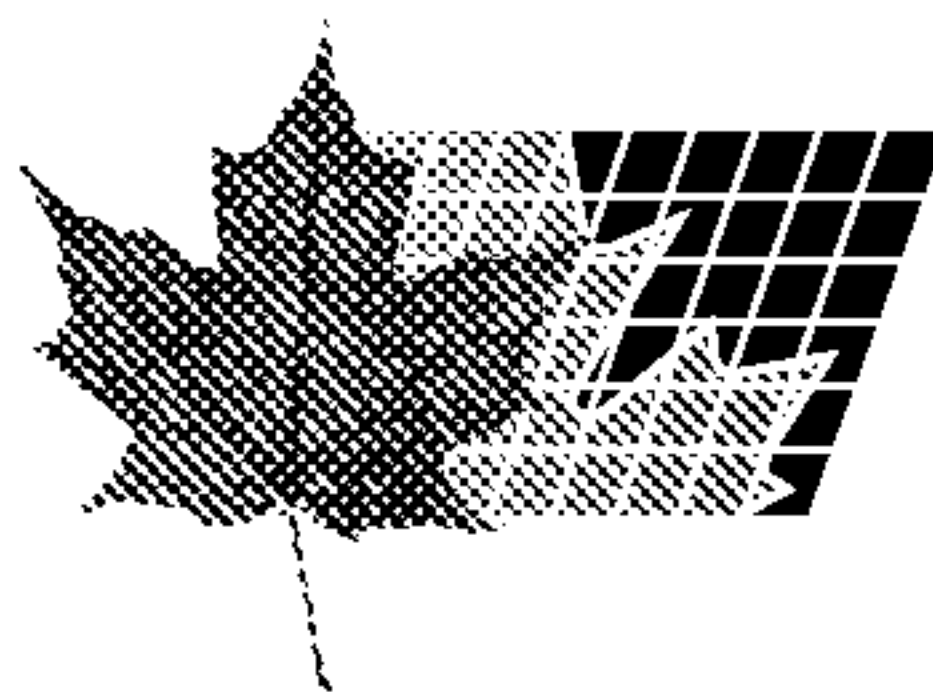




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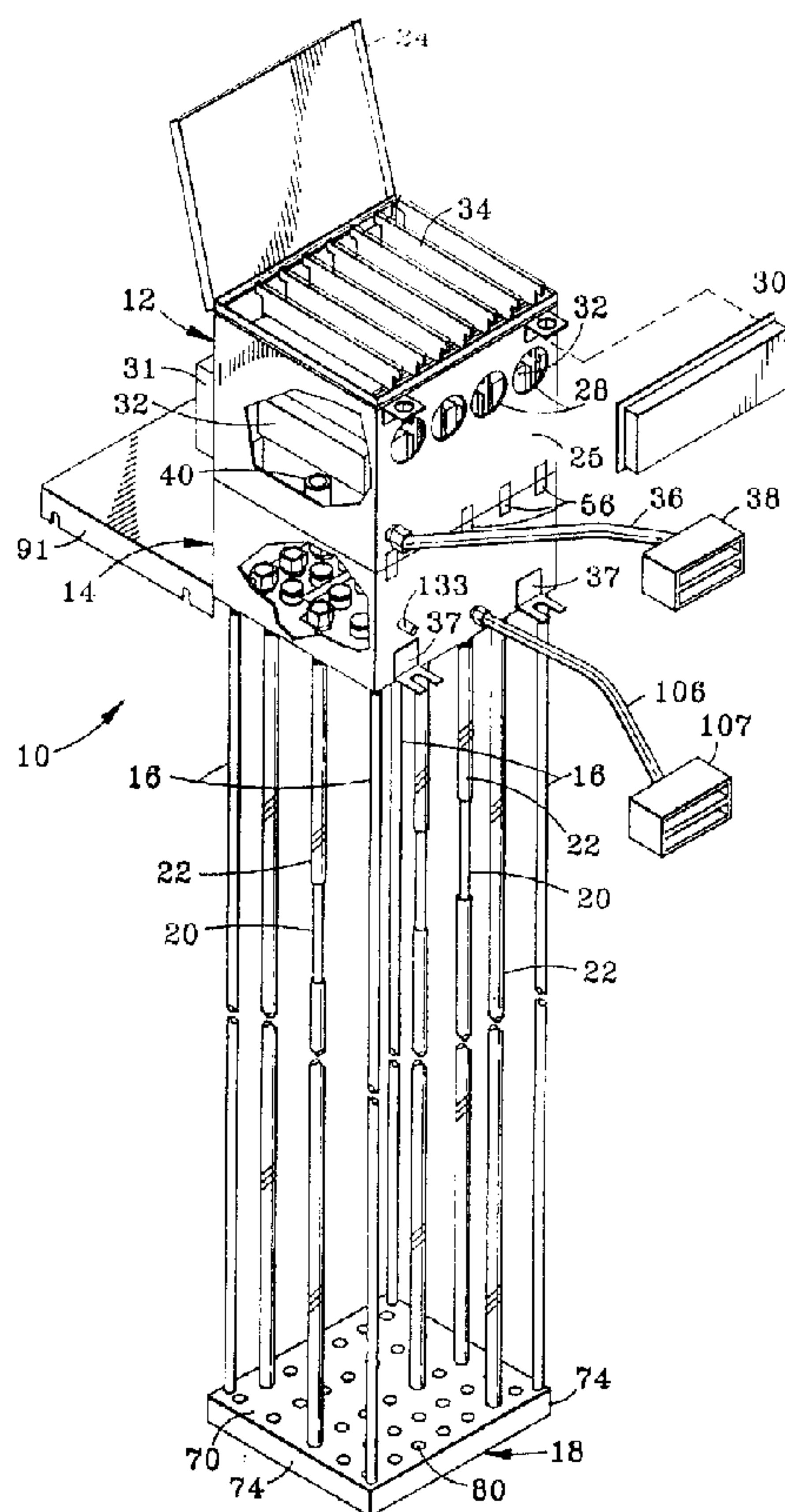
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(54) **APPAREIL A RAYONNEMENT POUR LE TRAITEMENT D'UN FLUIDE**

(54) **RADIATION APPARATUS FOR THE TREATMENT OF A FLUID**



(57) An apparatus for the treatment of a fluid is provided which includes a separate housing and enclosure for containing at least one ballast and electrical means, respectively, to power and control the operation of a plurality of vertically arranged radiation transmission sources in the form of ultraviolet lamps that are immersed in a fluid to be treated. An apparatus and method is included for removing material deposited on the corresponding transparent sleeves which protect the radiation transmission sources, the apparatus comprising (i) a wiper assembly that includes at least one retainer member provided with one or more openings for the passage of a corresponding number of protective sleeves and radiation transmission sources therethrough, (ii) an annular cleaning member disposed about each opening of said retainer member and slidably engaged with the exterior surface of the corresponding protective sleeve; and (iii) a drive mechanism for moving the retainer member along the longitudinal axis of the protective sleeve(s). The apparatus may also include a device and method for ultrasonically agitating the fluid surrounding the protective sleeves to dislodge materials deposited thereon.

ABSTRACT

An apparatus for the treatment of a fluid is provided which includes a separate housing and enclosure for containing at least one ballast and electrical means, respectively, to
5 power and control the operation of a plurality of vertically arranged radiation transmission sources in the form of ultraviolet lamps that are immersed in a fluid to be treated. An apparatus and method is included for removing material deposited on the corresponding transparent sleeves which
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15 cleaning member disposed about each opening of said retainer member and slidably engaged with the exterior surface of the corresponding protective sleeve; and (iii) a drive mechanism for moving the retainer member along the longitudinal axis of the protective sleeve(s). The apparatus may also include a device and method for ultrasonically agitating the fluid surrounding the protective sleeves to dislodge materials deposited thereon.

RADIATION APPARATUS FOR THE TREATMENT OF A FLUID

BACKGROUND OF THE INVENTION

This application is a continuation-in-part of Application Serial No. 08/843,560 filed April 18, 1997, which in turn is a continuation-in-part of Application Serial No. 08/363,527 filed December 23, 1994, now U.S. Patent 5,660,719 issued August 26, 1997.

1. Field Of The Invention

The present invention relates to a radiation transmission apparatus and module for the treatment of a fluid, such as waste water, by destroying undesirable bacteria and microorganisms. The apparatus and module employ a particular arrangement of ballasts, electronics, and one or more radiation transmission sources, e.g., an ultraviolet lamp (hereinafter "UV lamp") for the treatment of a fluid, and according to the invention herein, also include an apparatus and method for removing debris and contaminants that have been deposited on the exterior surface of the protective, transparent jacket surrounding the radiation transmission source.

2. Related Art

U.S. Patent 5,019,256 issued to Ifill et al. on May 28, 1991 discloses a UV lamp rack assembly comprising a vertical array of horizontally disposed UV lamp units for the treatment of wastewater wherein each UV lamp unit can be separately removed. A power control panel is provided at a location remote from the rack assembly for the inclusion of ballasts and various electronics to control the operation of the lamp units.

The patent indicates that the ballasts may alternatively be housed in a submerged waterproof enclosure located immediately above the lamp units and below a deflector D (shown in Figures 2, 3 and 5), or that the ballasts and some electronic circuits can be housed in a conduit forming part of the frame for the lamp rack.

U.S. Patent 5,133,945 issued to Hallett on July 28, 1992 discloses a brush device for cleaning the protective quartz sheath of a single high intensity, high temperature, vertically aligned UV lamp reactor used for treating a fluid medium. The UV lamp reactor is provided with a fan to direct cooling air onto the ceramic mounting portion of the lamp end. However, the required ballasts and electronics for powering and controlling the reactor are not included with the reactor apparatus and the patent is silent with regard to their disposition and location. Only one ultraviolet lamp can be used in this apparatus.

U.S. Patent 5,151,174 issued to Weismann on September 29, 1992 discloses a UV irradiation apparatus for disinfecting clarified sewage comprising a plurality of UV radiators that are grouped together to form modular, individually replaceable, radiator groups (Figure 2) which are mounted into a siphon (Figure 1) such that the groups are arranged in a plane perpendicular to the direction of sewage flow. Electrical fittings for operating the UV radiators are arranged at the upper side of each radiator group, although there is no indication as to the positioning or location of ballasts that are required for powering the lamps. The patent further indicates that the siphon and its hydraulic fittings, electrical fittings, and an electric supply system for the operation of the apparatus, can all be designed as a compact modular unit. However, no disclosure is offered regarding the details of such a module or how it may be accomplished.

U.S. Patent 5,006,244 issued to Maarschalkerweerd on April 9, 1991 discloses a vertical array of horizontally disposed UV lamps between two parallel frame legs, one of which serves as a conduit for the containment and passage of electrical lead wires leading from a ballast to the individual lamp sockets. The ballast is incorporated as part of a horizontal frame member that connects the frame legs.

Systems and devices have been disclosed for cleaning a singular quartz sheath surrounding an ultraviolet lamp in an apparatus that is used for the purification of water. For example, U.S. Patent 3,462,597 issued to Young on August 19, 1969 discloses a wiper system composed of spaced-apart wiper rings surrounding a single quartz sheath and corresponding lamp, the wiper rings being positioned on a rod that extends through one end of the reactor. The wiper rings are moved along the quartz sheath by manually moving the end of the rod with a push-pull action. Unfortunately, the wiper rings and rod would be totally inadequate for an apparatus using a greater number of lamps and corresponding protective sleeves because it would entail the cumbersome use of a corresponding number of rods.

U.S. Patent 3,562,520 issued to Hippen on February 9, 1971 discloses a wiper system consisting of a number of ring-like wiper elements surrounding the external surface of a protective quartz sleeve that houses a single ultraviolet lamp. The wiper assembly is urged along the single quartz sleeve by the action of a coil spring and is moved to the opposite end of the reactor when the water to be purified ceases to flow through the reactor. The wiper system of U.S. Patent 3,904,363 issued to Free on September 9, 1975 is also activated by water flow, and is achieved in such a way that the wiper system is moved to one end of the quartz tube and kept there as long as the water continues to flow through the reactor. When water ceases to

flow through the apparatus, the wipers will descend to the base of the reactor by operation of gravity due to the vertical orientation of the reactor. The drawback of each of the foregoing wiping systems is that their operation is dependent upon water flow and also upon the water flow direction being concurrent with the axial orientation of the single ultraviolet lamp. Each of these systems would be inadequate for treatments involving continuous water flow operations over extended periods of time.

In U.S. Patent 4,002,918 issued to Graentzel on January 11, 1977, the ultraviolet light apparatus employs an annular arrangement of ultraviolet lamps surrounding a centrally disposed protective tube through which contaminated water flows. A rotor, which is provided with radially disposed bores containing wiping pins for cleaning the inner surface of the radiation pervious protective tube, is inserted into the center of the protective tube, and as the contaminated water flows between the rotor and tube, and the rotor rotated, the wiping pins are forced outwardly into contact with the protective tube for clearing the contaminants deposited on the inside of the tube. Limits are placed on the number of lamps and protective sleeves that can be utilized.

Finally, U.S. Patent 5,332,388 issued to Schuerch et al. on July 26, 1994 discloses a portable and immersible ultraviolet light module for irradiating waste fluids directed through a channel. The module, which is lowered into the channel, contains a plurality of ultraviolet lamps that are vertically oriented between a top and lower header. The top of the lower header is provided with a multiplicity of openings to permit air to flow into the waste water about the jackets of the ultraviolet lamps. As the air rises in the form of bubbles about the lamp jackets, their cleaning action keeps contaminants in the water from being deposited onto the outside

surface of the jackets.

SUMMARY OF THE INVENTION

In its broadest aspect, the invention provides an apparatus that includes a separate housing and enclosure for containing at least one ballast and electrical means, respectively, to power and control the operation of one or more vertically arranged radiation transmission sources that are immersed in a fluid for the treatment thereof, and an apparatus for the substantial removal of material that is deposited on the exterior surface of the protective sleeve surrounding the radiation transmission source(s) during a fluid treatment process. By housing the ballast and electrical means in compartments that are separate from each other, and providing the ballast and electrical means with detachable electrical couplers, each compartment serves as an individually sealed and isolated area for offering greatly enhanced accessibility, maintenance and maximum performance of the various components of a radiation apparatus in the environment intended for its operation and use.

More specifically, the invention provides a radiation transmission apparatus for the treatment of a fluid comprising at least one, commonly a plurality, vertically arranged radiation transmission source accompanied by appropriate means to permit submersion of the radiation transmission source in the fluid to be treated, e.g., by the use of a radiation pervious protective sleeve. The radiation apparatus further includes a housing for containing at least one ballast to power the radiation transmission source(s), although a plurality of ballasts may be utilized when several radiation transmission sources are employed. At least one enclosure is provided for

containing electrical means that serve to operate the lamp by furnishing communication between the ballast and the radiation transmission source(s). The enclosure is disposed intermediate the housing and radiation transmission source(s). The housing, enclosure and radiation transmission sources are generally vertically aligned relative to each other to simplify access to the housing and enclosure. Each of these components may also be arranged to interface each other.

The radiation transmission source is vertically aligned relative to the enclosure. In order to prevent the fluid from accessing the electrical connections, a radiation pervious protective sleeve, generally made of quartz, is used to insulate the radiation transmission source, e.g., a UV lamp, one end of which is closed and the other end secured within the enclosure in waterproof relationship thereto. The enclosure is sealed to provide a water-resistant environment for the electrical means therein, usually with a waterproof seal to prevent the substantial entrainment of moisture into the enclosure, thereby offering a dry environment for the enclosed electrical means and any other electrical apparatus that may be utilized with the radiation apparatus.

Inasmuch as a substantial amount of heat is generated during the operation of the ballast, the housing may be provided with a means for cooling the ballast which in one embodiment comprises at least one opening in the housing for the passage of ambient air therethrough, and the addition of at least one fan operatively communicating with the opening for the circulation of ambient air in the housing. Alternatively, the housing may be provided with an air conditioning means for cooling the ballasts, or a sealed heat exchanger. By utilizing the air conditioning means or heat exchanger, the housing is configured to be closed to the ambient environment.

The electrical means, which is housed in the enclosure, includes lead wires connecting the radiation transmission source ends with detachable couplers also disposed within the enclosure. In similar fashion, the ballast, which is compartmentalized in its own housing, includes lead wires connected to detachable couplers that may be disposed within the housing or enclosure for detachably connecting the ballast to the electrical means. This systematic arrangement of the ballast within its housing and the electrical means within its corresponding enclosure, permits either one of these components and the radiation transmission source(s) to be separately addressed or removed while residing in its operating environment. Maintenance operations can be carried out without materially disturbing the unaffected members of the apparatus.

The electrical means may further include a means for sensing the functional status of one or more of the radiation transmission sources contained within the apparatus. As used herein, the phrase "functional status" is meant to describe whether the lamp is "ON" or "OFF" for the purpose of emitting ultraviolet light, i.e., whether the lamp is or is not emitting ultraviolet light.

