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(54) Title: LINEAR MOTION COMPRESSION CONNECTOR

(57) Abstract: Embodiments relate to compression connectors that can form a seal by a force applied in a linear motion, without torque.

LINEAR MOTION COMPRESSION CONNECTOR

Field of Invention

This invention relates to compression connectors, e.g., for chromatography.

Background of the Invention

In chromatography, compounds in a mixture are separated by placing the mixture on a medium in a column and flowing a fluid though the column. Because the compounds have different relative affinities for the fluid and the medium, they elute from the end of the column sequentially.

The column is typically attached to a fluid source by plumbing. For example, in liquid chromatography, the fluid is taken from a reservoir by a pump and directed through tubing of stainless steel or polymer to the inlet end of the column. The outlet end of the column is connected via tubing to a detector or sample collection apparatus. Because the columns are replaced and exchanged frequently, depending on the analysis, the connections between the column and tubing must be reversible.

The most common connector for this application is a compression swage connector that includes a threaded bolt, a conical ferrule, and a tapped and chamfered well. The bolt, ferrule and well include a passageway into which the chromatography tubing may be inserted. By manually torquing the bolt, e.g., with a wrench or finger action, the conical ferrule is forced into the well, causing the tubing to seat at the bottom of the well and the passageway through the ferrule to collapse around the tubing, forming a seal.

Summary of the Invention

The invention relates to a compression connector that forms a seal by a force applied in a linear motion.

In one aspect, the invention features a compression connector for fluid chromatography that has at least two fitting elements that mate to form a seal by a force applied by a substantially linear motion.

In another aspect, the invention features a chromatography connector system. The system includes a pair of reversible compression connectors that form a seal by a force applied by a substantially linear motion. The connectors include at least two fitting elements that can be mated to form a seal and a pair of force applicators for applying the force by the linear motion. The connectors and force applicators are arranged to apply the force in substantially opposing directions along a common axis.

In another aspect, the invention features a force applicator for a chromatography connector system. The force applicator is capable of applying force by linear motion, and includes a pathway that accepts chromatography conduit and is sized to apply the linear force to a chromatography connector engaging the conduit.

In another aspect, the invention features a chromatography connector system including a pair of force applicators for applying force by the linear motion, the force applicators are arranged to apply the force in substantially opposing directions along a common axis.

In another aspect, the invention features a chromatography flow switching system for directing fluid flow to multiple alternate paths. The system includes a reversible compression fitting that forms a seal by a force applied by a substantially linear motion, multiple fluid conduits through which the fluid flow may be directed, and a force applicator.

In another aspect, the invention features a chromatography flow path selector. The selector includes a manifold including multiple connector fitting elements. The fitting elements are compression connector elements that mate to form a seal by a force applied by a substantially linear motion. The elements either define wells or arc elements sized for positioning in a well. A mating fitting element is connected to a flow source. The mating fitting element is compatible with the fitting elements of the manifold and either defines a well or an element for positioning in a well. A translator brings the mating fitting element and fitting elements of the manifold into registration. A force applicator can apply force by linear motion.

In another aspect, the invention features a compression fitting for connecting fluid conduits that includes at least two fitting elements that are mated to form a seal by force applied in a substantially linear motion.

In another aspect, the invention features a flow switching system for directing fluid flow to multiple alternate paths. The system includes a releasable compression fitting that forms a seal by a force applied by a substantially linear motion, multiple fluid conduits through which the fluid flow may be directed, and a force applicator.

In other aspects, the invention features methods of connection and methods of analysis. In another aspect, the invention features a chromatography connector that seals without torque.

Embodiments may include one or more of the following. The interior of the well and the other fitting element have substantially complementary shapes including complementary mating surfaces disposed at an angle with respect to the linear motion. The complementary shapes define a substantially conical mating surfaces. One of the mating elements is a ferrule. The fitting elements have a different hardness. The fitting elements comprise metal or polymer. The connector is constructed for connecting fluid conduits by including a passage disposed through the elements in which a conduit may be disposed and sealed.

Embodiments may also includes one or more of the following. The connector includes a force applicator. The force applicator applies the substantially linear force by pneumatics. The force applicator applies the substantially linear force by hydraulics. The force applicator applies the substantially linear force by electromotives. The force applicator applies the substantially linear force by mechanical tool. The force applied is about 20 lbs. or more. The force applicator includes a piston.

Embodiments may also include one or more of the following. The force applicator is reversible to release the substantially linear force for uncoupling the fitting. One of the fitting elements is fixed to a chromatography column. The fitting elements are sized to accept chromatography tubing having an od of about 1/32 inch to about 1/8 inch. The connector is adapted for sealing at fluid pressures of about 1000 to about 8000 psi.

Embodiments may also include one or more of the following. A conduit holder is provided that orients a conduit on an axis in registration with the linear motion. The fluid conduits are chromatography columns. The compression fitting includes at least two fitting elements that mate to form a seal and at least one of the fitting elements is fixed to each of the columns. The other of the fitting elements is attached to the force applicator. The multiple conduits are arranged on a translator that may be moved to bring the conduit and force applicator into registration. The translator is a carousel. The translator is a conveyor belt.

Embodiments may also includes one or more of the following. The system includes multiple fluid pumps and multiple force applicators wherein fluid flowing from each of the pumps may be alternately directed to alternate conduits. The system operates at about 6000 psi or more. A controller is connected to the switching system for directing fluid flow along multiple alternate flow paths in accordance with a predetermined algorithm.

Embodiments of the invention may include one or more of the following advantages. The linear force compression connectors provides a fast, low dead volume connection that can be readily automated. The connection can greatly reduce the frequency of failures and leaks due to misalignment and abuse associated with fittings that are coupled and uncoupled by torque. The linear motion of the sealing operation provides an ergonomically simple operation which can require substantially less space for access to the connector than a torque-type connector in which the user's hand or a tool must engage the connector. This advantage can reduce the path length of the connector plumbing, which improves performance by reducing dead volume.

