of claim 55, wherein the locking lever comprises a tapered leading edge configured to be secured within a portion of the multi-use fitting.
57. The dust cap of claim 55 or 56, wherein the locking lever further comprises a finger press configured to flex the locking lever to facilitate the connection to the multi-use fitting.
58. The dust cap of claims 50-57, wherein the connector is configured to mate with a bore of a multi-use fitting.
59. The dust cap of claim 58, wherein the closed end of the dust cap is configured to terminate a fluid flow path defined at least partially by the bore of the multi-use fitting.
60. A connection system comprising:
a multi-use fitting comprising:
a body comprising a bore defining a fluid flow path and at least a first portion of a slot; and
at least one engaging surface extending from the body and being configured to displace a sensor;
a single-use fitting comprising:
a body defining an outlet at a first end;
a connector extending from a second end of the body opposing the outlet, the connector defining an inlet;
a flange extending from the connector and being configured to displace the sensor; and
a fluid flow path extending from the first end to the second end,
wherein the at least one engaging surface is configured to displace the sensor a first distance, and the flange is configured to displace the sensor a second distance beyond the first distance, and
wherein the connector is configured to mate with the bore to connect the single-use fitting to the multi-use fitting, thereby connecting the fluid flow path of the multi-use fitting with the fluid flow path of the single-use fitting.

61. The connection system of claim 60, wherein when the single-use fitting is connected to the multi-use fitting, the flange is configured to extend through the slot to displace the sensor.
62. The connection system of claim 60 or 61, wherein the at least one engaging surface comprises a flat surface extending from the body and a curved surface extending from the body along an end of the flat surface.
63. The connection system of claim 62, wherein the curved surface is configured to displace the sensor.
64. The connection system of claims 60-63, wherein the at least one engaging surface comprises a first engaging surface and a second engaging surface, the first and second engaging surfaces defining at least a second portion of the slot therebetween.
65. The connection system of claims 60-64, further comprising at least one wing extending from the body of the multi-use connector, the at least one wing defining at least one retaining rib configured to secure the at least one wing to an interface.
66. The connection system of claim 65, wherein the at least one wing comprises a tapered leading edge, the tapered leading edge being configured to fit within the interface.
67. The connection system of claims 65 or 66, wherein the at least one wing comprises a finger press configured to flex the at least one wing to secure the at least one wing within the interface and to remove the at least one wing from the interface.
68. The connection system of claims 65-67, wherein the at least one wing comprises a first wing and a second wing, and the at least one retaining rib comprises a first retaining rib disposed on the first wing and a second retaining rib disposed on the second wing.
69. The connection system of claims 68, wherein the first retaining rib and the second retaining rib correspond, respectively, to a first retaining lip and a second retaining lip on the interface to secure, respectively, the first wing and the second wing within the interface.

70. The connection system of claims 60-69, wherein the flange defines an edge, and the edge comprises a vertical portion extending from the connector and a slanted portion extending from the vertical portion.

71. The connection system of claim 70, wherein the slanted portion of the edge is configured to displace the sensor.

72. The single-use fitting of claim 70 or 71, wherein the vertical portion of the edge extends from the connector to define an orthogonal angle therebetween, and the slanted portion of the edge extends from the vertical portion at an angle that is not orthogonal relative to the connector.

73. The single-use fitting of any of claims 70-72, further comprising a stop extending from the body, the stop being configured to at least partially impede the connection of the single-use fitting to the multi-use fitting.

74. The connection system of claims 60-73, wherein the body of the multi-use fitting further defines a socket, and the single-use fitting comprises a locking lever configured to be received within the socket, further connecting the single-use fitting to the multi-use fitting.

75. The connection system of claims 60-74, wherein the bore defines an inlet and an outlet, the inlet of the bore being configured to be connected to a first tubing and the outlet of the bore being configured to mate with the connector of the single-use fitting,

wherein the outlet of the single-use fitting is configured to be connected to a second tubing, thereby defining a system fluid flow path from the first tubing, through the fluid flow path of the multi-use fitting and the flow path of the single-use fitting, to the second tubing, and

wherein the system fluid flow path is configured to receive a medicament and deliver the medicament to a patient downstream of the second tubing.