Another aspect of the invention contemplates the utilization of a radiation module for the treatment of a fluid, which, in addition to the aforestated radiation transmission sources, protective sleeves, housing, enclosure, electrical means, and apparatus for the substantial removal of material deposited on the exterior surface of the radiation pervious protective sleeve(s), includes a plurality of ballasts for powering the radiation transmission sources, typically on the order of one or two UV lamps per ballast, and a support structure communicating with the enclosure for maintaining the radiation transmission sources in vertical alignment with the enclosure. The support structure may take the form of a base

comprising one or more vertically arranged support members communicating with the enclosure for supporting the radiation transmission sources between the enclosure and base. In this fashion, all of the elements making up the module are integrated into a single unit which can be easily handled and lowered into an appropriately configured vessel, such as a tank, channel or conduit, for the treatment of a fluid contained therein or passing therethrough. The base may be in the form of a plate member provided with a plurality of openings for receiving the lower portion of a corresponding number of protective sleeves. In another embodiment, the base may comprise a top and bottom member joined in spaced apart relationship by at least two opposing side walls, the top member comprising a plurality of openings for receiving the lower portion of a corresponding number of protective sleeves therein. The openings for either configuration of the base may also be provided with a receptacle for receiving and maintaining the lower portion of the protective sleeve(s) therein. The base may also be configured as a compartment comprising a top and bottom member joined in spaced apart relationship by a pair of opposing side walls.

It will be appreciated that as the fluid to be treated, commonly in the form of clarified waste water, flows past the radiation transmission source(s), contaminants within the fluid will, over time, adhere to the surface of the protective sleeve(s) of the radiation transmission source(s). This buildup of deposits on the surface of the protective sleeves occludes the radiation, e.g., ultraviolet light, emitted by the radiation transmission source(s). Therefore, in addition to the radiation transmission source(s), protective sleeve(s), housing, and enclosure, the radiation apparatus or module also includes an apparatus for the substantial removal of material deposited on the exterior surface of the radiation pervious protective sleeve(s) during the fluid treatment process. This

apparatus comprises a wiping device that includes (a) a wiper assembly including (i) at least one retainer member provided with at least one opening for receiving therethrough a corresponding number of protective sleeves, and (ii) an annular cleaning member disposed about each opening of the retainer member and slidably engaged with the exterior surface of the protective sleeve; and (b) a drive mechanism operably communicating with the enclosure and the wiper assembly for the movement of the wiper assembly along the longitudinal axis of the protective sleeve.

When more than one retainer member is utilized, they may be connected to each other in parallel spaced apart relationship relative to each other by one or more connecting members.

The annular cleaning member may comprise a resilient means or a semi-rigid material plastic material that is unaffected by ultraviolet light, e.g., Teflon. The resilient means has an annular configuration that will make slidable contact with the exterior surface of the protective sleeve(s) to substantially remove the deposited material that has accumulated thereon. It therefore has an inner circumference smaller than the outer circumference of the protective sleeve. In this way, the resistance fit of the cleaning member about the exterior surface of the protective sleeve permits the cleaning member to come in constant slidable contact with the deposited material when the wiper assembly moves along the axis of the protective sleeve. Any debris that has accumulated on the surface of the sleeve will be removed by the cleaning member in an efficient manner. The resilient means may be constructed of a synthetic material, such as EPDM, BUNA or Viton®, or a natural material such as rubber. In the case of stubborn deposits, the resilient means may be comprised of bristles, the ends of which extend radially inward from the circumference of the opening in

the retainer member of the wiper assembly so that frictional contact is made with the exterior surface of the protective sleeve.

Several drive mechanisms for the movement of the wiper assembly along the longitudinal axis of the protective sleeve(s) may be used in accordance with the invention herein. In one aspect of the invention, the drive mechanism may comprise a piston disposed within a chamber that is in fixed relationship with the enclosure and/or support structure, and is operatively engaged with the cleaning element for its movement along the longitudinal axis of the protective sleeve(s). For economy of operation and access, the chamber may be secured to the underside of the enclosure. When the apparatus is provided with a support structure comprising, for example, a base and one or more vertically arranged support members that communicate with the enclosure and the base for maintaining the ultraviolet lamp(s) therebetween, the chamber for the piston may be disposed intermediate the enclosure and the base, typically by securing it to either the enclosure or the base.

The piston may be operatively engaged with the wiper assembly by a shaft connected to the piston and retainer member of the wiper assembly. In the event that a plurality of retainer members forms the wiper assembly, the shaft may be connected to the retainer member closest to the vertical midpoint of the protective sleeve. This applies regardless of whether the chamber is secured to the enclosure or to the support structure, e.g., the base. It also assumes that the multiple retainer members are connected to each other in parallel spaced apart relationship by one or more connecting members. Operational movement of the wiper assembly along the protective sleeve(s) may be accomplished by pneumatically or hydraulically moving the piston within the chamber.

In another aspect of the invention, particularly if more than one retainer member is utilized for the wiper assembly, the drive mechanism may comprise a fluid operated linear slide for the operation of the wiper assembly. The linear slide includes a stationary partition disposed within a movable housing for the guided axial movement of the housing and wiper assembly along an elongate hollow shaft extending from either side of the partition through the respective ends of the movable housing, the opposing respective ends of the shafts being supported by the support structure and enclosure. The movable housing and wiper assembly are arranged such that they move in concert in response to a differential pressure communicated to the movable housing from a source of pressurized fluid.

More particularly, the linear slide comprises (a) a movable housing including an annular cavity, the movable housing communicating with said wiper assembly for their movement along the longitudinal axis of the protective sleeves; (b) a stationary partition disposed within the annular cavity and slidably engaged with the movable housing thereby forming a first and second chamber therein; (c) a stationary first and second elongate hollow shaft including a first and second passage communicating respectively with the first and second chambers, each shaft having one end extending from one side of the partition in the axial direction of the annular cavity, and the respective opposing ends of the shafts being supported by the support structure and the enclosure and being adapted to communicate with the source of pressurized fluid; and (d) a first and second annular sealing device mounted about the respective ends of the movable housing in fluid tight relationship thereto and in slidable and fluid tight relationship about the respective shafts, for the guided movement of said housing in the axial direction of said shafts

in response to a differential pressure communicated to the annular cavity from the source of pressurized fluid via the first and second passages.

The movable housing is generally concentric with the central axis of the elongate hollow shafts whose end portions may be supported by the base of the support structure and the enclosure. It will be understood, however, that concentricity of the movable housing with the respective elongate hollow shafts is not a requirement for the operation of the linear slide.

The partition has a sealing means provided about the circumference of the partition for slidable engagement with the movable housing and for maintaining a fluid tight seal between the first and second chambers. The sealing means may comprise a pair of cup seals or such other seals that will accomplish the aforestated functions. When cup seals are used as the sealing means, each cup seal has their U-shaped opening, or a portion thereof, communicating respectively with the first and second chambers. The communication of the U-shaped portion of the cup seal with its respective chamber enables the fluid under pressure to extend into the cup seal for augmenting the seal between the partition and internal wall of the movable housing. The partition may also be provided with a guide member about its circumference for engagement with the housing, for example, by having the guide member annularly disposed about the partition between the pair of cup seals. The guide member will generally be configured as a wear bushing.

Each side of the partition may include a protrusion extending in an axial direction therefrom for receiving the respective ends of the first and second elongate shafts in fluid tight relationship. The first and second passages of the respective elongate shafts are aligned with a corresponding

passageway provided in the protrusions for communicating the fluid under pressure between the interior of the first and second shafts and the respective first and second chambers.

It will be understood that the pressurized fluid for the operation of the linear slide can be introduced exclusively at one end of the slide as opposed to its introduction at both ends thereof. In accordance with this aspect of the invention, one of the first or second shafts may include therein an axially disposed stationary conduit forming an actuation conduit, with the remaining shaft being hermetically sealed about its supportive end. The actuation conduit has one end communicating in fluid tight relationship with a passageway axially extending through the partition into the interior of the remaining shaft. The opposite open end of the actuation conduit, as well as the open end of the shaft, is adapted to connect with the source of pressurized fluid.

The partition may also be configured with a protrusion on either of its sides for receiving the respective first and second shafts in fluid tight relationship therewith. In another aspect of the invention, one end of the actuation conduit communicates in fluid tight relationship with a passageway disposed in the partition and in the protrusions that communicates with the passage of the remaining shaft. The opposite open ends of the shaft and actuation conduit are adapted to be connected with the source of pressurized fluid. The remaining shaft is hermetically sealed about its supportive end. This arrangement permits a pressure differential to be created in the housing by the introduction of fluid under pressure to one end of the linear slide, generally through the end of the slide that is supported by the enclosure.

One or both of the first and second sealing devices may be fixedly secured or detachably secured about the ends of the

housing. In the latter case, one or both of the sealing devices can be in detachable threaded engagement with the end of the housing.

Each of the first and second sealing devices may include an annular end cap slidably mounted about the interior of the end of the movable housing and about its respective elongate hollow shaft. The end cap includes an annular bore about its inner annular surface for receiving therein annular sealing means to provide a slidable hermetic seal between the shaft and the corresponding chamber of the movable housing. The sealing means may comprise at least one lip seal, generally a pair of lip seals, disposed in back-to-back relationship relative to each other with one of the lip seals having at least a portion of its U-shaped opening communicating with the corresponding chamber of the housing. The annular end cap may optionally be provided with an annular guide member about an annular bore provided in the cap's inner annular surface for engagement with the cap's respective shaft, for example, by having the guide member annularly disposed about the shaft between the inner lip seal (the lip seal proximate to the respective chamber) and the respective chamber or between the pair of lip seals themselves. The guide member may also be disposed in an annular bore provided in the end cap between the pair of lip seals. The guide member will generally be configured as a wear bushing.

In accordance with yet another aspect of the invention, the drive mechanism may also comprise a rotatable threaded rod, supported by the enclosure and the support structure, and operatively engaged with a threaded opening provided in the retainer member of the wiper assembly for moving the wiper assembly along the longitudinal axis of the protective sleeve(s). The threaded opening of the retainer member may take the form of one more threaded nuts fixed about an opening

provided in the retainer member. When more than one retainer member is utilized for the wiper assembly, the threaded rod may be engaged with one or more correspondingly threaded nuts disposed about an opening provided in each of the retainer members, the retainer members being spaced apart in parallel relationship along the threaded rod by a predetermined distance. Rotation of the threaded rod may be obtained by being operably connected to a means for rotating the rod in order to effect movement of the wiper assembly along the longitudinal axis of the protective sleeve(s). The means for rotating the threaded rod may include an electric motor which may be disposed within the enclosure. When the motor is activated to turn the threaded rod in either direction, i.e., clockwise or counter-clockwise, the retainer member(s) of the wiper assembly is correspondingly moved along the longitudinal axis of the protective sleeves.

As an adjunct to the foregoing drive mechanisms, particularly when the apparatus or module includes a base in the form of a compartment, specifically a base that comprises a top and bottom member joined in spaced apart relationship by a pair of opposing side walls, the apparatus or module may optionally include a means for agitating the fluid about the protective sleeve(s). Such means comprises, in addition to the foregoing base, at least one passage disposed in the base for receiving a cleaning fluid therein, and one or more apertures disposed in the top member of the base proximate to the protective sleeves for the passage of the cleaning fluid therethrough and into contact with the protective sleeve(s). The cleaning fluid may be in the form of a compressed gas (e.g., air or an inert gas such as nitrogen, argon, etc.) that will produce gas-containing bubbles when introduced into the fluid under treatment. The gas-containing bubbles will cause agitation of the fluid about the protective sleeve(s) for preventing residue or contaminants contained in the fluid from

collecting onto the protective sleeve's surface. In one embodiment, at least one support leg of the module serves as a conduit for the passage of the cleaning fluid to the base. The cleaning fluid may be introduced to at least one of the leg supports from a source external to the module via a conduit provided in the enclosure communicating with the leg support.

In another aspect of the invention, the apparatus for the substantial removal of material deposited on the exterior surface of the protective sleeve(s) may be a means for ultrasonically agitating the fluid surrounding the protective sleeve(s) which includes an electronic generator coupled with one or more transducers for the generation and transmission of ultrasonic waves to the fluid surrounding the protective sleeve(s). The arrangement of the generator and transducer(s) is such that the generator may be retained by the enclosure and the transducer(s) positioned below the enclosure for immersion in the fluid being treated. When ultrasonic waves are generated by the generator and transmitted to the fluid by way of the transducer(s) at an ultrasonic frequency of at least 18 kHz, and generally in the range of about 18 to 120 kHz, removal of tenacious contaminants and deposits on the protective sleeve(s) is readily accomplished. An ultrasonic frequency may be generated in the range of about 18 to 25 kHz and/or about 35 to 70 kHz depending on the nature of material to be removed from the protective sleeve(s) and the colligative properties and flow characteristics of the fluid being treated.

In yet another aspect of the invention, a device is provided for the substantial removal of deposited material on the exterior surface of at least one radiation pervious protective sleeve surrounding at least one vertically arranged radiation transmission source in a radiation apparatus configured for immersion in a fluid for the treatment there. The device includes (a) a wiper assembly comprising (i) at

least one retainer member provided with at least one opening for receiving the protective sleeve therethrough, and (ii) an annular cleaning member disposed about the opening and slidably engaged with the exterior surface of the protective sleeve; and (b) a drive mechanism operably communicating with the wiper assembly and radiation apparatus for moving the wiper assembly along the longitudinal axis of the protective sleeve. While not intending to be limited to the various embodiments of the device, the various embodiments for the wiper assembly, cleaning member and drive mechanism of the device are the same as those set forth and described above for the apparatus for the substantial removal of material deposited on the exterior surface of the radiation pervious protective sleeve(s).

In accordance with another aspect of the invention, a method is also provided for the simultaneous treatment of a fluid and the substantial removal of material deposited on the radiation pervious protective sleeve surrounding a radiation transmission source in a radiation module, comprising the steps of:

(a) installing a wiper assembly about the longitudinal axis of the protective sleeves of the radiation module;

(b) mounting a drive mechanism to the wiper assembly, the drive mechanism being supported by the radiation module which includes (i) an enclosure for receiving the electrical ends of the radiation transmission sources and containing the electrical means for the operation of the radiation transmission source, and (ii) a support structure communicating with the enclosure for maintaining the radiation transmission sources and corresponding protective sleeves in vertical alignment therebetween;

(c) installing the radiation module in a vessel containing the fluid to be treated; and

(d) treating the fluid by the operation of the radiation transmission sources while simultaneously causing the wiper

assembly to move in the axial direction of the protective sleeves by the actuation of the drive mechanism.

The vessel into the which the radiation module is installed may be in the form of a tank, channel or conduit. When a conduit is utilized, it has an upstream and downstream end for allowing the passage of fluid therethrough and the module is installed between the upstream and downstream ends.

While not intending to be limited to the various embodiments of the components utilized in the foregoing method, the various embodiments for the radiation module, wiper assembly, and drive mechanisms of the method are the same as those set forth and described above for the same components.

When the support structure comprises a base in the form of a compartment described hereinbefore, the movement of the wiper assembly along the longitudinal axis of the protective sleeves may be accompanied by the introduction of a cleaning fluid through a plurality of apertures provided in the top member of the base for making contact with the outer surface of the protective sleeves. The optional step of utilizing a cleaning fluid prevents deposits from forming on the surface of the protective sleeves which augments the cleaning of the protective sleeves undertaken by the wiper assembly.

Another method for the substantial removal of material deposited on the exterior surface of a radiation pervious protective sleeve surrounding a vertically arranged radiation transmission source disposed between (i) an enclosure for housing electronic means for the radiation transmission source's operation, and (ii) a support structure in a radiation apparatus configured for immersion in a fluid for the treatment thereof, is also provided. The method comprises the steps of:

(a) installing an electronic generator with the enclosure;

(b) operatively coupling the generator with a plurality of transducers disposed below the enclosure of the radiation apparatus;

(c) immersing the radiation module in the fluid to be treated; and

(d) operating the electronic generator and transducers for the generation and transmission of ultrasonic waves to the fluid surrounding the protective sleeve at an ultrasonic frequency of at least 18 kHz, and generally in the range of from about 18 to about 120 kHz. Agitation of the fluid may be carried out at an ultrasonic frequency range of about 18 to about 25 kHz and/or about 35 to about 70 kHz depending on the nature of the material to be removed from the protective sleeve and the colligative properties and flow characteristics of the fluid being treated by the radiation module.

BRIEF DESCRIPTION OF THE DRAWINGS

A complete understanding of the present invention may be obtained by reference to the following specification when taken in conjunction with the accompanying drawings wherein certain preferred embodiments are illustrated and wherein like numerals refer to like parts throughout.

FIGURE 1 illustrates an isometric perspective view of a radiation module in accordance with the invention herein.

FIGURE 2 is an elevated segmented and partial cross-sectional plan view of a major portion of the radiation module shown in Figure 2.

FIGURE 3 is an elevated side view of the upper portion of the radiation module illustrating the compartments shown in Figure 2.

FIGURE 4 is an elevated cross-sectional view of the upper portion of the radiation module shown in Figure 3 illustrating an embodiment for the hinged removal of the top compartment of the module.

FIGURE 5 is an elevated cross-sectional plan view on an enlarged scale of the circled detail identified by the letter A in Figure 2, which illustrates the assembly of a leg support, UV lamp and protective sleeve with the lower compartment of the module in accordance with one embodiment of the invention.

FIGURE 6 is a cross-sectional plan view on an enlarged scale of the circled detail identified by the letter B in Figure 2, which illustrates the assembly of a leg support, UV lamp and protective sleeve with the base of the module in

accordance with another embodiment of the invention.

FIGURE 7 is an enlarged schematic plan view of the interior of the lower compartment of the module illustrated in Figure 1 selectively illustrating the electronics housed therein in accordance with another embodiment of the invention.