Advantages may include a short fluid path that minimizes peak dispersion, selection and operation of a single column in low dispersion mode from a choice of multiple columns, increased system efficiency due to elimination of mechanical couplings and valves that cause peak broadening, facile connection of columns to minimize leaks and errors by multiple users, simple and efficient control possible by manual or software controlled operation, and limitless flexibility allowing usage as single column connector or a multiple column switcher. The systems permit rapidly connecting and disconnecting a number of chromatography columns to an LC system at any pressure while maintaining optimal connection conditions such as short path length (low dispersion), consistent leakproof connection, and heavy duty cycle.

Advantages may also include the following. The linear compression connector can make unnecessary large valve manifolds while allowing any number of columns to be connected/disconnected, washed and run automatically enabling a variety of techniques for chemistry, organic chemistry, combinatorial chemistry and drug discovery. For example, an analysis may be run on-line while preparing a column offline in parallel (reducing total sample process time). The systems allow rapid/continuous use of any number of SEC/RPC or normal phase columns to be used in the drug discovery process. Automatic column switching and peak detection software allow for the isolation and analysis of a continuous stream of samples processed through size exclusion chromatography for use in drug discovery.

In fluid path selector embodiments, the invention can provide fluid path selectors without sealing members between the flow paths, thus reducing cross contamination. In rotary valves on the other hand, fluid flows through channels in the valve head. With repeated use the seal between ports may wear down. Contaminant buildup in the valve head can create scoring on the seal face, thus furthering seal decay. This can cause fluid to bleed between ports resulting in solvent mixture. This is known as "crosstalk".

Still further features, aspects and advantages, follow.

Description of the Preferred Embodiments

We first briefly describe the drawings.

Drawings

Fig. 1 is a schematic of a chromatography system;

Figs. 2-2B are cross-sectional views illustrating a compression fitting sealed by a force applied by linear motion;

Figs. 3 and 3A are cross-sectional views of a compression connector system using a piston force applicator;

Fig. 4 is a perspective view of a flow switching system;

Fig. 5 is a plan view of a chromatography system with a flow switching system;

Fig 6. is side view, partial cross-section of an embodiment; and

Figs. 7 and 7a are schematics of a flow switching manifold.

<u>Description</u>

Referring to Fig. 1, a liquid chromatography system 2 includes a fluid source 4, a pump 6, a column 8, and a receptacle 10. These components are interconnected by tubing lengths 10, 12, 14, which may be polymer (e.g. polyetheletherketone (PEEK)) or metal (e.g. stainless steel). In operation, fluid is drawn from the source 4 through tubing 10 to the pump, which directs the fluid under pressure through the tubing 12 to the inlet end 9 of column 8. The fluid exits the outlet end 11 of the column to tubing 14 which directs the flow to a receptacle 10, e.g., a spectroscopic detector or sample collector. Alternatively, after detection, for example, the fluid may flow to a waste container.

At the inlet 9 and outlet 11 ends of the column are compression connectors 18, 20 which permit the column to be reversibly connected and sealed to the tubing 12, 14. The connector may be reversibly sealed by application of a substantially linear motion along the axis of the column.

The connectors may be controlled by an electronic controller 3, which may be manually activated, or preprogrammed to couple and uncouple the connectors based on input, e.g., from the pump or receptacle 10. The column may be held by a holder 7, which prevents motion of the column as linear force is applied to the connectors. Connections between the source and pump and to the receptacle may also use the connectors.

Refer as well to Figs. 2-2B, cross sections through a connector, the connector includes a generally conical ferrule 24 and a fitting 26 that defines a well 28. The well includes a chamfered, generally conical portion 30 complementary to the ferrule 24. The ferrule 24 includes a passageway 32 to accept a length of chromatography tubing 34. The well 28 also includes a linear cylindrical portion 36 in which the end 38 of the chromatography tubing is seated. The well also includes an upper cylindrical section which permits access to the top of the ferrule for applying force by linear motion. A passageway 39 allows fluid to be directed to the column.

Referring particularly to Fig. 2B, the connector forms a seal by application of a force applied by a linear motion (arrows 40), in this case against the ferrule. (Alternatively, the force could be applied to the fitting 26 or opposing forces applied to the ferrule and the fitting.) The force directs the ferrule deeper into the conical section of the well, which causes the passageway 32 of the ferrule to collapse over tubing and the end of the tubing to be seated against the bottom of the well, thus forming a seal. As evident, the fitting does not require tapping or other thread arrangements to permit torquing.

Referring as well to Figs. 3 and 3A, the linear force may be applied by an actuator arrangement 50 which includes a piston 52 and a pneumatic piston translator 54 that allows controlled motion of the piston in the direction of arrows 56. The piston includes a passageway 61 through which the chromatography tubing is directed. The system in Fig. 3 illustrates an optional engagement 58, e.g., a bayonet fitting, between the translator 54 and fitting 26 to prevent movement of the fitting 26 when the piston is actuated. In cases where actuators are provided on both sides of a generally linear column, such an engagement may not be used since the force of the opposing actuators prevents such motion. Alternatively, as mentioned, a column holder 7 may be constructed to hold the column.

As illustrated in Fig. 3, before the cylinder 52 is activated, the ferrule rests in the well without sealing engagement. In this condition, the connector is disengaged and the tubing and column may be easily separated.

Referring to Fig. 3A, when the actuator is activated to direct the piston 52 in direction 60, the end of the piston engages the top of the ferrule with a linear force that causes the fitting to seal, without applying torque. The connector is disconnected by reversing the direction of gas flow in the cylinders.

In addition to pneumatic actuators, other actuators capable of generating force by linear motion may also be employed to establish satisfactory leak proof connections. For example, a solenoid or motorized actuator that provides linear force, or a manual actuator or hand tool that applies force through a mechanical advantage, e.g., a lever arrangement, may also be used. For example, a tool with a squeeze handle that moves a piston, similar to a paper punch, may be used.

For standard 1/16 inch tubing high pressure liquid chromatography ferrules and fittings, the linear force is typically in the range of about 20 to 100 lbs for PEEK ferrules and about 200 lbs or more for stainless steel ferrules, where the chromatography operates in a range of about 1000 to about 8000 psi. For larger columns and fittings (e.g. for preparatory size or industrial production columns) and higher pressure operations, the force may be greater, e.g. 1000 lbs to 2000 lbs or more. Lower pressures may be used at lower fluid pressures.