FIGURE 8 is a schematic diagram illustrating a manner of controlling the operation of a the radiation module shown in Figure 1 in accordance with yet another embodiment of the invention.

FIGURE 9 is an isometric perspective view of the radiation module illustrated in Figure 1 incorporating a wiping device in accordance with one aspect of the invention.

FIGURE 10 is an isolated isometric perspective view of the wiping device illustrated in Figure 9.

FIGURE 11 is a isometric perspective view of the drive mechanism illustrated in Figure 10 showing the manner of its attachment to the underside of the lower compartment of the radiation module illustrated in Figure 9.

FIGURE 12 is a combined segmented elevational plan view, on an enlarged scale, of the drive mechanism's attachment to the underside of the lower compartment of the radiation module illustrated in Figure 11, and an isometric perspective view of the circled detail identified by the letter D in Figure 10.

FIGURE 13 is an isometric perspective view, on an enlarged scale, of the circled detail identified by the letter C in Figure 9 illustrating the manner in which the wiper plate of and the annular cleaning member of the wiping device is disposed about the protective sleeve of a corresponding

ultraviolet lamp.

FIGURE 14 is an isometric perspective view of an alternative wiping device for inclusion in the radiation module illustrated in Figure 9 in accordance with another aspect of the invention.

FIGURE 15 is an elevated segmented plan view, on an enlarged scale, of the incorporation of the drive mechanism of Figure 14 incorporated with the lower compartment of the radiation module shown in Figure 9, and of the circled detail identified by the letter E in Figure 14.

FIGURE 16 is an isometric perspective view of the radiation module illustrated in Figure 1 utilizing a fluid operated linear slide as the drive mechanism for the wiping device in accordance with another aspect of the invention.

FIGURE 17 is an elevational plan view, on an enlarged scale, of the circled detail designated as VIEW F in Figure 16.

FIGURE 18 is an elevational plan view, on an enlarged scale, of the circled detail designated as VIEW H in Figure 16.

FIGURE 19 is an elevational plan view, on an enlarged scale, of the circled detail designated as VIEW G in Figure 16.

FIGURE 20 is an expanded and segmented cross-sectional plan view of the fluid operated linear slide 200 illustrated in Figure 16.

FIGURE 21 is an expanded cross-sectional plan view of sealing device 256 illustrated in Figure 20.

FIGURE 22 is a segmented cross-sectional plan view of a

portion of another embodiment of the linear slide illustrated in Figure 20.

FIGURE 23 is a segmented cross-sectional plan view of another embodiment of the linear slide illustrated in Figure 20.

FIGURE 24 is a segmented cross-sectional plan view of a portion of a second embodiment of the linear slide illustrated in Figure 20.

FIGURE 25 is a segmented cross-sectional plan view of another embodiment of the linear slide illustrated in Figure 24.

FIGURE 26 is a segmented cross-sectional plan view of another embodiment of the sealing device illustrated in Figure 18.

FIGURE 27 is a segmented cross-sectional plan view of another embodiment of the linear slide illustrated in Figure 25.

FIGURE 28 is an isometric perspective view of an ultrasonic cleaning device incorporated with the radiation module illustrated in Figure 1.

FIGURE 29 is a segmented elevated plan view, on an enlarged scale, of the ultrasonic cleaning device shown in Figure 28.

DETAILED DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENTS THEREOF

The present invention provides a radiation apparatus, generally in the form of a modular configuration, for the purification and/or treatment of a fluid which, upon exposure to one or more vertically arranged radiation transmission sources, e.g., exposure to the ultraviolet light emitted from a UV lamp, will destroy harmful bacteria and microorganisms contained within the body of the fluid. Typically, the body of fluid is clarified sewage that is directed through a vessel, such as a conduit or channel, within which the radiation apparatus is inserted. Rather than have the ballasts and electronics that power and operate the UV lamps disposed externally of the apparatus in a remote location, which presents logistical problems associated with excessive wiring, time consuming maintenance and downtime, the apparatus according to the invention integrates the UV lamps (or other radiation transmission sources) with the ballasts and electronics by segregating the ballasts and electronics into separate compartments for easy access and handling. This is an important design feature in that individual components of the radiation apparatus can be maintained, repaired or replaced without disturbing the other components of the apparatus. Detachable electrical couplers, which are integrated with the wiring and cabling communicating between the various components, may be utilized to great advantage in order to enhance the functioning and maintenance of the apparatus, viz., the ballasts, electronics and UV lamp(s).

Furthermore, by allocating a separate housing for the ballasts apart from an enclosure for the radiation transmission source electronics, high voltage arcing between the connections of the radiation transmission sources and electronics is

virtually eliminated. Arcing generally occurs when ambient air, which is moisture laden due to the apparatus' proximity to the fluid being treated, is circulated over the ballasts to remove excessive heat during their operation. The arcing is prevented by restricting the ballasts to a separate housing which permits the electronics to be insulated from the moist ambient air used for cooling the ballasts.

Another distinct advantage offered by the invention is that by providing a sealed enclosure for the radiation transmission source connections and associated electronics, contaminants from the waste water will be unable to find their way into the radiation pervious protective sleeves which would otherwise impair radiation of the UV light to the waste water. Maximum use and efficiency of the apparatus are not only achieved: operation of the radiation transmission sources is significantly enhanced. Moreover, maintenance can be accomplished while the apparatus is on site in its operating environment. In addition, all of the components of the apparatus, or the entire apparatus itself, can be accessed or removed without disturbing other similar or like units that are functioning in close proximity. The radiation apparatus may be used in combination with like or similar apparatus for the purification of a fluid. Maximum use and operation of the radiation apparatus is thereby achieved.

Referring now to Figures 1, 2 and 3, a radiation apparatus is illustrated in the form of a radiation module 10 constituting a preferred embodiment of the invention. The module comprises a stainless steel (or other non-corrosive material) top compartment 12 overlying and interfacing a lower compartment 14 which is supported by a plurality of support legs 16 mounted to a support base 18. A plurality of transparent quartz sleeves 22 having corresponding UV lamps 20 inserted therein, are positioned between and mounted to

support base 18 and the underlying portion of the lower compartment 14 in a manner that is described in greater detail below.

The top compartment 12 is provided with a cover 24 that has a hinge 26 (Figure 2) for enabling the cover to be swung open in the manner shown in Figure 1. Compartment 12 houses a plurality of ballasts 32 connected to alignment plates 34 for the separation and alignment of the ballasts within the compartment. Ballasts 32, which are used for powering UV lamps 20, are connected to a cable 36 configured to exit compartment 12 and terminate in a multi-pin electrical coupler 38 which communicates with a source of electrical power contained within a control console in a manner that is described in greater detail below. Due to the amount of heat given off by the ballasts during the operation of UV lamps 20, a plurality of openings 28 are incorporated into one side 25 of compartment 12 overlaid by a shroud 30 that is open on one side. The opposite side of compartment 12, i.e., the side opposite to side 25, has similar openings 27 (see Figure 3) which is also covered by a shroud 31 interfacing a fan 29 for drawing ambient air into the bottom of the compartment 12 interior. Electrical fan 29, which is mounted in the bottom interior of compartment 12, directs the ambient air over the ballasts which then exits through openings 28. A filter (not shown) can also be provided within shroud 31 to prevent unwanted foreign objects, e.g., insects, from entering the interior of compartment 12.

As an alternative to electrical fan 29, an air-conditioning or heat exchanger unit may be operatively connected with compartment 12 for cooling the interior thereof. The location of such units can be remote, or affixed to compartment 12 in the location occupied shrouds 30 and/or 31. The alternative arrangement would necessitate the replacement of compartment openings 27 and 28 with appropriate openings to

accommodate such units. Appropriate seals (not shown) are provided to insulate top compartment 12 from ambient conditions with the same integrity offered by the seals described below for lower compartment 14.

The bottom of top compartment 12, which is shown with greater clarity in the embodiment illustrated in Figure 2, is coincident with the top of lower compartment 14. In other words, dividing wall 39 is common to both the top and lower compartments. Dividing wall 39 is provided with an electrical wire conduit 40 for the passage therethrough of electrical wires 42 leading from receptacles 44 that are provided with detachable couplers 45, which in turn receive lead wires 46 from the corresponding ballasts 32. With this arrangement any one of ballasts 32 can be removed from compartment 12 without disturbing the electrical connections of the other ballasts and the electrical connections to the electronics contained in lower compartment 14. In order to provide a water-tight seal for the interior of lower compartment 14, any means known in the art may be used to close electrical wire conduit 40, preferably with an annular seal (not shown) in the form of an "O" ring mounted on top of the inlet about which a threaded sleeve is provided to insure a proper seal about the wires passing through the "O" ring and wire conduit 40. It will be understood that in place of common dividing wall 39, the top and lower compartments can be configured to be separated from one another.

Referring to Figure 4, lower compartment 14 has a box-like construction, preferably made of stainless steel, that includes side walls 48 and bottom member 50, to form a separate enclosure for the electronics used to operate UV lamps 20. The tops of side walls 48 are provided with indented extension walls 52 that are configured to be received within depending walls 54 extending downwardly from top compartment 12 and

dividing wall 39. This arrangement enables top compartment 12, including the dividing wall 39, to be swung open in the manner illustrated in Figure 4 by the provision of a hinge 56 fixed to the exterior of depending walls 54 and side walls 48. A seal 58, e.g., rubber or neoprene stripping, is fastened to the underside of dividing wall 39 along the perimeter thereof such that when top compartment 12 is lowered onto lower compartment 14, seal 58 will make compression contact with the top of indented side walls 52 when the top and bottom compartments are secured by a plurality of latches 60. In this manner, a water-resistant or waterproof seal may be provided to the interior of lower compartment 14, depending on the materials used which are well known in the art. Any material commonly known in the art can be used for the seal that will produce the desired effect, i.e., a water-resistant or waterproof seal. The term "water-resistant", as used herein, is consistent with the description offered by the National Electrical Manufacturers Association (NEMA Standard 250) for an enclosure that has a 4X classification, i.e., the enclosure is intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water, undamaged by the formation of ice on the enclosure. The term "waterproof" is consistent with the NEMA 6 classification, i.e., enclosures intended for use indoors or outdoors where occasional submersion is encountered.

As illustrated in Figures 1, 5 and 6, transparent quartz sleeves 22 are configured in length and diameter to surround their corresponding UV lamps 20 for enclosing the same. The bottom of sleeve 22 extends beyond UV lamp 20 and is closed, while the opposite top end is open and also extends beyond the end of lamp 20 into a sleeve opening 62 of bottom member 50 of lower compartment 14. Bottom member 50 is provided with a plurality of such openings for receiving a corresponding number of transparent quartz sleeves 22 therethrough. Support leg

openings 64 are located in the corners of bottom member 50 for receiving collars 66, which have the configuration of a half coupling and are fixed to bottom member 50 by a weld 67. Each collar 66 is secured to and rests on the top portion 15 of support leg 16 by means of a weld 69 to secure support legs 16 to bottom member 50 of lower compartment 14.

As will be seen in Figure 6, support base 18 has a compartmentalized configuration that includes a top member 70 and bottom member 72 which are separated and joined at their perimeters by side walls 74 to provide a hollow interior 75. Top member 70 also includes support leg openings 76 located at the corners thereof for receiving support legs 16 therethrough into resting contact with the interior face of bottom member 72. Support legs 16 are secured within their respective openings 76 by welding the perimeter of leg 16 to top member 70 at 71. Top member 70 has a plurality of sleeve openings 78 for the insertion of cylindrical sleeve retainers 80 that are closed at one end and open at the opposite end for receiving the closed end 23 of corresponding transparent quartz sleeves 22 therein. The lower portions of sleeves 22 are slidably received within their respective retainers 80 to prevent the lateral movement of UV lamp 20 and sleeve 22 within top member 70 of support base 18. The lower portion of quartz sleeve 22 is regarded as that portion of quartz sleeve which is disposed below top member 70 (see Figure 6).

The base may be any type of structure that will maintain the lamp(s) in vertical alignment between the base and the enclosure. The base may also perform the function of a foundation for supporting the entire apparatus or module thereby enabling the apparatus or module to rest freely on the floor of a tank or conduit in which the module is placed. Top member 70, in conjunction with cylindrical sleeve retainers 80, may therefore act alone as a base for the quartz sleeves in

question or in conjunction with any other structure that will fulfill the aforestated purposes and functions.

The waterproof coupling of sleeve 22 and UV lamp 20 within lower compartment 14 is best illustrated in Figure 5. As noted herein, bottom member 50 has a plurality of openings 62 to permit the insertion of corresponding sleeves 22 therethrough. A waterproof compression fitting 84 is provided that includes a stainless steel threaded nipple 85 having a flange 86 at the base thereof. Flange 86 rests on bottom member 50 and is configured to fit within opening 62 where it is welded at 68 to provide a water-proof seal between the nipple flange 86 and bottom member 50. The open end of sleeve 22 extends through the top of nipple 85. A threaded gland nut 87, which may be of stainless steel construction or a hardened plastic material, e.g., polyvinylchloride, is provided for engagement with nipple 85 to accomplish the waterproof compression fit. Gland nut 87 has an opening 94 whose diameter is slightly less than the internal diameter of sleeve 22 but greater than the outside diameter of UV lamp 20, and an internal shoulder 92 for axially containing the top portion of sleeve 22 within the confines of gland nut 87. Gland nut 87 is also provided with an internal shoulder 88 for engagement with an O-ring 89 such that when the gland nut is positioned about the top end of sleeve 22 and threaded onto nipple 85, the combination insures the insulation of UV lamp 20 and the interior of lower compartment 14 from the fluid to be treated. With this type of fitting, only the detachable coupler 95 needs to be disconnected from its corresponding connector bracket 96 to allow UV lamp 20 to be lifted and removed from its quartz sleeve.

It will be understood that as a practical matter, only that portion of quartz sleeve 22 immediately below the upper UV lamp socket, and the support base 18 of module 10, will be inserted into the body of fluid contained by a vessel, such as

a tank (not shown) or the channel 90 illustrated in Figure 8, for subjecting the fluid to the radiation emitted by UV lamps 20. The insertion of only this portion of the radiation module avoids the entrainment of fluid into lower compartment 14. Moreover, in order to protect the electronics contained within lower compartment 14 from the effects of moisture or the sudden rise in fluid level in the vessel containing the radiation module, waterproof seals, as described herein, are implemented in the various openings of compartment 14.

Because of the intensity of light emitted by UV lamps 20, and the desire to protect the human eye from the UV light during the operation of module 10, the lower portion of bottom compartment 14 is provided with L-shaped mounts 37 (Figures 1 and 5) for attachment to a light shield 91 that is placed over channel 90 (Figure 8) adjacent to module 10. Engagement of the mounts, with the light shield is accomplished by placing the mounts, which are provided with laterally opened slots (Figure 1), over vertically extending attachment studs 35, incorporated and welded at 61 into shield 91, when module 10 is inserted into channel 90.

The UV lamps used in module 10 may be lamps that provide light transmission anywhere within the ultraviolet spectrum of light that produce significant amounts of UV light in what is considered the , i.e., within a light transmission range of approximately 150 to 400 nanometers. UV lamps that are commonly used are low pressure mercury lamps which provide an ultraviolet light transmission of approximately 185 or 253.7 nanometers, although any lamps producing an ultraviolet light sufficient to have a destructive effect on germicidal activity, can be utilized. This will include medium pressure ultraviolet lamps as well as capacitor discharge lamps that utilize pulse technology wherein a luminous output arises from the ionization in a gaseous discharge, examples of which include xenon lamps.

Each UV lamp has a pair of lead wires 93 leading through opening 94 in gland nut 87 and terminating in a detachable coupler 95 that detachably inserts into a corresponding 2-pin or 4-pin connector bracket 96 mounted to bottom member 50. It will be readily seen that sleeves 22 and UV lamps 20 can be easily removed by unhooking latches 60, swinging top compartment 12 to an open position (as shown by the broken lines in Figure 4), detaching coupler 95, and lifting the lamp and sleeve through its corresponding compression fitting 84. The servicing of each UV lamp 20 within module 10 can therefore be accomplished without the prerequisite of removing ballasts 32 or other electrical components, which are described in greater detail below, or for that matter, without removing module 10 from the body of fluid under treatment. Greater efficiency and economy for maintaining and servicing the module is thereby achieved.

Various electronics can be incorporated into lower compartment 14 of module 10 to facilitate the operation and control of UV lamps 20. As already noted hereinbefore under the Summary Of Invention heading, the apparatus according to the invention may optionally include a means for sensing the functional status of the UV lamps employed therein. Referring to Figure 7, a plurality of electrical coils 98 mounted to the underside of dividing wall 39 in lower compartment 14 are provided for sensing the electric current transmitted to UV lamps 20 by ballasts 32 during the lamps' operation. Also provided to the underside of dividing wall 39 is a backplane receptacle 100 which receives power through an AC/DC converter 101 derived from an AC source within control console 110 (Figure 8). Backplane receptacle 100 is operatively connected to electrical coils 98 by means of a ribbon cable (not shown) for receiving a signal from the coils reflecting the ON/OFF status of each UV lamp 20. Backplane receptacle 100 comprises a plurality of electrical slots (not shown) for receiving

therein a corresponding number of electronic lamp status circuit boards 102 whose function is to receive the signal generated by coils 98 and convert the signal from an analog signal to a digital signal (A/D converter) for transmission to a processing means in the form of an operatively connected microprocessor 103. Each lamp status circuit board 102 is designed to receive any number of signals from coils 98 reflecting the status of up to eight UV lamps utilized in the module per coil.

Microprocessor 103 is contained within a module interface board 105 which also receives its power through AC/DC convertor 101. Each lamp status circuit board 102 is operatively connected to microprocessor 103. Once the parallel data signals reflective of the ON/OFF status of UV lamps 20 are received by microprocessor 103, the serial data signals 103S generated within microprocessor 103 are transmitted to a remotely located wireway 104 (see Figure 8) via a cable 106 that has a multi-pin connector 107 at one end thereof (see also Figure 3) for attachment to the wireway, which in turn relays the serial data signals to a programmable logic controller 108 housed in a remotely located control console 110 for controlling the operation of module 10.

In another aspect of the invention, module 10 may also include a UV light sensor 112 housed in a tubular enclosure 113 that depends from bottom member 50 of lower compartment 14 (see Figure 2). Sensor 112 is capable of responding to the entire UV wavelength emitted by UV lamps 20, and will detect any change in UV light intensity, typically a decrease, as the result of the accumulation of fluid debris on the surface of the transparent quartz sleeves 22. Sensor 112 is usually positioned intermediate the support base 18 and lower compartment 14 for sensing the intensity of ultraviolet light generated by UV lamps 20 surrounding the sensor.

Referring to Figures 2 and 4, in order to accommodate the lead wires 114 extending from sensor 112 to the interior of lower compartment 14, tubular enclosure 113 extends through opening 116 and into a stainless steel threaded nipple 118 welded to bottom member 50 (Figure 4) in waterproof relationship thereto in the same manner as threaded nipple 85 of compression fitting 84 illustrated in Figure 5. A gland nut 117, which can also be made of a stainless steel or a hardened plastic material, e.g., polyvinylchloride, and having an internal shoulder engaged with an O-ring 119, is threaded onto nipple 118 for accomplishing a waterproof compression fit. Sensor lead wires 114 are connected to backplane receptacle 100 (Figure 7) which is provided with a slot (not shown) for receiving a UV light sensor board 120 that converts the electrical signal from sensor 112 to a logic level signal (A/D converter). The logic level signal containing parallel data is then transmitted to microprocessor 103 which in turn generates and transmits a UV sensor serial data signal that is transmitted with serial data signals 103S to the programmable logic controller 108 contained within control console 110 via wireway 104. The intensity of the ultraviolet light sensed by sensor 112 can then be displayed by appropriate electronics readily known in the art onto a local operator interface screen 122 located in control console 110.

Remotely located control console 110, through the use of appropriate electronics (which do not form a part of the invention herein), permits an operator to monitor and control radiation module 10, or a plurality of such modules, either automatically or manually, by receiving and interpreting the signals from lamp status circuit boards 102 and UV light sensor board 120. An operator of the radiation module(s) will also be assisted in the determination of the proper amount of fluid flow passing by module 10 by monitoring the incoming fluid flow into channel 90 through the use of adjustable electrically

monitored fluid level indicators (not shown). The foregoing information can also be utilized to determine the number of UV lamps required for the purification of the fluid at a given flow rate or fluid level in channel 90.

Wiping Devices

The apparatus or module according to the invention additionally includes apparatus for the substantial removal of material deposited on the exterior surface of the radiation pervious protective sleeves 22 surrounding their corresponding UV lamps 20. As illustrated in Figures 10-11, 14-15 and Figures 16 and 20, several wiping devices for cleaning the protective sleeves may be used with the apparatus and module described herein.

The wiping devices according to the invention generally include a wiper assembly mounted about the protective sleeves and a drive mechanism for the movement of the wiper assembly along the longitudinal axis of the protective sleeves. The wiper assembly comprises one or more wiper plates provided with at least one plate opening for the passage therethrough of a corresponding number of protective quartz sleeves 22; and an annular cleaning member disposed about each plate opening 144 for making slidable contact with the exterior surface of the protective quartz sleeve. Depending on the drive mechanism used, a single or multiple number of wiper plates may be used for cleaning the quartz sleeves.

One such wiping device that is integrated with and forms part of module 10 and which uses a plurality of wiper plates is illustrated in Figures 9 through 13. In the embodiment shown, wiping device 136 comprises an assembly of three stainless steel wiper plates 138, 139, and 140 containing a plurality of annular cleaning members 146 (see Figure 13), and a

piston/cylinder drive mechanism 141 (see Figures 9 to 12). Wiper plates 138, 139, and 140 are in parallel, spaced apart relationship and connected to each other by means of struts 142 secured to the corner of each wiper plate. As will be apparent from Figures 10 and 13, wiper plate 139 has incorporated therein a series of strut openings (not shown) for the passage therethrough and connection of corresponding struts 142 to wiper plate 139. Struts 142 and the ends thereof may be secured to wiper plate 139, as well as wiper plates 138 and 140, respectively, by any conventional means, for example, by welding or by threaded engagement accompanied by a corresponding nut (not shown). The plane of each of wiper plates 138, 139 and 140 are parallel to each other and are disposed perpendicularly to quartz sleeves 22 and their respective UV lamps 20 so that the final wiper assembly has the appearance of an open rectangular box (see Figure 10).

Each of wiper plates 138, 139 and 140 is provided with a multiple number of plate openings 144 for accommodating the passage therethrough of quartz sleeves 22, the plate openings being sized and configured to permit a loose fit for each quartz sleeve. Each plate opening 144 of wiper plates 138, 139, and 140, is aligned along a common vertical axis with the sleeve openings 62 in lower compartment 14 and sleeve openings 78 in base 18, to permit quartz sleeves 22 to be received through each wiper plate in vertical alignment with the lower compartment and base. As best seen in Figure 13, each plate opening 144 having a UV lamp and protective quartz sleeve passing therethrough is provided with an annular cleaning member 146 whose outer circumference is secured about the circumference of the plate opening. The inner circumference of cleaning member 146 is slightly smaller than the outer circumference of quartz sleeve 22 thereby providing a friction fit of the cleaning member about quartz sleeve 22. The outer circumference of cleaning member 146 is larger than the

circumference of plate opening 144, and may be held in place about the plate opening by any conventional means, generally by the use of a rectangular flat plate 148 having an opening configured to receive cleaning member 146 therein. As shown in Figure 13, flat plate 148 is bonded to wiper plates 138, 139, 140 about openings 144. Cleaning member 146 is then inserted into flat plate 148 and held in place by an overlapping annular locking member 150 secured to flat plate 148 by any conventional means, e.g., by bonding, soldering, rivets, bolts, screws, etc.

Flat plate 148 may be omitted by configuring cleaning member 146 in a grommet-like fashion, i.e., by providing cleaning member 146 with a circumferential groove about its outer surface to receive the perimeter of opening 144 therein (not shown). This permits cleaning member 146 to overlap plate opening 144 on both sides of the wiper plate to "lock" the cleaning member into place within plate opening 144.

For most fluid treatment applications, particularly water purification, annular cleaning member 146 may be any resilient synthetic or natural material that is chemically impervious to the fluid medium and the deposits left on the quartz sleeve, capable of removing contaminants deposited on the quartz sleeve by the reciprocation of cleaning member 146 along the sleeve's surface, and one that is suitably resistant to the light emitted by the radiation transmission source(s), e.g., ultraviolet light. The choice of material, therefore, will depend to a large extent on the nature of the fluid being subjected to treatment and the corresponding deposits or contaminants accumulated on the protective quartz sleeves 22. In the case of synthetic materials, ethylene propylene rubber (otherwise known in the trade as EPM or EPDM available under the trademark names of Nordel®, Royalene®, Vistalon®, Epsyn® or Epcar®) may be used. Other candidates include Viton® (a

synthetic rubber based on a copolymer of vinylidene fluoride and hexa-fluoropropene) and BUNA (a polymerization product of butadiene with sodium). Rubber is an alternative as a natural substance. For fluids containing contaminants that adhere to the quartz sleeve surface in a stubborn manner, annular cleaning member 146 may be composed of Teflon® which is a somewhat rigid material having only a slight resiliency. Resilient bristles may also be used, the ends of which extend radially inward relative to the circumference of plate opening 32. The bristles may be composed of any resilient material capable of removing stubborn deposits on the quartz sleeve surface and which will withstand the radiation effects of ultraviolet light.

Drive Mechanism

The drive mechanisms according to the invention will generally have a cross-sectional area that will not take up an excessive amount of space within the confines of the module. Having a small cross-sectional area or "footprint" for the drive mechanisms will minimize or avoid any buildup in head pressure losses within a conduit through which the fluid flows.

Piston/Cylinder

Referring now to Figures 11 and 12, a "piston/cylinder" drive mechanism 141 is shown for carrying out the reciprocation of wiper plates 138, 139 and 140 along the axis of quartz sleeves 22, which, as illustrated, is accomplished by the use of a pneumatically or hydraulically operated piston 152 housed in a chamber 154 that slidably extends through wiper plate 138 via an appropriate opening (not shown) for securement to the underside of bottom member 50 of lower compartment 14 of module 10. Securement of chamber 154 to bottom member 50 is accomplished by means of an attachment plate 156 welded to the

top of chamber 154, which in turn is bolted to bottom member 50, utilizing an intermediate gasket 157, by a plurality of nuts and bolts 155. The opposite end of piston 152 is connected to a shaft 158 that extends beyond the lower end of chamber 154 and terminates in the form of a threaded attachment bolt 159. Plate 139 contains an opening (not shown) that receives attachment bolt 159 therethrough for securing shaft 158 (and piston 152) in a fixed manner to plate 139 via a locking nut 160 (one nut on the top side of plate 139). In this manner, when piston 152 is activated, the assembly of wiper plates 138, 139, 140 will move in concert with the piston along the longitudinal axis of quartz sleeves 22.

Chamber 154 is received through an appropriate opening (not shown) in wiper plate 138 and secured to plate 139 by means of shaft 158 (see Figures 9 and 10). In order to allow the vertical length of quartz sleeve 22 that is submerged in the fluid to be wiped, the vertical distance between the top wiper plate 138 and middle wiper plate 139 should approximate the total length of chamber 154 and the exposed portion of shaft 158 when the shaft is fully retracted within the chamber. This permits the upper portion of quartz sleeve 22 to be wiped by wiper plate 138 owing to the height of chamber 154.

It should also be noted that the "piston/cylinder" drive mechanism illustrated in Figures 9-11 may be operated from support base 18 by securing chamber 154 to the top member 70 of base 18. This is accomplished in the same manner described for the drive mechanism's securement to bottom member 50 of lower compartment 14. In this case, shaft 158 will also be bolted to plate 139 for reciprocating the assembly of wiper plates 138, 139, 140, and the same guideline applies regarding the vertical distance to be maintained between plates 140 and 139. In the event that more than three plates are used for the plate assembly, shaft 158 will be connected to the second from the

top plate when chamber 154 is secured to lower compartment 14, or connected to the second from the bottom plate when chamber 154 is secured to base 18. If two wiper plates are used, then the plate closest to the vertical midpoint of quartz sleeve 22 will be chosen for attachment to shaft 158.

The reciprocal movement of piston 152 within chamber 154 may be accomplished pneumatically or hydraulically, generally by the use of a solenoid 162 shown in Figure 11 that regulates gas (e.g., air) or hydraulic fluid from a corresponding source of compressed gas or pressurized hydraulic fluid, respectively. The gas or fluid enters into chamber 154 via conduit 164 on either side of piston 154 through fluid lines 166 and 168. It will be understood that chamber 154 is pneumatically or hydraulically sealed, as the case may be.

In operation, solenoid 162 is activated in response to an electrical signal that may be received from a control source external of the module (not shown) or within lower compartment 14. The electrical signal is directed through lead wires 170 and 171 extending from the interior of lower compartment 14, which in turn are connected to solenoid 162. Because it is possible that all or a portion of the lead wires may be submerged in the fluid medium when, for example, the receiving tank, conduit or channel 90 (Figure 8) becomes flooded, the wires and their connections are made water resistant, or alternatively, a waterproof conduit is provided (not shown) to insulate the wires from the fluid medium and/or water moisture.

If it is desired to lower wiping device 136 along the longitudinal axis of quartz sleeves 22, the corresponding electrical signal will direct solenoid 162 to admit air or fluid into the top of chamber 154 via fluid line 166 thereby causing piston 152 to move in a downward direction. The direction of the wiping device can be reversed in the upward

direction by the solenoid's admission of pneumatic or hydraulic fluid into the lower portion of chamber 154 via fluid line 168 in response to a corresponding electrical signal causing piston 152 to rise.

It will be appreciated that the "piston/cylinder" arrangement is particularly useful when employed with the apparatus according to the invention without an accompanying support structure, or more specifically, base 18. This arrangement finds application when the apparatus is suspended from the top of a tank or conduit for immersion of the UV lamps, accompanying protective sleeves and wiper assembly into a body of fluid to be treated.

Linear slide

Another drive means that can be utilized for the movement of two or more wiper plates along the longitudinal axis of protective quartz sleeves 22 is a fluid operated linear slide, the details and embodiments of which are illustrated in Figures 16 through 26. Referring to Figures 16 and 20, slide 200 comprises a pair of stainless steel, vertically extending, tubular shafts, 202 and 203, connected to a fluid powered stainless steel cylinder 204 for moving wiper plates 205 and 206 in the axial direction of protective quartz sleeves 22. Slide 200 is disposed in vertical, parallel alignment with protective sleeves 22 by the securement of one end of shaft 202 to bottom member 50 of lower compartment 14, and the securement of the opposite end of shaft 203 to top member 70 of support base 18 (see Figures 17 and 19). The parallel disposition of slide 200 relative to protective sleeves 22 allows for the reciprocal movement of plates 205 and 206 between lower compartment 14 and support base 18.

As shown in Figure 16, wiper plates 205 and 206 have the

same configuration as wiper plates 138 and 139 illustrated in Figure 9 in that the wiper plates are provided with a plurality of vertically aligned openings 144 for the containment of a corresponding number of annular cleaning members 146 to allow the slidable passage therethrough of a corresponding number of protective quartz sleeves 22 and accompanying UV lamps 20. Wiper plates 205 and 206 are separated from each other in parallel relationship by a strut 208 secured about the corner of each wiper plate. The securement of struts 28 may be accomplished by any conventional means, e.g., by engaging the end of strut 208 and each wiper plate with a threaded nut, welding, etc.

It will be noted that only that portion of the quartz sleeve that is submerged in the fluid being purified and which is directly exposed to the UV light emanating from between the UV lamp terminals, will require cleaning by the wiper devices described herein. Accordingly, the wiping distance between each wiper plate 205 and 206 in Figure 16 is defined as that distance which either plate 205 or 26 must travel along that portion of protective quartz sleeve requiring wiping action by annular cleaning members 146. The distance between each wiper plate 205 and 206 in Figure 16 will therefore be determined by the distance that the wiper plates must travel to accomplish the wiping of the sleeve portion in question. Because of the limited stroke or distance that cylinder 204 can travel due to the axial length of partition 216 and the axial length of the sealing devices located at each end of cylinder 204, the length of cylinder 204 must be greater than one half of the wiping distance described above for the two wiper plates utilized, or greater than one third of the wiping distance if three equally spaced apart wiper plates are utilized. For this reason, one end of cylinder 204 will have to be extended through an opening in one of the wiper plates.

Referring to Figure 20, cylinder 204 is annularly mounted for reciprocal movement along shafts 202 and 203, which, as indicated above, are supported by bottom member 50 of lower compartment 14 and top member 70 in support base 18, respectively. As best illustrated in Figure 17, the end portion 207 of shaft 202 is received into the interior of lower compartment 14 through an annular mounting sleeve 218 placed over an opening 219 provided in bottom member 50 and secured thereto with a nut and bolt arrangement 220, or by any means that will detachably secure mounting sleeve 218 to bottom member 50. The end portion 207 of shaft 202 in Figure 17 is held in place within mounting sleeve 218 by means of O-ring 223. A locking collar (not shown) may also be included on the top of mounting sleeve 218 about the shaft's end portion 207 for assisting in the prevention of the vertical shifting of shaft 202. The exposed end of shaft 202 is sealed by the insertion of a stainless steel cap 224 into the interior of shaft 202 which is then welded into place. Cap 224 is provided with a pair of openings to receive a corresponding pair of stainless steel tubes 225, 226 therethrough to which fluid lines 227, 228 are respectively connected. Stainless tube 225 extends internally within shaft 202 through partition 216 for the passage of fluid under pressure (e.g., air) to and from the internal space of shaft 203 (see Figures 23 and 25).

Referring to Figures 16 and 19, View G shows the manner of connection of shaft 203 of linear slide 200 to support base 18. A shaft retainer 230 is fixed to the surface of top member 70 of support base 18 via welds 231 for receiving the lower portion 209 of shaft 203. Shaft 203 rests within a bore 232 provided within shaft retainer 230, and is surrounded with an annular sealing ring 233 for hermetically sealing the shaft end. Sealing ring 233 and shaft 203 are locked into place by an annular retainer plate 234 with screws 235.