The column connector may be used as a stand-alone device to connect a single column. Alternatively, the addition of a column changer allows for unattended and automated changeover of multiple columns for routine applications.

Referring to Fig. 4, a column switching system 70 includes four sets 72, 74, 76, 78 of linearly opposed linear connectors positioned on either side of a column wheel or disc 80. The connectors and wheel are mounted on a frame 81. The column wheel 80 includes multiple holder slots 82 in which columns can be held, e.g., by a clamp. Each column can be alternatively positioned at the locations of the connectors by rotation of the wheel 80, e.g., by actuating stepper motor 84. Other looping transport systems (e.g. a conveyor belt) can be used instead of a rotating disc. Alternatively, a linear translator, e.g., an x, y, z, positioner can also be used to bring columns into registration with the connectors. Alternatively, the connectors could be moved or both the connectors and columns could be moved. For example, a linear array of columns could be arranged on a frame and the connectors moved to the column of choice. The array could be a single line or a two-dimensional array. Multiple connectors systems could be constructed to independently move to the columns of choice in the array.

Referring to Fig. 5, for example, a system may include a high performance liquid chromatography (HPLC) system 92 and a secondary HPLC pump 94. For this description, the system will include four columns (numbered 1-4). The column connector at position I is connected to the HPLC system. The inlets of the other three are connected to the HPLC pump and the outlets to a waste collector. During operation, all four column connectors are activated thereby connecting the respective tubing to each column and the HPLC pump is activated. While the column in position I is used to process a sample, the other three columns are washed with specific liquids in a cleaning step.

When sample processing is complete, the HPLC pump is deactivated and the connectors are decoupled to release the columns. The disc is rotated one step of the stepper motor resulting in displacement of the column from position I to position II, the column from position II moving to position III, etc. When the system is reactivated, the column that had been previously used to process a sample undergoes the first of three steps of a wash cycle. The cycle is repeated to obtain consistent supply of clean columns for continuous operation of the HPLC system. The design of the column connector allows for any number of positions on the disc depending upon system requirements.

Both the column connector and the column changer are operated manually or by a remote signal. For column connector manual mode, air flow to the cylinders is controlled by a manually operated valve. For the column changer, manual depression of a push button switch will trigger the cylinders and disc stepper motor. In remote mode, a contract closure or TTL signal will trigger solenoid valves and the stepper motor. The system can be programmed by computer to initiate flows through the columns in a desired sequence.

Examples

The following examples describe particular embodiments.

Connector System

Referring to Fig. 6, a connector system for reversible connection includes two linearly opposed connectors 92, 94 bolted to a base 96 of 1/4 inch stainless steel. The base also includes a column holder 98 with a flange 100 including a 1/4 inch slot into which a column 102 may be positioned. Motion along the axis of the column is prevented by interference between column end fittings 104, 106 and the flange portion around the slot. The frame may also include brace members (not shown) extending between the upright walls of the frame.

The connectors include pneumatic pistons 108, 110 (model SS 2.00 X 1.5000 SB Space Saver, available from Mead Fluid Dynamics, Chicago, IL) which are driven by an air source at a pressure of about 60 psi. The air source is directed to both heads through a manifold 112, which includes a lever 114 that may be actuated to simultaneously drive both pistons.

The heads of the pistons include adaptor fittings 116, 118 of steel including necks 120, 122 that have a cross section (about 2.5mm) substantially the same as the base of ferrules 124, 126. The adapter fittings include slots 128, 130 and neck passageways 132, 134 which are provided for chromatography tubing 136, 138. The ferrules can be seated in chromatography connection bolts 140, 142 which are attached by threads to the column end fittings 104, 106. The ferrules and connection bolt may be standard 1/16 inch PEEK HPLC fittings (e.g., Model Rheodyne Rheflex PEEK 6000-

051, available from Upchurch, Oak Harbor, WA). (The threaded bolt that is torqued into the end of the connector bolt is not used.)

The bolt is tightened onto the column. The ferrule is placed over the end of the tubing and linearly forced into well of the bolt. After a connection cycle, the ferrule crimps onto the end of the tubing and remains on the tubing when the connectors are decoupled. Operating conditions are given in Table I.

Table I

Specifications	
Column Lengths	30mm, 50mm
Tubing Material	PEEK
Tubing Diameter	0.0625 inches
Ferrule Material	PEEK
Seal Force @ 2500psi fluid flow	100lbs
Cylinder Operating Pressure	60psi

System Performance

Experiments were conducted to test chromatographic efficiency of size exclusion (SEC) columns for deoxycytidine under identical elution conditions. The liquid phase was an aqueous buffer of 15 mMolar Na-PO_4/0.15 mMolar NaCl with 2 percent DMSO. The column was a 50mm x 4.6mm (id) steel column (column hardware Isolation Technologies, Hopedale, MA) packed with Ichrome SEC media (media available from Ichrome, Davion, IL). The same column was tested in three different configurations: a six-column, valve-based selector in which columns are manually connected via compression fittings prior to running and a software-controlled column selector designed to operate with any one of six columns (Scout System, BioCAD instrument manual, PerSeptive Biosystems, Framingham, MA USA, the content of which is incorporated by reference), b) direct connection through conventional 1/16 inch torque compression fittings, and c) connection using linear connectors with a six column wheel-type switching system. (In (a) and (b), the column was not switched during the runs.) The results are given in Table II.

Table II

Run Type	Retention Time	Peak Width Time	Pressure (bar)	Column Efficiency (Plate Count)	Efficiency (N/meter)
F=0.5 ml/min					
Manual	1.060	0.091	19	. 2231	44617
Perkin Elmer Scout	1.097	0.108	27	1658	33057
Linear Column Connector	1.068	0.082	23	2739	54786
F=2.0 ml/min					
Manual	0.288	0.028	119	1643	32862
Perkin Elmer Scout	0.302	0.035	132	1209	24177
Linear Column Connector	0.282	0.027	112	1737	34747

*Column Efficiency calculated by BioCAD software, standard half-height method.