The manner of the securement of cylinder 204 with wiping plate 205 is detailed in View H of Figure 18. An annular sealing device 210, which is mounted about shaft 202 and secured to the end of cylinder 204, is provided with an annular, stainless steel collar 212 secured about the sealing device's outer surface. Collar 212 may be a two-piece split collar utilizing a pair of hex-head cap screws (not shown) for holding the collar together and to provide a positive lock on sealing device 210. Collar 212 may also be hinged for connecting two halves of the collar which are clamped about sealing device 210 and held into place with a clamp screw (not shown). A pair of bolts 214 may be inserted through corresponding openings provided in plate 205 and into collar 212 for securely fixing the plate to the collar, and hence to cylinder 204. The same arrangement can be provided for securing wiper plate 206 about the opposite end of cylinder 204 (see Figure 20) in the event that wiper plates 205 and 206 are not connected by struts 208 (as shown in Figure 16). Under this circumstance, a connection of wiper plates 205 and 206 with cylinder 204 must be established in order for the plates to move in concert with the movement of cylinder 204.

It is noted that the attachment of collar 212 to wiper plate 205 (and collar 213 to wiper plate 206) with screws 214 is optional. Referring to Figure 20, since wiper plates 205 and 206 move as a unit (hereinafter the "wiper plate 205, 206 assembly") by virtue of their connection to each other utilizing struts 208, collars 212 and 213 may be clamped at predetermined points along cylinder 204 (and/or the cylinder's respective sealing devices shown in dotted lines in Figure 20) between plates 205 and 206 so that collars 212 and 213 will impact against their respective wiper plates for moving the wiper plate 205, 206 assembly along quartz sleeves 22. By using the predetermined positioning of collars 212 and 213 along cylinder 204 (and/or the cylinders respective sealing

devices), the wiping distance that cylinder 204 must travel for enabling wiper plates 205 and 206 to wipe that portion of quartz sleeves requiring cleaning can be satisfied.

As best viewed in Figures 24 and 25, the ends of shafts 202 and 203 that are opposite to the ends supported by base 18 and lower compartment 14, are secured in fluid tight relationship to partition 216 by a weld 237 about the circumference of the shafts' abutment with the respective sides of the partition. As such, partition 216 and shafts 202 and 203 are stationary and fixed within module 10. Partition 216 is slidably engaged in fluid tight relationship with the internal wall of cylinder 204 so as to divide the cylinder's cavity into two annular chambers 240 and 241. In one embodiment, and as illustrated in Figures 20, 22-23, and 27, partition 216 is provided with lugs 242 and 243 axially extending from either side of the partition. The lugs are mateable and hermetically sealed with the interior of shafts 202 and 203, respectively. In Figure 20, each of shafts 202 and 203 has a respective port 244 and 245 that is respectively aligned with an L-shaped passageway 246 and 247 in corresponding lugs 242 and 243 for communicating fluid under pressure (e.g., air or hydraulic fluid) from a pressurized fluid source into the interior of shafts 202 and 203 and into corresponding chambers 240 and 241 of cylinder 204. The L-shaped passageways 246 and 247 can be omitted by locating ports 244 and 245 at a distance beyond the penetration of lugs 242 and 243 into their respective shafts (see Figure 22). Fluid tight securement of the shaft ends with their respective partition lugs may be obtained by any conventional method known in the art, some examples of which include welding, soldering, or threaded engagement accompanied with an appropriate sealant.

Various other embodiments for communicating pressurized fluid to the interior of chambers 240 and 241, as well as the

securement of shafts 202 and 203 with stationary partition 216 of linear slide 200, may be used in accordance with the invention herein. As indicated hereinbefore and as shown in Figure 24, partition 216 is without the presence of lugs 242 and 243 extending therefrom, in which case shafts 202 and 203 are secured to partition 216 by the use of a continuous weld 237 surrounding the circumference of the shaft ends, or by any other conventional means known in the art.

In the embodiments illustrated in Figures 20, 22 and 24, activation of the movement of cylinder 204 in the axial direction of shafts 202 and 203 is accomplished by the passage of fluid under pressure from a pressurized fluid source into the exposed ends of shafts 202 and 203 of linear slide 200. Alternatively, the introduction of pressurized fluid for moving cylinder 204 may be undertaken exclusively at one end of linear slide 200 by the installation of a conduit that may be in the form of a stainless steel tube 225 along the interior length of either of shafts 202 or 203, and extending through partition 216 into the opposing shaft. More specifically, and as illustrated in Figures 23 and 25, tube 225 extends along the interior length of shaft 202, through partition 216, and terminates with the open end exposed to the interior of shaft 203. In Figure 27, tube 225 is connected with L-shaped passageway 247 of lug 243 which communicates the fluid under pressure directly to and from chamber 241 of cylinder 204 via opening 245 in shaft 203. Figure 17 illustrates the manner of introduction of pressurized fluid (e.g., compressed air or hydraulic fluid) from the interior of lower compartment 14 to linear slide 200, via fluid lines 227, 228 and tubes 225, 226.

The slidable, fluid tight engagement of partition 216 with the internal wall of cylinder 204 is accomplished by a pair of annular cup seals 250 and 251 disposed about the circumference of partition 216 (see Figures 20, 22-25 and 27). In the

embodiments illustrated in the respective figures, the U-shaped sides of cup seals 250, 251 are uneven, with the longer exterior annular side being in contact with interior wall of cylinder 204. Cup seals 250 and 251 also have a portion of their respective U-shaped openings 250a and 251a exposed to the interior of corresponding chambers 240 and 241. The net effect of this arrangement is that when chambers 240 and 241 are pressurized with a fluid (e.g., compressed air or hydraulic fluid), the longer side wall of the seal will have a greater pressure exerted on its opposing surface (the interior cylindrical wall of cylinder 104) than the shorter side of the seal that makes contact with its seat in partition 216. This forms an effective slidable fluid tight seal between partition 216 and cylinder 204 as well as a fluid tight barrier between chambers 240 and 241. The partition seal(s) may include any seal that is capable of withstanding the internal chamber pressures, provide an effective seal between chambers 240 and 241, and one that will act in a resilient manner without deformation during the slide's operation. The material making up the construction of the cup seals and the lip seals described below may be the same as those resilient materials described for annular cleaning member 146.

As shown in Figures 20, 23 and 27, partition 216 may optionally include a wear bushing 254 the purpose of which is to allow cup seals 250 and 251 to accomplish their function without supporting the load of partition 216 within cylinder 204. Wear bushing 254 may be constructed of any material that has a low coefficient of friction, will not score the interior surface of the cylinder, and which will have a higher rate of wear than the surface that it bears against, in this case, the interior wall of cylinder 204. Suitable examples are a plastic material, such as teflon or nylon, or a soft metal material such as brass.

A fluid tight seal is provided about both ends of cylinder 204 in the form of a sealing device for hermetically sealing the cylinder with shafts 202 and 203 to prevent the escape of pressurized fluid during the slide's operation. The sealing devices may be permanently fixed with the cylinder or detachably secured depending on such factors as the need for on-site servicing of radiation module 10. In general, any sealing device may be used for the operation of the linear slide as long as a hermetic seal is provided to allow pressurization of interior chambers 240 and 241 of cylinder 204. However, from an economical standpoint, it is desirable that the sealing device have a cross-sectional area that approximates the cross-sectional area of cylinder 204 to permit the maximum number of UV lamps in the space allowable by the radiation module.

In keeping therewith, several embodiments of the sealing devices are illustrated in Figures 18, 20 and 26 all of which may be used exclusively or in combination with each other according to the invention herein. Referring to Figure 20, linear slide 200 has a detachable sealing device 256 mounted about the end of cylinder 204 and slidably engaged with shaft 203 to provide a hermetic seal for chamber 241. The opposite end of cylinder 204 has a fixed sealing device 258 mounted thereto which is in slidable engagement with shaft 202 to provide a hermetic seal for chamber 240.

Sealing device 256 is best viewed in Figure 21 in which a stainless steel annular sleeve 260 is secured to the outside surface of the end portion of cylinder 204 by any conventional means, e.g., welding, threaded engagement (not shown), etc., for slidably receiving a T-shaped annular end cap 262 into the interior chamber 241 of the end portion of cylinder 204. The underside of the "T" portion of end cap 262 is seated upon an O-ring 263 inserted into an annular groove 264 provided in

sleeve 260 for obtaining the hermetic seal between end cap 262 and sleeve 260. An annular bore 265 is provided in end cap 262 for retaining a pair of annular, U-shaped lip seals 270 and 271, disposed back-to-back, for slidable engagement with shaft 203. A pair of channels 267 and 268 are provided in end cap 262 for making a passageway between the open end 271a of lip seal 271 and chamber 241 of cylinder 204. Like the cup seals 250 and 251 described above for partition 216, the U-shaped sides of lip seals 270, 271 are uneven. However, the interior annular surface of the lip seal is the longer side and is in contact with the exterior wall of shaft 203. When chamber 241 is pressurized with a fluid (e.g., compressed air or hydraulic fluid), the opening 271a of lip seal 271 will receive the pressurized fluid via channels 267 and 268, thereby exerting a greater pressure on the side of the U-shaped lip seal in contact with shaft 203. This arrangement assists in providing an effective fluid tight seal about shaft 203 to prevent egress of pressurized fluid from chamber 241 into the environment. The hermetic sealing of cylinder 204 also prevents the fluid being treated by the UV lamps from entering chamber 241.

End cap 262 is locked into place by an annular, stainless steel, seal cover 273, which, as shown in Figure 21, is in the form of a washer, placed over end cap 262 and detachably secured therein by a snap ring seated in annular groove 276. End cap 262 may optionally contain a wear bushing 278 whose properties are identical to wear bushing 254 described above for partition 216. Wear bushing 278, which may be configured as a split ring, is inserted into annular groove 276 in end cap 262 proximate to lip seal 271.

Another detachable sealing device 280 is illustrated in Figure 26 wherein end cap 282 is provided with threads 284 for engagement with the correspondingly threaded interior wall of the end portion of cylinder 204. Normally, the threaded

engagement will be augmented with a fluid proof sealant to insure the hermetic seal or an appropriate O-ring and seat provided in the end cap (not shown). End cap 282 has an annular bore 286 to receive the pair of annular lip seals 270 and 271 which are disposed back-to-back in the annular bore and which hermetically seal chamber 240 about shaft 202. The utilization of wear bushing 288 is optional which is placed into annular groove 289 in end cap 282 proximate to lip seal 271. Lip seals 270 and 271 are held in place within annular bore 286 by the securement of a removable annular cover 290 to end cap 282 with a socket head bolt 291. In order to convert detachable sealing device 280 to a fixed sealing device with cylinder 204, annular cover 290 may be permanently secured with end cap 282 by welding cover 290 directly to the end cap, thereby obviating the need for socket head bolt 291. The advantage of this particular sealing device is that it has the same cross-sectional area as that of cylinder 204, thereby economizing on space for the implementation of linear slide 200 in radiation module 10.

In accordance with another aspect of the invention, the sealing devices for cylinder 204 may be configured to attach to cylinder 204 in a permanent fashion. Figure 20 shows a fixed annular sealing device 258 whose end cap 294 is partially inserted into and secured to the open end of cylinder 204 about shaft 202 by a continuous weld 296. End cap 294 has an annular bore 298 for receiving annular lip seals 270 and 271 therein in a back-to-back fashion which hermetically seal chamber 240 with shaft 202. An annular cover plate 300 placed directly over lip seal 270 for maintaining it in place, is locked into position by snap ring 301 which is received by annular groove 302 disposed proximate to the opening of annular bore 298. As with the sealing device 256 illustrated in Figure 21, a pair of channels 304 and 305 are provided in end cap 294 for creating a passageway between the open end of lip seal 271 and chamber 240

of cylinder 204. With this arrangement of the sealing device, end cap 294 is permanently fixed to cylinder 204, but the removable cover plate 300 allows lip seals 270 and 271 to be serviced or replaced as circumstances warrant.

Fixed sealing device 210 illustrated in Figure 18 is essentially the same as detachable sealing device 280 in Figure 26 with the exception that end cap 282 of sealing device 210 is permanently secured to cylinder 204 by means of a continuous weld 215 placed about the seam between the end of cylinder 204 and end cap 282.

As with cup seals 250 and 251 used with partition 216, lip seals 270, 271 may be replaced by any resilient seal to obtain the necessary hermetic slidable seal about the surface of shafts 202 or 203. Therefore, any seal capable of hermetically containing the operating chamber pressures of cylinder 204 and which will act in a resilient manner without deformation during its slidable movement along shafts 202 or 203, can be utilized. Linear slide 200 will typically operate in the range of about 20 to 150 psig when compressed air is used as the pressurized fluid, and up to 3,000 psig when hydraulic fluid is used as the pressurized fluid. In accordance with the invention, it will be understood that any combination of the seals described herein, or their functional equivalents, such as O-rings and quad rings, may be substituted for either or both of cup seals 250, 251 or lip seals 270, 271.

Reference is now made to Figures 16, 17 and 20 for the assembly and operation of linear slide 200. Fluid under pressure, e.g., air or hydraulic fluid, will enter lower compartment 14 via quick disconnect fittings 308 and 309 from a source external to radiation module 10 (not shown). The fluid under pressure will then enter shaft 202 for entry to and from chambers 240 and 241 using fluid lines 227 and 228 secured to

respective fittings 309 and 308 (Figures 16-17). Assuming the utilization of linear slide 200 shown in Figure 20 using the partition 216 arrangement illustrated in Figure 27, the slide's assembly is initiated by fixing annular sleeve 260 about the end of cylinder 204 (e.g., by welding) and then securing tube 225 into partition 216 (Figure 27). This is followed by the securement of shafts 202 and 203 to respective lugs 242 and 243 of partition 216. Once shafts 202 and 203 are assembled with partition 216 so that L-shaped passageways 246 and 247 are respectively aligned with ports 244 and 245, sealing device 258 is secured to the top end of cylinder 204. The remaining open end of cylinder 204 with annular sleeve 260 in place is then slid over partition 216. Thereafter, the installation of sealing device 256 is completed by inserting end cap 262 with accompanying wear bushing 278 and cup seals 270, 271 into annular sleeve 260, and locking the end cap into place with seal cover 273 and snap ring 275. It will be understood that any combination of sealing devices described herein may be substituted for either or both of sealing devices 256 and 258.

Linear slide 200 is then incorporated with the wiper plate 205, 206 assembly by its insertion through the respective opening of wiper plate 206 (not shown) and a corresponding opening in wiper plate 205. Once plates 205 and 206 are properly in place about cylinder 204, the wiper plate 205, 206 assembly may be attached to cylinder 204 in the manner shown in Figure 18, or cylinder 204 may be allowed to "float" between the vertical confines of wiper plates 205 and 206 as shown in Figure 20. In the latter arrangement, collar 212 is clamped about sealing device 258 and collar 213 is clamped about cylinder 204. The placement of collars 212 and 213 is such that any movement of cylinder 204 will cause the collars to come in contact with their respective adjacent wiper plates for the simultaneous movement of the wiper plate 205, 206 assembly in either vertical direction. The advantage of this

arrangement is that physical attachment of the wiper plates with the linear slide bay be dispensed with. The dotted lines in Figure 20 represent the placement of wiper plate 206 and collar 213 about sealing device 256 which necessitates a larger opening in wiper plate 206 for accommodating sealing device 256.

After the assembly of linear slide 200 with the wiper plate 205, 206 assembly, the open ends of shafts 202 and 203 are placed into position and respectively secured with lower compartment 14 (Figure 17) and support base 18 (Figures 16 and 19).

The operation of linear slide 200 is next described utilizing the introduction of fluid under pressure into one end of linear slide 200 through lower compartment 14 of radiation module 10. Referring to Figures 16 and 17, cylinder 204 reciprocates along shafts 202 and 203 in response to fluid being fed under pressure to chambers 240 and 241. A pressurized fluid source is located externally of module 10 (not shown) and supplied to fluid lines 227 and 228 in lower compartment 14 via quick disconnect fittings 309 and 308 located on the side of lower compartment 14 (Figure 16). As indicated above, fluid under pressure is fed into shaft 202 through fluid line 228 and into chamber 240 via passageway 246 and port 244 (see Figures 23, 25 and 27) which will initiate movement of cylinder 204 in the direction of lower compartment 14. As long as the fluid pressure in chamber 240 is greater than that in chamber 241 and the difference between the two chamber pressures is sufficient to overcome the frictional forces of the lip seals and cup seals in the respective sealing devices and partition, cylinder 204 and accompanying wiper plates 205 and 206 will continue to move in the same direction. The direction of cylinder 204 is reversed in the direction of support base 18 by simultaneously bleeding the pressurized

fluid from chamber 240 (by the same way it was introduced), and feeding the pressurized fluid to chamber 241 via fluid line 227, tube 225, passageway 247, and port 245 in partition 216.

In accordance with the embodiments illustrated in Figures 20, 22 and 24, the fluid under pressure can be introduced into both of shafts 202 and 203 at their respective ends via lower compartment 14 and support base 18. Under these conditions, shaft retainer 230 illustrated in Figure 19 may be eliminated in which case shaft 203 will extend through top member 70 into the interior of support base 18, and will be secured to the top member 70 in the same fashion as shaft 202 is secured to bottom member 50 of lower compartment 14 (Figure 17). Pressurized fluid may then be introduced into the confines of support base 18 (see Figure 6) where it enters shaft 203 and into chamber 241 by way of passageway 247 and port 245 in partition 216 (see Figure 20). It should be noted that support base 18 may take the form of top member 70 supported by two sidewalls 74, in which case fluid line 227 will be led to the underside of top member 70 and attached to the end of shaft 203 in the same manner illustrated for the attachment of fluid line 228 to shaft 202 (see Figure 17).