The results indicate that the linear connector system showed the highest efficiency for column performance. This is due to short path for the sample to travel to the detector and absence of mechanical devices such as valves or fluid-connectors that lead to peak broadening.

Other Embodiments

Referring to Figs. 7 and 7a, in embodiments, the linear connector can be used as a fluid path selector that eliminates cross contamination between multiple fluid paths. An embodiment includes a manifold element 130, e.g., machined steel or polymer, that has a first well 132 that directs fluid to a first fluid path 133 and a second well 134 that directs fluid to a second path 135. The element 130 can be translated by a pneumatic cylinder 138 in the direction of arrow 140. A second cylinder 142 provides linear motion in the direction of arrow 144 that provides a force to direct a ferrule 146 and tubing 148 into either well 132 or 134. In position A, pneumatic cylinder 138 is retracted and pneumatic cylinder 142 is positioned inline with port 134. In position B, pneumatic cylinder 138 is extended and pneumatic cylinder 142 is positioned inline with port 132. As evident, there is no sealing member between the wells. Repeated use results in fluid path switching with zero crosstalk. The number of ports can easily be increased.

The connector can be adapted for use in various types of chromatography including low and high pressure liquid chromatography, SEC/RPC or normal phase columns supercritical fluid chromatography, and gas chromatography. The connector can also be used in various other applications in which fluid flows may be directed, e.g., chemical process streams and other plumbing. The connector can be adapted to operate at high fluid pressures, e.g., above 6000 psi or above 20,000 psi. While the connector is preferably arranged to seal a conduit, it may also be constructed without a passageway for a conduit, and thus form a plug for column storage while not in use.

The applications include improvements in productivity of chromatographic processes, such as high efficiency separation, simultaneous analysis and column regeneration, multi-column separations with capability to process individual columns.

In combinatorial chemistry, the system allows parallel chromatography for analysis of a large number of combinatorial chemistry samples and acidic deprotection and simultaneous purification. A technique for analysis of assays of combinatorial libraries is described in U.S. 5,877,030 and Nash et al. U.S.S.N. 09/024,592, filed February 17, 1998, the entire contents of both of which are incorporated herein by reference. The libraries, which are mixtures of large numbers of compounds can be assayed by exposure to a target. Binding pairs can be separated from unbound species by chromatography.

In other areas, the system can be used in increased productivity due to simultaneous analysis and column regeneration. Other applications include multi-mode chromatography and analytical applications such as HPLC of organic compounds, small and large biomolecules, quality control applications, peptide mapping, epitope mapping, chromatography assays, preparative chromatography.

In pharmaceutical applications, the system can be useful in high-throughput screening, rapid chromatography for large sample throughput, and quality control of drug molecules and formulations.

In column manufacturing, the system can be used for automated processes for testing HPLC columns, QC column performance, and washing regeneration of columns.

Other applications are column electro-chromatography, and supercritical chromatography. The system can be used with X-Y-Z tables connected to the column connector, which can be used to select from a large array of columns/column types and routes to a variety of detectors including but not limited to MS, MS/MS, UV, Radiometer etc. automatically based on sample type (stored in a field on sample table or accessed through database).

Still further embodiments are in the following claims.

What is claimed is:

1. A compression connector for fluid chromatography comprising at least two fitting elements that mate to form a seal by a force applied by a substantially linear motion.

2. The connector of claim 1 wherein one of the fitting elements defines a well and the other fitting element is sized for positioning in said well.

3. The connector of claim 2 wherein the interior of the well and the other fitting element have substantially complementary shapes including complementary mating surfaces disposed at an angle with respect to said linear motion.

4. The connector of claim 3 wherein the complementary shapes define a substantially conical mating surfaces.

5. The connector of claim 4 wherein one of the mating elements is a ferrule.

6. The connector of claim 5 wherein the fitting elements have a different hardness.

7. The connector of claim 1 wherein said fitting elements comprise metal or polymer.

8. The connector of claim 1 constructed for connecting fluid conduits by including a passage disposed through said elements in which a conduit may be disposed and sealed.

9. The connector of claim 1 comprising a force applicator.

10. The connector of claim 7 wherein the force applicator applies said substantially linear force by pneumatics.

11. The connector of claim 7 wherein the force applicator applies said substantially linear force by hydraulics.

12. The connector of claim 7 wherein the force applicator applies said substantially linear force by electromotives.

13. The connector of claim 7 wherein the force applicator applies said substantially linear force by mechanical tool.

14. The connector of claim 1 wherein the force applied is about 20 lbs. or more.

15. The connector of any one of claims 9-14 wherein the force applicator includes a piston.

16. The connector of claim 1 wherein the force applicator includes is reversible to release the substantially linear force for uncoupling said fitting.

17. The connector of claim 1 wherein one of said fitting elements is fixed to a chromatography column.

18. The connector of claim 1 wherein said fitting elements are sized to accept chromatography tubing having an od of about 1/32 inch to about 1/8 inch.

19. The connector of claim 1 wherein said connector is adapted for sealing at fluid pressures of about 1000 to about 8000 psi.

20. A chromatography connector system, comprising:

a pair of reversible compression connectors that form a seal by a force applied by a substantially linear motion, said connectors including at least two fitting elements that can be mated to form a seal, a pair of force applicators for applying said force by said linear motion, said connectors and force applicators arranged to apply said force in substantially opposing directions along a common axis.

21. The system of claim 20 comprising a conduit holder that orients a conduit on said axis in registration with the linear motion.

22. A force application for chromatography connector system, said force applicator capable of applying force by linear motion, and including a pathway that accepts a chromatography conduit and sized to apply said linear force to a chromatography connector engaging said conduit.

23. A chromatography connector system, comprising:

a pair of force applicators for applying force by said linear motion, said force applicators arranged to apply said force in substantially opposing directions along a common axis.

24. The system of claim 23 comprising a conduit holder that orients a conduit on said axis in registration with the linear motion.

25. A chromatography flow switching system for directing fluid flow to multiple alternate paths, comprising:

a reversible compression fitting that forms a seal by a force applied by a substantially linear motion,

multiple fluid conduits through which the fluid flow may be directed, and

a force applicator.