Threaded Drive Rod

It should be noted that a single wiper plate can be utilized for wiping quartz sleeves 22. For example, as illustrated in Figures 14 and 15, an electrically operated wiping device 173 is provided in the form of a threaded nut 176 welded to the top of wiper plate 178 about an opening therein (not shown) for receiving through the plate opening and threaded nut, a vertically disposed, correspondingly threaded drive rod 177. The bottom 177A of drive rod 177 is enveloped and supported by a drive rod retainer bearing 180 positioned within retainer housing 179 which in turn is secured to top

member 70 of support base 18 by any conventional means, for example, by welds 186 in Figure 15.

As will be seen in Figure 15, top portion 177B of drive rod 177 extends through bottom member 50 via opening 175 into lower compartment 14 where it is coupled to the shaft 181 of electric motor 182 by any conventional means, such as coupling 183. Coupling 183 receives and contains a pair of set screws 184 and 185 for securing the coupling to shaft 181 and drive rod 177, respectively. Motor 182 is wired to a terminal strip 182A located within lower compartment 14, which in turn is connected to a 120 volt power source (not shown) for activating the motor. The passage of drive rod 177 into lower compartment 14 is accommodated by the provision of a drive rod retainer 187 containing an opening 188 through which drive rod 177 is inserted. Drive rod retainer 187 is welded to the underside of bottom member 50 such that opening 175 of bottom member 50 and opening 188 of the drive rod retainer are axially aligned. In order to prevent the fluid being treated from entering into lower compartment 14, an O-ring 189, which surrounds drive rod 177, is provided within the opening 188 of retainer 187 to maintain a water proof environment for the lower compartment.

When it is desired to wipe the exterior surface of the quartz sleeves by the vertical movement of wiper plate 178, electric motor 182 is activated which will rotate its associated shaft 181 and threaded drive rod 177. The rotation of drive rod 177 within nut 176 will cause wiper plate 178 to move in an upward or downward direction along the length of quartz sleeves 22 depending on the clockwise or counter-clockwise rotation of shaft 181. It is to be understood that the rotation of motor shaft 181 will be limited in the number of rotations it can make in either direction to prevent wiper plate 178 from topping or bottoming out in its travel along drive rod 177. Four U-shaped guide members 172, which

partially envelop their respective support legs 16, are provided about the corners of wiper plate 178 to relieve or prevent any rotational forces encountered by the wiper plate from being transferred to quartz sleeves 22. As a result, wiper plate 178 will be prevented from rotating and possibly shearing the quartz sleeves during the vertical reciprocation process.

A multiple number of wiper plates can be utilized with threaded drive rod 177 for wiping the quartz sleeves by spacing each wiper plate a predetermined distance from each other along the length of the drive rod. In that event, each wiper plate will be provided with a correspondingly threaded nut to enable drive rod 177 to reciprocate the wiper plates along the longitudinal axis of the quartz sleeves.

The wiping device according to the invention may be extended to include other drive mechanisms for causing a single or multiple number of wiper plates to be vertically moved in either direction. For example, the wiper plate may be joined about the leading end of a series of hollow collapsible shafts, such as that utilized for automobile radio antennas, whose hollow shafts, one within the other, are driven by a cable disposed within the shafts and connected to an electrical motor that will raise or lower the plate along the axis of the protective sleeve(s).

As indicated hereinbefore, the drive mechanisms described for use with the wiping device according to the invention have the distinct advantage of possessing a relatively small cross-sectional area, or "footprint," when compared to the amount of cross-sectional area that each protective quartz sleeve uses in the module. This space economization permits the maximum number of UV lamps to be utilized in a given area which is generally governed by the demands of a given site for the fluid

treatment process at issue. Moreover, less weight for the wiping devices are realized thereby leading to an easier handling and lifting of the apparatus and module.

Cleaning Fluid

In order to assist in the prevention of the accumulation of fluid debris onto the surface of sleeves 22, and in accordance with another aspect of the invention, radiation module 10 can additionally be provided with a means for agitating the fluid about the protective sleeves to prevent the deposit of materials onto the sleeve surfaces. Referring to Figure 6, top member 70 of support base 18 is provided with a plurality of apertures 124 surrounding and proximate to each sleeve retainer 80. Support leg 16 has a hollow construction such that a conduit 17 is formed along the entire length thereof. Communication between conduit 17 and hollow interior 75 of support base 18 is provided by removing a section of leg 16 in the manner illustrated in Figure 6 to provide a support leg opening 126.

Referring to Figure 5, and as already noted herein, collar 66 is inserted into the top opening 15 of support leg 16 with a weld 69. A properly configured hollow threaded compression fitting 128 is threaded into collar 66 such that a fluid tight seal is secured between the head of compression fitting 128 and the threaded axial opening of collar 66. The opposite end of compression fitting 128 is provided with a hollow stainless steel nipple 129 for forcible insertion into flexible tubing 130 to obtain a fluid tight seal between support leg 16 and tubing 130. As shown in Figure 2, a similar arrangement is provided for support leg 16 supporting the opposite end of lower compartment 14 using an identical flexible tubing 131.

The opposite end of flexible tubing 130 is secured to a

four way compression fitting 134 threaded to housing 133 that is welded to the side wall 48 of lower compartment 14. A source of cleaning fluid, which may be in the form of a compressed gas, such as air or other inert gas (not shown), is coupled with housing 133 via an appropriate conduit (also not shown). In operation, the cleaning fluid is introduced to lower compartment 14 via fitting 134 and housing 133, and communicated to the hollow interior 75 of support base 18 through flexible tubings 130 and 131 and conduits of support legs 16. After entry into the hollow interior 75 of support base 18, the cleaning fluid, if it is in the form of compressed air, will escape through apertures 124 of top member 70 in the form of air bubbles which will have the effect of agitating the fluid flowing past quartz sleeves 22 thereby preventing the accumulation of contaminants and debris onto the surface of quartz sleeves 22.

As noted above, the introduction of a cleaning fluid, e.g., a compressed gas, into base 18 and through apertures 124 of top member 70 to generate bubbles for preventing the collection of contaminants or debris onto the quartz sleeve surface can be used in conjunction with wiping devices 136 or 173 or 201. For simultaneous operation with wiping device 136 (Figure 9) or wiping device 201 (Figure 16), wiper plates 138, 139 and 140 of wiping device 136 (as well as wiper plates 205 and 206 of wiping device 201) are provided with at least one or more apertures 174 about wiper plate openings 144 (see Figure 13). As illustrated in Figure 13, apertures 174 will also extend through flat plate 148 in the event that the perimeter of plate 148 extends beyond an efficient radial distance from quartz sleeve 22 for maintaining the flow of gas bubbles close to the quartz sleeve as possible. Accordingly, as gas bubbles rise from base 18 through apertures 124, the apertures 174 in each of the plates will facilitate the bubbles' passage to the surface of the fluid alongside the respective quartz sleeves

22.

If a single plate is used with wiping device 173 as illustrated in Figure 14, a series of apertures about plate openings 144 will not be required since wiper plate 178 can be in a raised position when not in use, typically above the level of the fluid being treated. However, if simultaneous operation of wiping device 173 with the gas bubbling means for agitating the fluid about the protective sleeves is desired, then a multiple number of apertures can be introduced in wiper plate 178 about the plate openings 144 to accommodate the passage of gas bubbles through the wiper plate.

Ultrasonic Cleaning

In accordance with another embodiment of the invention, the ultrasonic cleaning assembly 189 illustrated in Figures 28 and 29 may be used for the apparatus and module as another means for the removal of material deposited on the exterior surface of the radiation pervious protective sleeves. Ultrasonic cleaning is generally utilized for the removal of insoluble particulate material adhering to the surface of hard substrate surfaces, particularly when the material is in the micron and sub-micron size range. It involves the immersion of an object in a suitable liquid bath and causing the bath to be agitated by subjecting it to high frequency or ultrasonic sound waves in the range of about 18 to 120 kHz for a brief period of time, usually several minutes. During this process, microscopic vacuum bubbles in the liquid bath implode under the pressure of the agitation (generally known as cavitation) which in turn produces shock waves that impinge on the object's surface to dislodge the adhering foreign matter. This process has been used to great advantage for cleaning tenacious deposits such as corrosion on metals.

Assembly 189, which has been designed to ultrasonically agitate the fluid surrounding the protective sleeves, comprises a relatively high powered electronic generator 190 housed in lower compartment 14. The generator is coupled with at least one transducer 191, preferably a plurality of transducers, contained in a transducer housing 191A, via a pair of cables 192 and 193. As will be readily seen in Figure 29, transducer housing 191A is connected to the lower end of a hollow steel tube 194 whose opposite end is fixed to the circumference of an opening (not shown) in bottom member 50 of lower compartment 14 by means of a weld 195. Tube 194 serves the dual function of a conduit for the connection of cables 192, 193 between generator 190 and transducers 191, and a mechanism for maintaining the immersion of the transducer in the fluid medium.

Because of the potential corrosive content of the fluid medium, especially when it is in the form of waste water, the immersible transducer housing 191A is preferably constructed of heavy gauge stainless steel. The transducer surfaces are electropolished to extend their life and reduce surface erosion. More than one transducer for use in a given tank or conduit is desired because most transducers produce an energy wave that propagates in a single direction only. "Dead spots," or areas where the tank surface or conduit walls are not contacted by ultrasonic waves as the result of incorrect transducer angle or wave diffraction, are therefore avoided.

Generator 190 is capable of producing ultrasonic frequencies greater than 18 kHz, and will generally be configured to operate in the range of anywhere between 18 to 120 kHz. The lower end of the frequency range, viz., 18 to 25 kHz, tends to produce larger cavitation bubbles that result in greater cavitation implosions. The cavitation intensity per unit of power is generally higher at lower frequencies. The upper frequency range, viz., about 35 to 70 KHz, tends to

create a more uniform distribution of cavitation and is effective for use with more delicate components and assemblies such as quartz sleeves 22 utilized in accordance with the invention herein. It will be understood that both frequency ranges can be used independently or simultaneously through the use of multiple transducers which in turn depend on various factors including the nature of the fluid being treated and the deposits that are left on the surfaces of the quartz sleeves.

The ultrasonic frequency ranges employed for the operation of assembly 189 will therefore ultimately depend on the colligative properties and flow characteristics of the liquid in which the ultrasonic transducers are immersed; and care must be exercised in selecting and controlling the cavitation result because of the quartz make-up of the protective sleeves. As noted above, the lower frequency ranges tend to generate a more intense ultrasonic field (and therefore increased cleaning effectiveness) as the result of larger vacuum bubbles generated by the cavitation. This frequency range is suitable for removing deposits adhering to the surface of an object. However, even though ultrasonic frequencies used for cleaning lie just above the audible frequency range, operating at a lower ultrasonic frequency (e.g., 20 kHz) will tend to be noisier than operating at a higher frequency (e.g., 40 kHz). This is due to the harmonics of the fundamental frequency combined with vibrations generated at the conduit walls and fluid surface. Furthermore, a high intensity ultrasonic field (lower operating frequency) is capable of exerting a force that is capable of etching glass and eroding quartz after repeated or prolonged cleanings.

A higher ultrasonic frequency range (viz., about 35 to 70 kHz), while not as intense as the lower range, may be employed to produce smaller cavitation bubbles which are useful in the removal of particulate material that tend to collect in the

pores or crevices of an object, and are particularly useful for cleaning delicate objects such as glass, quartz and ceramics, including the quartz protective sleeves 22. Since the energy required to form a cavitation bubble in a liquid is largely proportional to both surface tension and vapor pressure, the temperature and vapor pressure of the liquid becomes a factor, especially when operating at the higher ultrasonic frequency range (about 35 to 70 kHz).

In the case of water, when the liquid medium is cold, cavitation tends to be difficult to produce because of the higher surface tensions that exist. As a result, stronger energy fields are required to produce a cavitation bubble that will overcome the increased surface tension. This may be alleviated by operating assembly 189 at the lower frequency range of about 18 to 27 kHz to produce an increased intensity field, or by adding a surface-active agent. Citric acid is commonly utilized when waste water applications are involved. The latter circumstance usually entails the removal of the apparatus or module from its operating environment to a tank wherein a citrus acid containing bath is employed. Alternatively, if module 10 is retained within channel 90, the citric acid may be added to channel 90, and the deposited materials, once removed, are carried away by the normal flow of the fluid being treated and siphoned off from channel 90 by appropriate piping (not shown). As the temperature of the waste water is increased to an ideal temperature of about 120° to 140°F., the cavitation bubbles are easier to produce at the higher frequency range of about 35 to 70 kHz.

In operation, electronic generator 190 is activated by a source of power external of the module illustrated in Figure 28, whereupon ultrasonic energy is produced and impressed on transducers 191 via cables 192, 193. Transducers 191, in turn, transmit ultrasonic waves to the surrounding fluid medium with

the result that materials and/or contaminants deposited or adhering to protective sleeves 22 will be dislodged. As the deposited materials are removed, they are carried away by the normal flow of the fluid being treated and siphoned off from channel 90 through appropriate piping (not shown). If severe operating conditions prevail, such as when operating at the lower frequency ranges due to stubborn deposits and/or cold temperature conditions, module 10 may be removed and placed into an appropriate tank (not shown) for carrying out the ultrasonic cleaning described above.

The apparatus, modules, devices and methods according to the invention herein provide an inexpensive and economical means by which the individual components thereof can be maintained, wiped, cleaned, repaired and/or replaced without disturbing many of the collateral components therein. By arranging the individual operating components into separate functional compartments, on-site maintenance and/or removal of the components can be effected without the removal of the entire apparatus. Moreover, the means and devices for the removal of material deposited on the exterior surface of the radiation pervious protective sleeves for the apparatus and modules herein, provide an efficient and economical resource for facilitating the wiping and/or maintaining clean the protective quartz sleeves surrounding the ultraviolet lamps. As a result, the maintenance time required for the efficient operation of the apparatus and modules is considerably lessened.

Since other modifications and changes may be varied to fit the particular operating requirements and environments of the invention, which will be apparent to those skilled in the art, the invention is not considered to be limited to the exemplary embodiments chosen for purposes of disclosure and illustration, and covers all changes, modifications and/or equivalents within

the meaning and range of the claims which do not constitute departures from the true spirit and scope thereof.

WHAT IS CLAIMED IS:

1 1. An ultraviolet light apparatus for the treatment of a
2 fluid, comprising

3 at least one vertically arranged radiation transmission
4 source;

5 a corresponding radiation pervious protective sleeve for
6 said radiation transmission source;

7 at least one ballast for powering said radiation
8 transmission source;

9 at least one housing for containing the ballast therein;

10 electrical means providing communication between the
11 ballast and radiation transmission source to permit operation
12 of the radiation transmission source;

13 at least one enclosure disposed intermediate the housing
14 and radiation transmission source for the containment of the
15 electrical means therein; and

16 apparatus for the substantial removal of material
17 deposited on the exterior surface of said protective sleeve
18 comprising a wiping device that includes

19 (a) a wiper assembly including (i) at least one
20 retainer member provided with at least one opening for
21 receiving therethrough a corresponding number of protective
22 sleeves, and (ii) an annular cleaning member disposed about
23 each opening of said retainer member and slidably engaged with
24 the exterior surface of said protective sleeve; and

1 (b) a drive mechanism operably communicating with
2 said enclosure and said wiper assembly for the movement of said
3 wiper assembly along the longitudinal axis of said protective
4 sleeve.

1 2. The apparatus according to claim 1 which includes a
2 plurality of radiation transmission sources and a corresponding
3 number of radiation pervious protective sleeves, and the wiper
4 assembly includes a corresponding number of openings and
5 cleaning members in said retainer member.

1 3. The apparatus according to claim 1 additionally
2 comprising a support structure communicating with the enclosure
3 for maintaining the protective sleeve in vertical alignment
4 with said enclosure.

1 4. The apparatus according to claim 3 wherein said
2 support structure comprises a base and at least one support
3 member communicating with the base and the enclosure for
4 maintaining said radiation transmission source and protective
5 sleeve in vertical alignment with said enclosure and said base.

1 5. The apparatus according to claim 4 wherein said base
2 is provided with at least one opening for receiving the lower
3 portion of a corresponding number of protective sleeves.

1 6. An ultraviolet light module for the treatment of a
2 fluid, comprising
3 a plurality of vertically arranged radiation transmission
4 sources;
5 a radiation pervious protective sleeve about each
6 radiation transmission source;
7 a plurality of ballasts for powering said radiation
8 transmission sources;
9 at least one housing for containing said ballasts therein;
10 electrical means providing communication between the
11 ballasts and radiation transmission sources to permit operation
12 of said radiation transmission sources;
13 at least one enclosure disposed intermediate the housing
14 and radiation transmission sources for the containment of the
15 electrical means therein;
16 a support structure communicating with the enclosure for
17 maintaining the radiation transmission sources in vertical
18 alignment with said enclosure; and
19 apparatus for the substantial removal of material
20 deposited on the exterior surface of the radiation pervious
21 protective sleeves comprising a wiping device that includes
22 (a) a wiper assembly including (i) at least one
23 retainer member provided with a plurality of openings for
24 receiving therethrough a corresponding number of protective
25 sleeves, and (ii) an annular cleaning member disposed about
26 each opening of said retainer member and slidably engaged with
27 the exterior surface of said protective sleeve; and
28 (b) a drive mechanism operably communicating with
29 said enclosure and said wiper assembly for the movement of said
30 wiper assembly along the longitudinal axis of said protective
31 sleeves.