26. The system of claim 25 wherein the fluid conduit comprise multiple chromatography columns.

27. The system of claim 26 wherein the compression fitting includes at least two fitting elements that mate to form a seal and at least one of the fitting elements is fixed to each of said columns.

28. The system of claim 27 wherein the other of said fitting elements is attached to said force applicator.

29. The system of claim 27 wherein said fitting elements comprise a well and ferrule.

30. The system of claims 25 or 26 wherein said multiple conduits are arranged on a translator that may be moved to bring said conduit and force applicator into registration.

31. The system of claim 30 wherein the translator is a carousel.

32. The system of claim 30 wherein the translator is a conveyor belt.

33. The system of claim 30 comprising multiple fluid pumps and multiple force applicators wherein fluid flowing from each of said pumps may be alternately directed to alternate conduits.

34. The system of claim 33 wherein the chromatography system operates at about 6000 psi or more.

35. The system of claim 34 comprising a controller connecting to said switching system and for directing fluid

flow along multiple alternate flow paths in accordance with a predetermined algorithm.

36. A compression fitting for connecting fluid conduits including at least two fitting elements that are mated to form a seal by force applied in a substantially linear motion.

37. A flow switching system for directing fluid flow to multiple alternate paths, comprising:

a releasable compression fitting that forms a seal by a force applied by a substantially linear motion,

multiple fluid conduits through which the fluid flow may be directed, and

a force applicator.

38. A chromatography flow path selector, comprising:

a manifold including multiple connector fitting elements, said fitting elements being compression connector elements that mate to form a seal by a force applied by a substantially linear motion, wherein said elements either define wells or elements sized for positioning in a well, a mating fitting element connected to a flow source, said mating fitting element being compatible with the fitting elements of said manifold and either defining a well or an element for positioning in a well;

a translator to bring said mating fitting element and fitting elements of said manifold into registration, and

a force applicator.

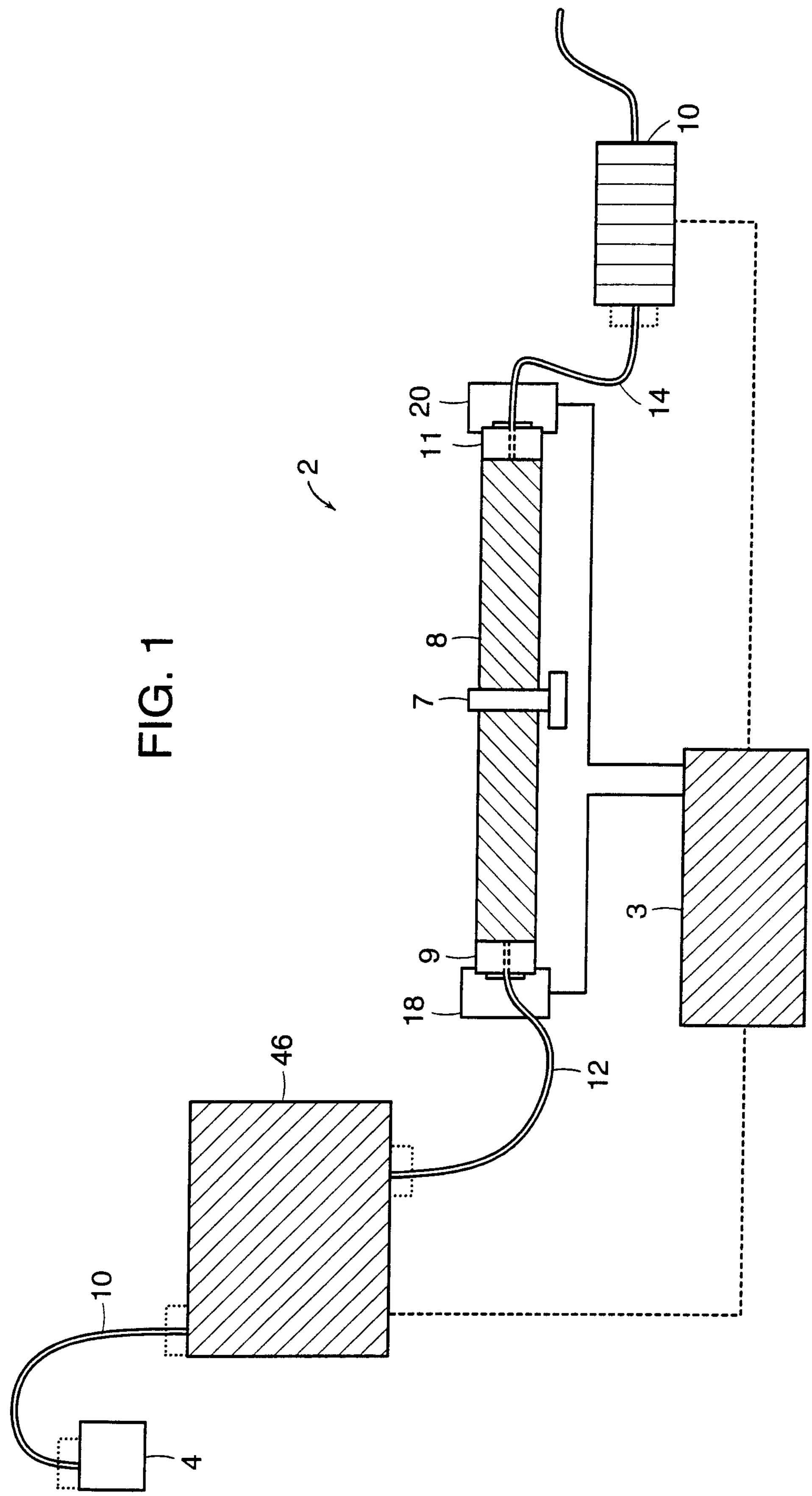
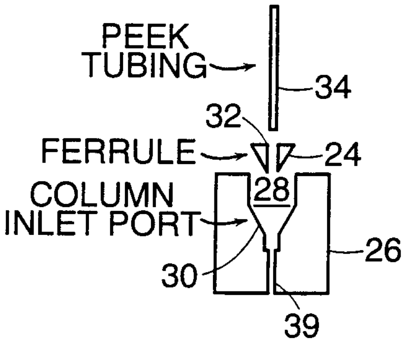


FIG. 1



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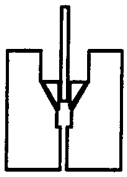

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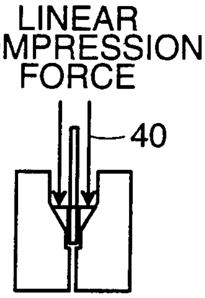

FIG. 2

FIG. 2A

FIG. 2B

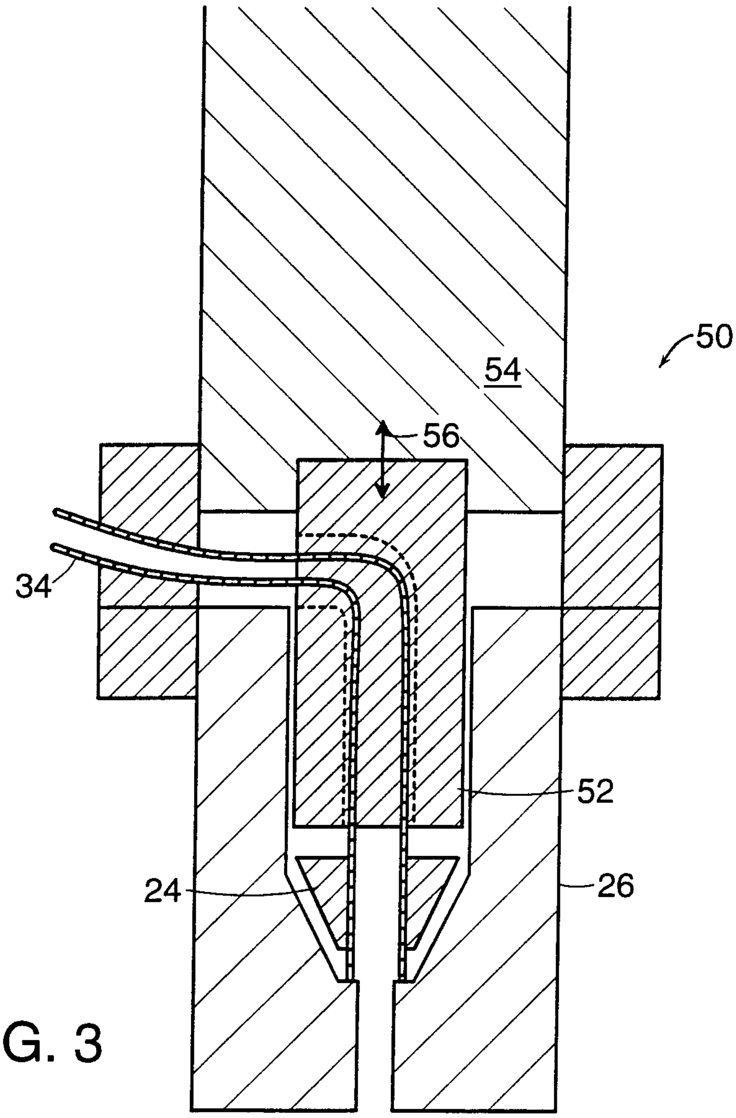

FIG. 3

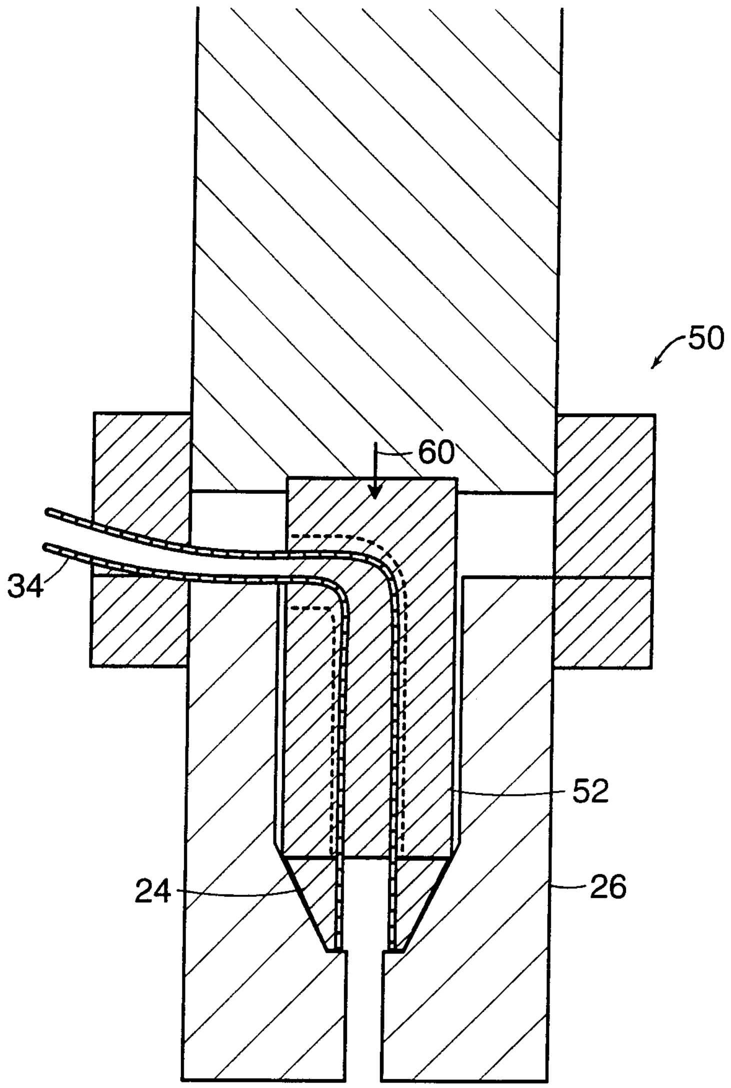

FIG. 3A

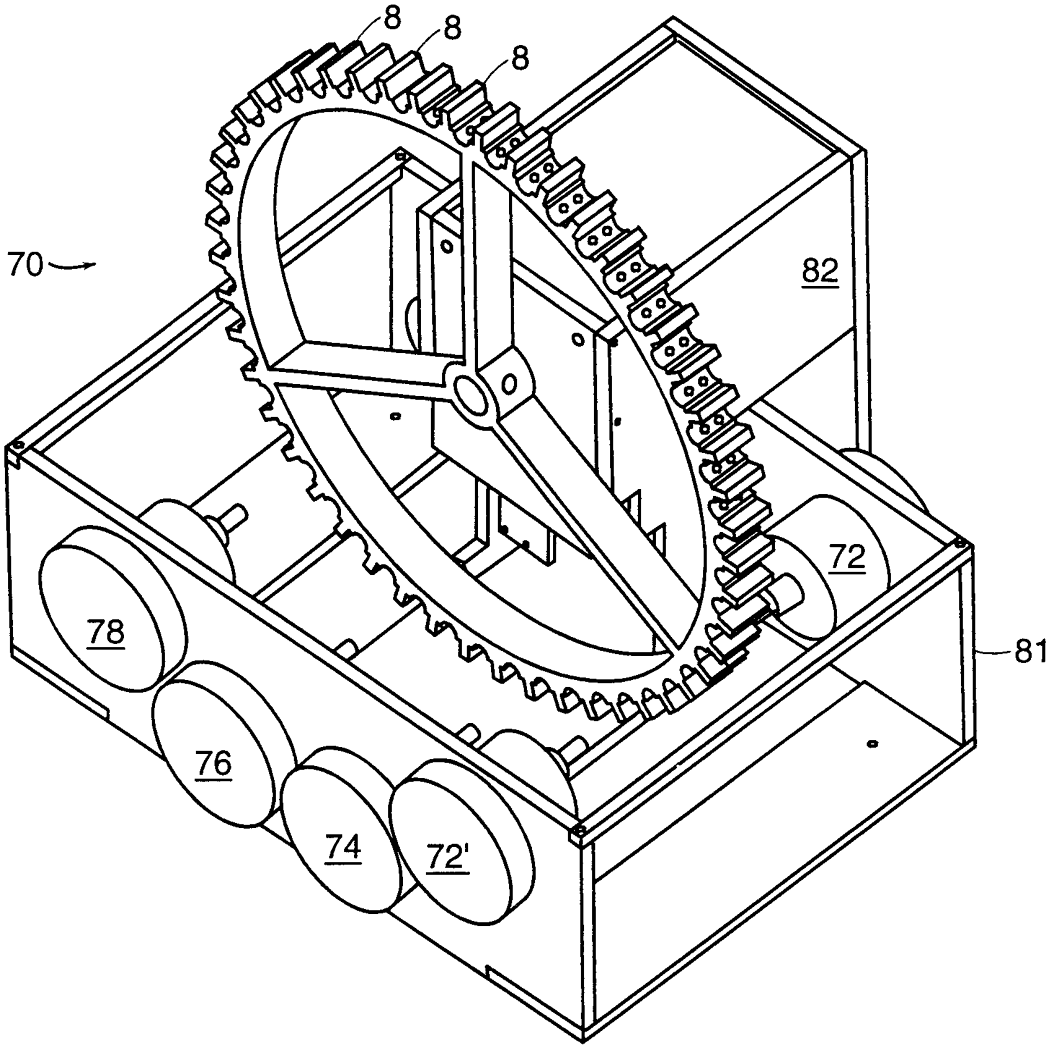

FIG. 4

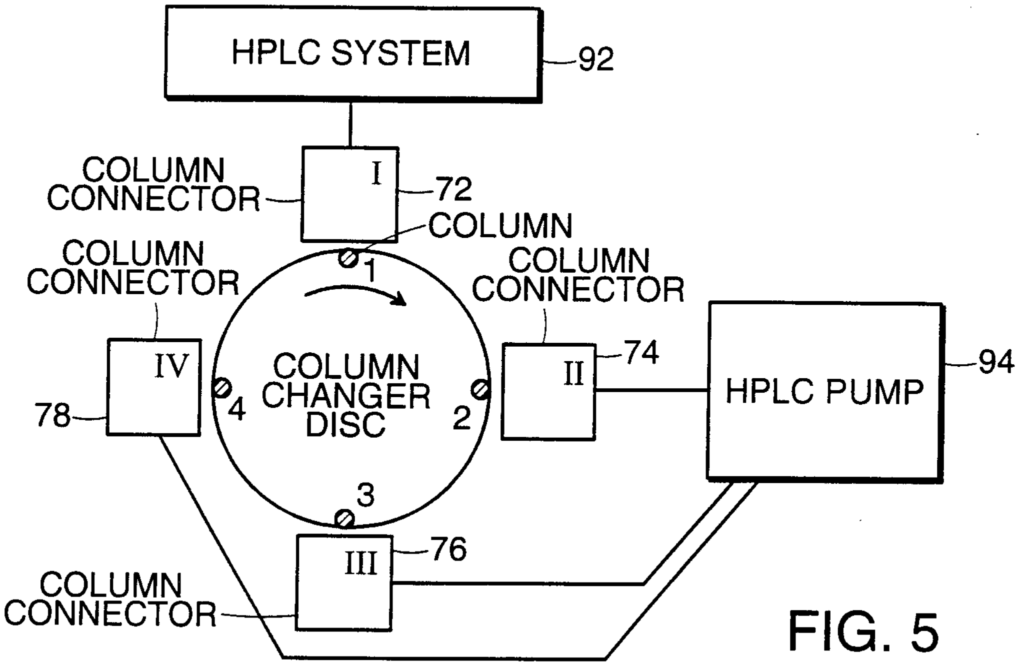