1 7. The module according to claim 6 wherein the support
2 structure comprises a base and one or more support members
3 communicating with the base and the enclosure for maintaining
4 said radiation transmission sources in vertical alignment with
5 said enclosure and said base.

1 8. The module according to claim 7 wherein said base is
2 provided with a plurality of openings for receiving the lower
3 portion of a corresponding number of protective sleeves
4 therein.

1 9. A device for the substantial removal of material
2 deposited on the exterior surface of at least one radiation
3 pervious protective sleeve surrounding at least one vertically
4 arranged radiation transmission source in a radiation apparatus
5 configured for immersion in a fluid for the treatment thereof,
6 comprising:

7 (a) a wiper assembly comprising (i) at least one retainer
8 member provided with at least one opening for receiving said
9 protective sleeve therethrough, and (ii) an annular cleaning
10 member disposed about said opening and slidably engaged with
11 the exterior surface of said protective sleeve; and

12 (b) a drive mechanism operably communicating with said
13 wiper assembly and said radiation apparatus for the movement of
14 said wiper assembly along the longitudinal axis of said
15 protective sleeve.

1 10. The device according to claim 9 wherein the retainer
2 member of said wiper assembly comprises a plurality of openings
3 for receiving therethrough a corresponding number of protective
4 sleeves.

1 11. The device according to claim 10 wherein the drive
2 mechanism comprises a piston disposed within a chamber that is
3 in fixed relationship with said radiation apparatus, said
4 piston being operatively engaged with the wiper assembly for
5 moving the wiper assembly along the longitudinal axis of said
6 protective sleeves.

1 12. The device according to claim 10 wherein the drive
2 mechanism comprises a rotatable threaded rod, supported by said
3 radiation apparatus and operatively engaged with a threaded
4 opening provided in said retaining member for moving said wiper
5 assembly along the longitudinal axis of said protective
6 sleeves.

1 13. The device according to claim 12 wherein said
2 threaded opening comprises at least one nut secured about an
3 opening provided in said retainer member.

1 14. The apparatus or module according to claims 1 or 6
2 wherein the protective sleeve is constructed of quartz, one end
3 of which is closed and the other end secured within the
4 enclosure in waterproof relationship thereto.

1 15. The apparatus or module according to claims 1 or 6
2 wherein the radiation transmission source is an ultraviolet
3 lamp.

1 16. The apparatus or module according to claims 2 or 6
2 wherein a plurality of ballasts is used for powering said
3 radiation transmission sources.

1 17. The apparatus or module according to claims 2 or 6
2 wherein said housing, enclosure and plurality of radiation
3 transmission sources are in vertical alignment relative to each
4 other.

1 18. The apparatus or module according to claim 5 or 6
2 wherein the housing and enclosure interface each other.

1 19. The apparatus or module according to claims 4 or 7
2 wherein the base is a plate member provided with a plurality of
3 openings for receiving the lower portion of a corresponding
4 number of protective sleeves.

1 20. The apparatus or module according to claim 19 wherein
2 each opening of said plate member is provided with a receptacle
3 for receiving and maintaining the lower portion of said
4 protective sleeves therein.

1 21. The apparatus or module according to claims 4 or 7
2 wherein said base comprises at least two opposing side walls
3 joined in spaced apart relationship by a plate member, said
4 plate member comprising a plurality of openings for receiving
5 the lower portion of a corresponding number of protective
6 sleeves therein.

1 22. The apparatus or module according to claim 21 wherein
2 said base is in the form of a compartment comprising a top and
3 bottom plate member joined in spaced apart relationship by two
4 pairs of opposing side walls, said top plate member comprising
5 a plurality of openings for receiving the lower portion of a
6 corresponding number of protective sleeves therein.

1 23. The apparatus or module according to claims 1 or 6
2 wherein the wiper assembly includes a plurality of retainer
3 members, said retainer members being maintained in spaced apart
4 parallel relationship along the longitudinal axis of said
5 protective sleeve(s) by one or more connecting members secured
1 to each retainer member.

1 24. The apparatus or module according to claim 23 wherein
2 the wiper assembly includes a top and bottom retainer member in
3 parallel spaced apart relationship.

1 25. The apparatus or module according to claims 1 or 6
2 wherein the drive mechanism comprises a piston disposed within
3 a chamber that is in fixed relationship with said enclosure,
4 said piston being operatively engaged with the wiper assembly
5 for the movement of the wiper assembly along the longitudinal
6 axis of said protective sleeve(s).

1 26. The apparatus or module according to claim 25 wherein
2 said chamber is secured to the underside of said enclosure.

1 27. The apparatus or module according to claim 25 wherein
2 said piston is operatively engaged with the wiper assembly by a
3 shaft connected to the piston and the retainer member of said
4 wiper assembly.

1 28. The apparatus or module according to claim 25 wherein
2 said piston is pneumatically operated within said chamber.

1 29. The apparatus or module according to claim 25 wherein
2 said piston is hydraulically operated within said chamber.

1 30. The apparatus or module according to claim 25 wherein
2 the wiper assembly includes a top, middle and bottom retainer
3 member maintained in parallel spaced apart relationship along
4 the longitudinal axis of said protective sleeve(s) by one or
5 more connecting members, the end portion of the shaft being
6 secured to the middle retainer member.

1 31. The apparatus or module according to claims 3 or 6
2 wherein the drive mechanism comprises a rotatable threaded rod,
3 supported by said enclosure and said support structure,
4 operatively engaged with a threaded opening provided in said
5 retainer member for moving said wiper assembly along the
6 longitudinal axis of said protective sleeve(s).

1 32. The apparatus or module according to claim 31 wherein
2 said threaded opening comprises at least one threaded nut fixed
3 about an opening provided in said retainer member.

1 33. The apparatus or module according to claim 32 wherein
2 the threaded rod is engaged with at least one threaded nut
3 disposed about an opening provided in a plurality of retainer
4 members, said retainer members being spaced apart in parallel
5 relationship along the threaded rod by a predetermined
6 distance.

1 34. The apparatus or module according to claim 31 wherein
2 the threaded rod is operably connected to a means for rotating
3 the rod in said threaded opening for the movement of said wiper
4 assembly along the longitudinal axis of said protective
5 sleeve(s).

1 35. The apparatus or module according to claim 34 wherein
2 the means for rotating the threaded rod comprises an electric
3 motor.

1 36. The apparatus or module according to claim 31 wherein
2 the threaded rod is operably connected to an electric motor,
3 disposed within the enclosure, for rotating the rod in said
4 threaded opening for the movement of said wiper assembly along
5 the longitudinal axis of said protective sleeve(s).

1 37. The module according to claim 6 wherein the wiper
2 assembly comprises at least two retainer members and the drive
3 mechanism comprises a fluid operated linear slide that includes
4 a stationary partition disposed within a movable housing for
5 the guided axial movement of said housing and said wiper
6 assembly along an elongate hollow shaft extending from either
7 side of said partition through the respective ends of said
8 movable housing, the opposing respective ends of said shafts
9 being supported by said support structure and said enclosure,
10 whereby said movable housing and said wiper assembly move in
11 concert in response to a differential pressure communicated to
12 the movable housing from a source of pressurized fluid.

1 38. The module according to claim 37 wherein said slide
2 comprises:

3 (a) a movable housing including an annular cavity, said
4 movable housing communicating with said wiper assembly for
5 their movement along the longitudinal axis of said protective
6 sleeve(s);

7 (b) a stationary partition disposed within the annular
8 cavity and slidably engaged with said movable housing to
9 provide a first and second chamber therein;

10 (c) a stationary first and second elongate hollow shaft
11 including a first and second passage communicating with the
12 first and second chambers, respectively, each shaft having one
13 end extending from one side of said partition in the axial
14 direction of the annular cavity, and the respective opposing
15 ends of said shafts being supported by said support structure
16 and said enclosure and being adapted to communicate with said
17 source of pressurized fluid; and

18 (d) a first and second annular sealing device mounted
19 about the respective ends of said movable housing in fluid
20 tight relationship thereto and in slidable and fluid tight
21 relationship about the respective shafts, for the guided
22 movement of said housing in the axial direction of said shafts
23 in response to a differential pressure communicated to the
24 annular cavity from said source of pressurized fluid via said
25 first and second passages.

1 39. The module according to claim 38 wherein said support
2 structure comprises a base and a plurality of support members
3 communicating with the base and enclosure, and wherein the
4 respective ends of said shafts are supported by said base and
5 said enclosure.

1 40. The module according to claim 38 wherein said movable
2 housing is concentric with the central axis of said elongate
3 hollow shafts.

1 41. The module according to claim 38 wherein a sealing
2 means is provided about the circumference of the partition,
3 said sealing means being slidably engaged with said movable
4 housing for maintaining a fluid tight seal between the first
5 and second chambers.

1 42. The module according to claim 41 wherein said sealing
2 means comprises a pair of cup seals, each cup seal having at
3 least a portion of their U-shaped opening communicating
4 respectively with said first and second chambers.

1 43. The module according to claim 42 wherein a guide
2 member is provided about the circumference of said partition
3 for slidable engagement with said housing.

1 44. The module according to claim 43 wherein said guide
2 member is disposed about the partition between said pair of cup
3 seals.

1 45. The module according to claim 44 wherein said guide
2 member is a wear bushing.

1 46. The module according to claim 38 wherein one of said
2 first or second elongate hollow shafts includes therein an
3 axially disposed stationary conduit forming an actuation
4 conduit, and the remaining shaft is hermetically sealed about
5 its supportive end, said actuation conduit having one end
6 communicating in fluid tight relationship with a passageway
7 axially extending through said partition into the interior of
8 the remaining shaft, and the opposite open end of the actuation
9 conduit and the open end of the shaft being adapted to connect
10 with said source of pressurized fluid.

1 47. The module according to claim 38 wherein either or
2 both sides of said partition includes a protrusion extending in
3 an axial direction therefrom for receiving the respective ends
4 of said first and second elongate hollow shafts in fluid tight
5 relationship, said first and second passages of the respective
6 shafts being respectively aligned with a corresponding
7 passageway provided in said protrusions for communicating
8 pressurized fluid between the interior of the first and second
9 shafts and the first and second chambers of said movable
10 housing.

1 48. The module according to claim 47 wherein one of said
2 first or second shafts includes therein an axially disposed
3 stationary conduit forming an actuation conduit, said conduit
4 having one end communicating in fluid tight relationship with a
5 passageway disposed in said partition and in said protrusions
6 that communicates with the passage of the remaining shaft, and
7 the opposite open ends of the conduit and one of said shafts
8 being adapted to connect with the source of pressurized fluid,
9 the remaining shaft being hermetically sealed about its
10 supportive end.

1 49. The module according to claim 38 wherein each of said
2 sealing devices includes an annular end cap slidably mounted
3 about the interior of the end of said movable housing and about
4 its respective elongate hollow shaft, said end cap including an
5 annular bore about its inner annular surface for receiving
6 therein annular sealing means to provide a slidable hermetic
7 seal between said shaft and the corresponding chamber of said
8 movable housing.

1 50. The module according to claims 49 wherein the sealing
2 means comprises at least one lip seal.

1 51. The module according to claim 49 wherein the sealing
2 means comprises a pair of lip seals disposed in back-to-back
3 relationship relative to each other, one of said lip seals
4 having at least a portion of its U-shaped opening communicating
5 with the corresponding chamber of said housing.

1 52. The module according to claim 38 wherein one or both
2 of said first and second sealing devices is fixedly secured to
3 said housing.

1 53. The module according to claim 38 wherein one or both
2 of said first and second sealing devices is detachably secured
3 to said housing.

1 54. The module according to claim 38 wherein one or both
2 of said first and second sealing devices is in detachable
3 threaded engagement with said housing.

1 55. The apparatus or module according to claims 1 or 6
2 wherein said cleaning member comprises a resilient means.

1 56. The apparatus or module according to claim 55 wherein
2 the resilient means is a synthetic material.

1 57. The apparatus or module according to claim 55 wherein
2 the resilient means is rubber.

1 58. The apparatus or module according to claim 55 wherein
2 the resilient means comprises bristles, the ends of which
3 extend radially inward from the circumference of said opening.

1 59. The apparatus or module according to claims 1 or 6
2 wherein the cleaning member is Teflon.

1 60. The module according to claim 7 wherein said base
2 comprises a top and bottom member joined in spaced apart
3 relationship by at least two opposing side walls, said top
4 member comprising a plurality of openings for receiving the
5 lower portion of a corresponding number of protective sleeves
6 therein.

1 61. The module according to claim 60 additionally
2 comprising means for agitating the fluid about said protective
3 sleeve(s), said means comprising at least one passage in said
4 base for receiving a source of cleaning fluid therein and one
5 or more apertures in the top member of said base proximate to
6 said protective sleeve(s) for the passage of said cleaning
7 fluid therethrough and into contact with said protective
8 sleeve(s).

1 62. The module according to claim 61 wherein at least
2 one support member serves as a conduit for the passage of the
3 cleaning fluid to said base.

1 63. The module according to claim 62 wherein the
2 cleaning fluid is introduced to the support member from a
3 source external to the apparatus via a conduit provided in the
4 enclosure communicating with said support member.

1 64. The module according to claim 63 wherein the cleaning
2 fluid is a compressed gas.

1 65. The module according to claim 63 wherein the cleaning
2 fluid is compressed air.

1 66. The apparatus or module according to claims 1 or 6
2 wherein the apparatus for the substantial removal of material
3 deposited on the exterior surface of said protective sleeve(s)
4 comprises means for ultrasonically agitating the fluid
5 surrounding the protective sleeve that includes an electronic
6 generator retained by the enclosure and coupled with one or
7 more transducers immersed in the fluid to be treated, whereby
8 generation and transmission of ultrasonic waves to the fluid
9 surrounding the protective sleeve(s) are effected.

1 67. The apparatus or module according to claim 66 wherein
2 the transducer(s) is disposed below the enclosure.

1 68. The apparatus or module according to claim 66 wherein
2 the generator is capable of generating an ultrasonic frequency
3 of at least 18 kHz.

1 69. The apparatus or module according to claim 68 wherein
2 an ultrasonic frequency is generated within the range of about
3 18 to about 120 kHz.

1 70. The apparatus or module according to claim 69 wherein
2 an ultrasonic frequency is generated within the range of about
3 18 to 25 kHz.

1 71. The apparatus or module according to claim 69 wherein
2 an ultrasonic frequency is generated within the range of about
3 35 to 70 kHz.

1 72. A method for the simultaneous treatment of a fluid
2 and the removal of material deposited on the radiation pervious
3 protective sleeve surrounding a radiation transmission source
4 in a radiation module, comprising the steps of:

5 (a) installing a wiper assembly about the longitudinal
6 axis of the protective sleeves of said radiation module;

7 (b) mounting a drive mechanism to said wiper assembly,
8 said drive mechanism being supported by said module which
9 includes (i) an enclosure for receiving the electrical ends of
10 said radiation transmission sources and for containing
11 electrical means for the operation of said radiation
12 transmission sources, and (ii) a support structure
13 communicating with the enclosure for maintaining the radiation
14 transmission sources and corresponding protective sleeves in
15 vertical alignment therebetween;

16 (c) installing the radiation module in a vessel containing
17 the fluid to be treated; and

18 (d) treating said fluid by the operation of said radiation
19 transmission sources while simultaneously causing the wiper
20 assembly to move in the axial direction of said protective
21 sleeves by the actuation of said drive mechanism.

1 73. The method according to claim 72 wherein said vessel
2 is a conduit having an upstream end and a downstream end for
3 allowing the passage of fluid through said conduit, the module
4 being installed between said upstream and downstream ends.

1 74. The method according to claim 72 wherein said wiper
2 assembly comprises (i) at least one retainer member provided
3 with a plurality of openings, each opening receiving a
4 protective sleeve therethrough, and (ii) an annular cleaning
5 member disposed about each opening and slidably engaged with
6 the exterior surface of said protective sleeve.

1 75. The method according to claim 72 wherein the wiper
2 assembly comprises a plurality of retainer members separated
3 from each other in parallel spaced apart relationship along the
4 longitudinal axis of said protective sleeves by one or more
5 connecting members.

1 76. The method according to claim 75 wherein at least one
2 of said retainer members is connected with said drive
3 mechanism.

1 77. The method according to claim 72 wherein the support
2 structure comprises a base and one or more support members
3 communicating with the base and enclosure, said base comprising
4 a top and bottom member joined in spaced apart relationship by
5 a pair of two opposing side walls, said top member comprising a
6 plurality of openings for receiving the lower portion of a
7 corresponding number of protective sleeves therein.

1 78. The method according to claim 77 wherein the movement
2 of said wiper assembly is optionally accompanied by the
3 introduction of a cleaning fluid through a plurality of
4 apertures provided in the top member of said base for making
5 contact with the outer surface of said protective sleeves.

1 79. The method according to claim 72 wherein the drive
2 mechanism for moving the wiper assembly along the longitudinal
3 axis of the protective sleeves comprises a piston disposed
4 within a chamber communicating with said enclosure, said piston
5 being operatively engaged with the wiper assembly for its
6 movement along the longitudinal axis of said protective
7 sleeves.