FIG. 5

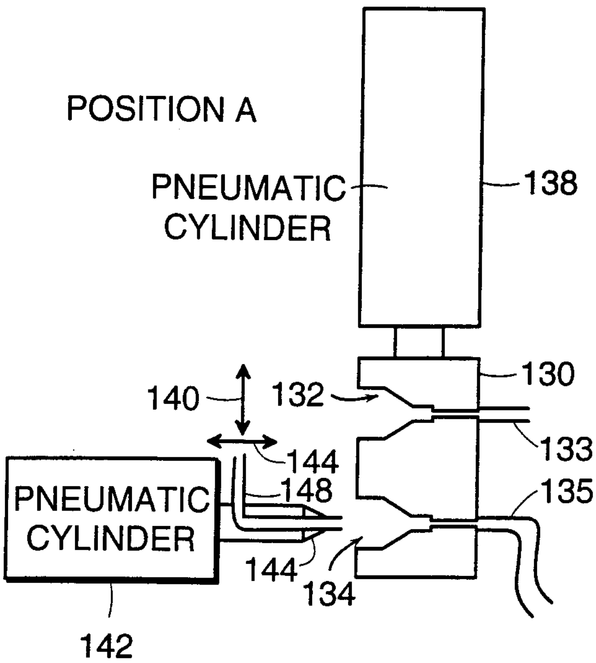

FIG. 7

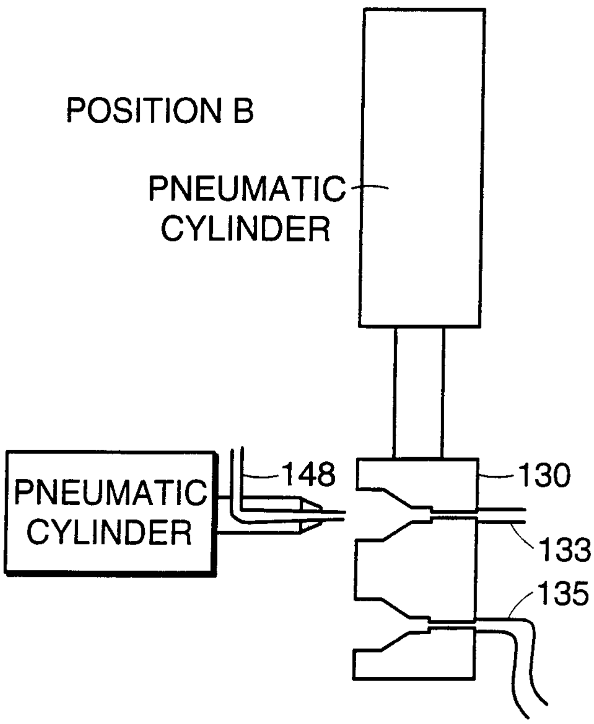

FIG. 7A

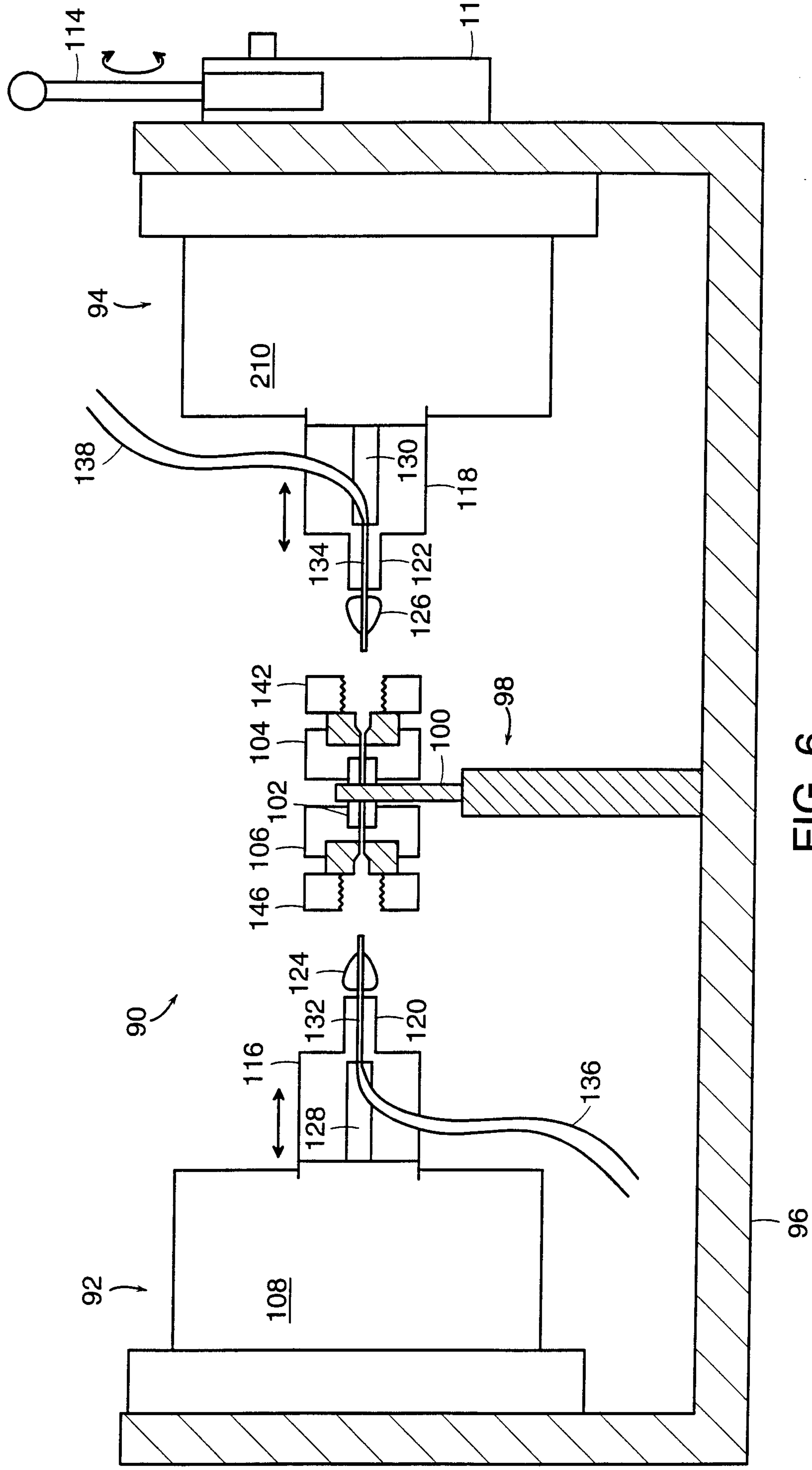
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FIG. 6