1 80. The method according to claim 72 wherein the drive
2 mechanism comprises a rotatable threaded rod engaged with a
3 corresponding threaded opening provided in said retainer
4 member, said threaded rod being supported by the enclosure and
5 the support structure and operatively engaged with a means for
6 rotating the threaded rod for effecting movement of the wiper
7 assembly along the longitudinal axis of said protective
8 sleeves.

1 81. The method according to claim 72 wherein the drive
2 mechanism comprises a fluid operated linear slide that includes
3 a stationary partition disposed within a movable housing for
4 the guided axial movement of said movable housing and wiper
5 assembly along an elongate hollow shaft extending from either
6 side of said partition through the respective ends of said
7 movable housing, the opposing respective ends of said shafts
8 being supported by said enclosure and said support structure,
9 whereby said movable housing and wiper assembly move in concert
10 in response to a differential pressure communicated to the
11 movable housing from a source of pressurized fluid.

1 8²: A method for the removal of material deposited on the
2 exterior surface of a radiation pervious protective sleeve
3 surrounding a vertically arranged radiation transmission source
4 disposed between (i) an enclosure for housing electronic means
5 for the radiation transmission source's operation, and (ii) a
6 support structure in a radiation apparatus configured for
7 immersion in a fluid for the treatment thereof, comprising the
8 steps of:

9 (a) installing an electronic generator with the enclosure;

10 (b) operatively coupling the generator with a plurality of
11 transducers disposed below the enclosure of the radiation
12 apparatus;

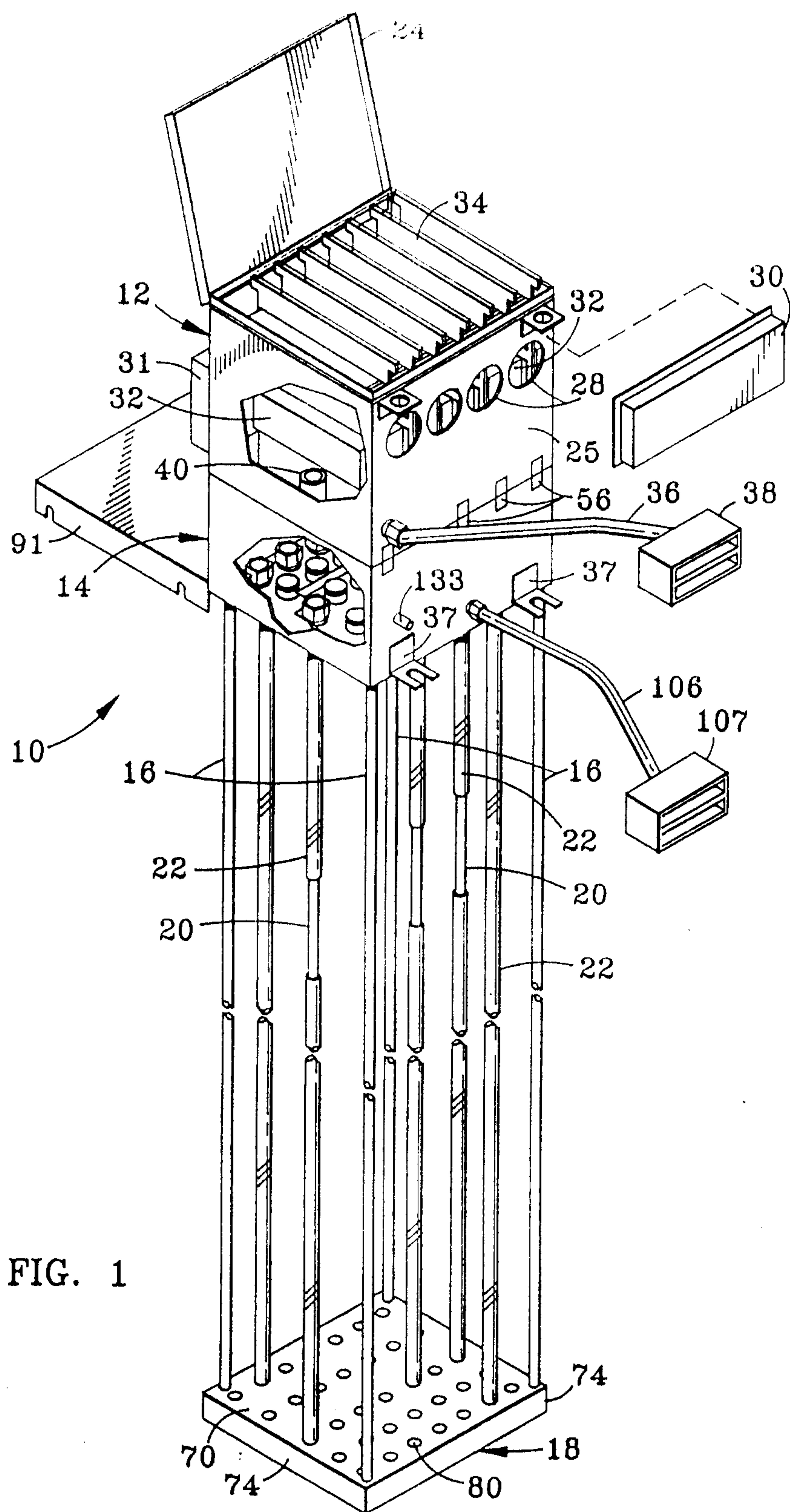
13 (c) immersing the radiation module in the fluid to be
14 treated; and

15 (d) operating the electronic generator and transducers for
16 the generation and transmission of ultrasonic waves to the
17 fluid surrounding the protective sleeve at an ultrasonic
18 frequency of at least 18 kHz.

1 83. The method according to claim 82 wherein the
2 agitation of the fluid is carried out at an ultrasonic
3 frequency of from about 18 to about 120 kHz.

1 84. The method according to claim 82 wherein the
2 agitation of the fluid is carried out at an ultrasonic
3 frequency of about 18 to about 25 kHz.

1 85. The method according to claim 82 wherein the
2 agitation of the fluid is carried at an ultrasonic frequency of
3 about 35 to about 70 kHz.



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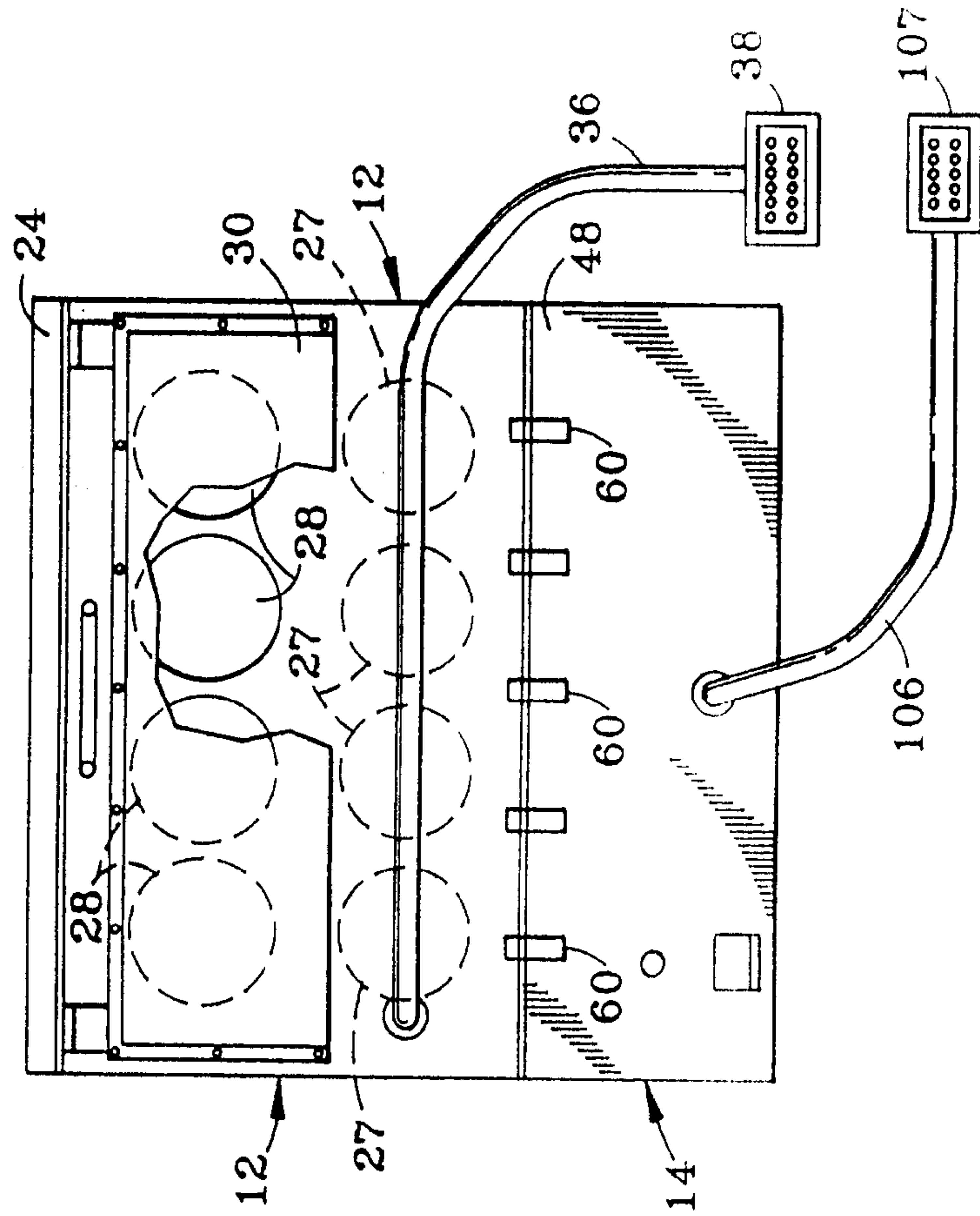


FIG. 3

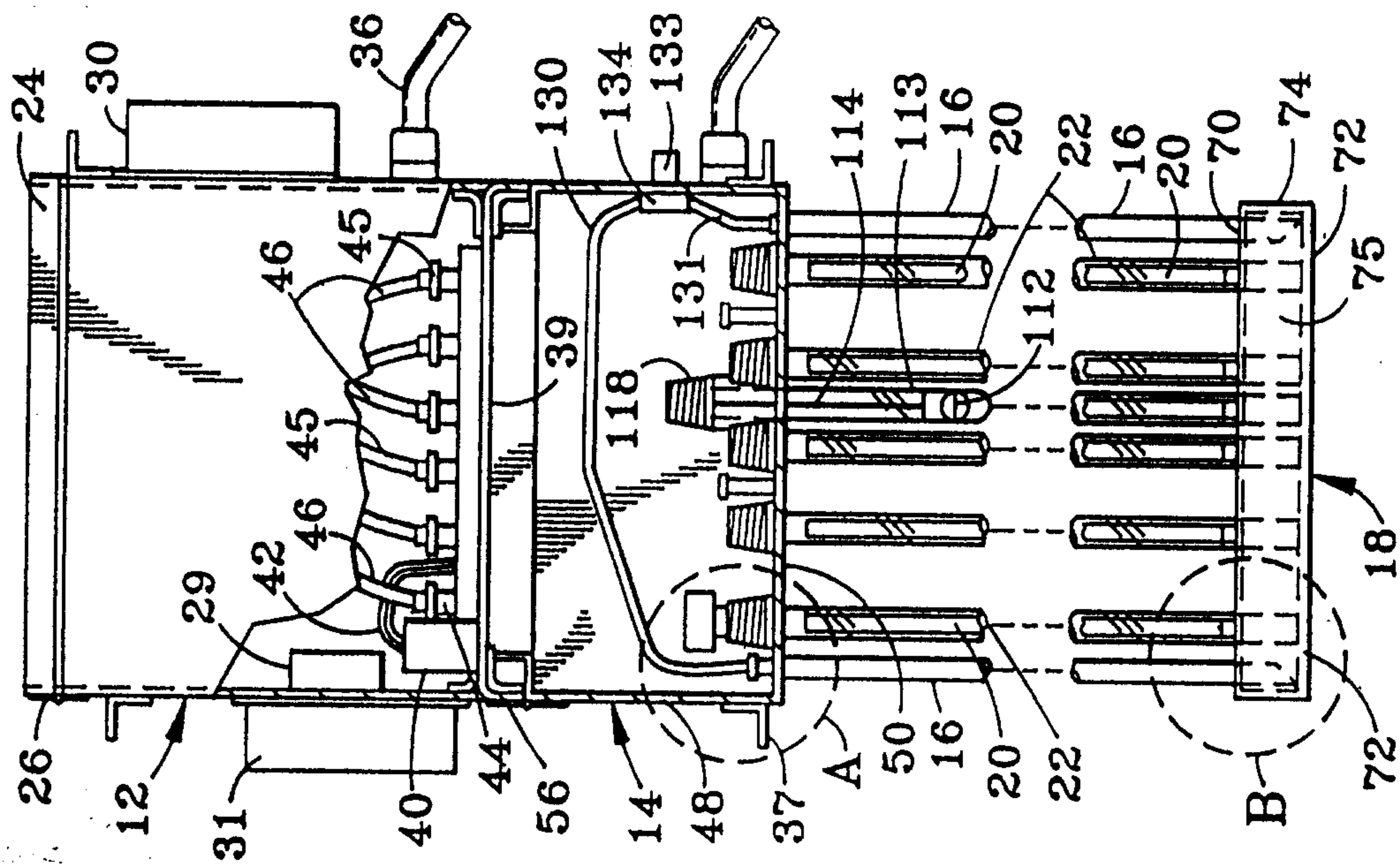


FIG. 2

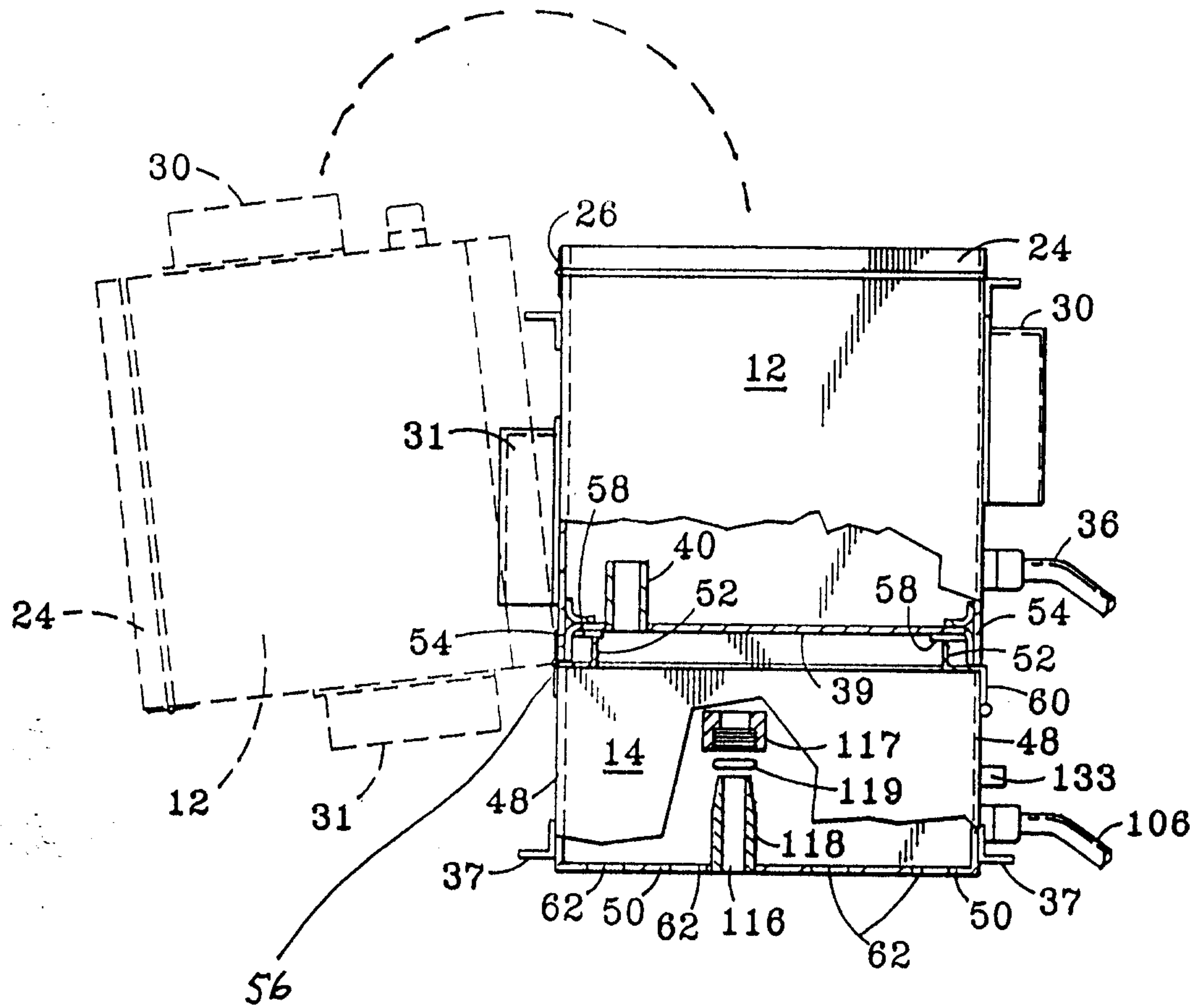


FIG. 4

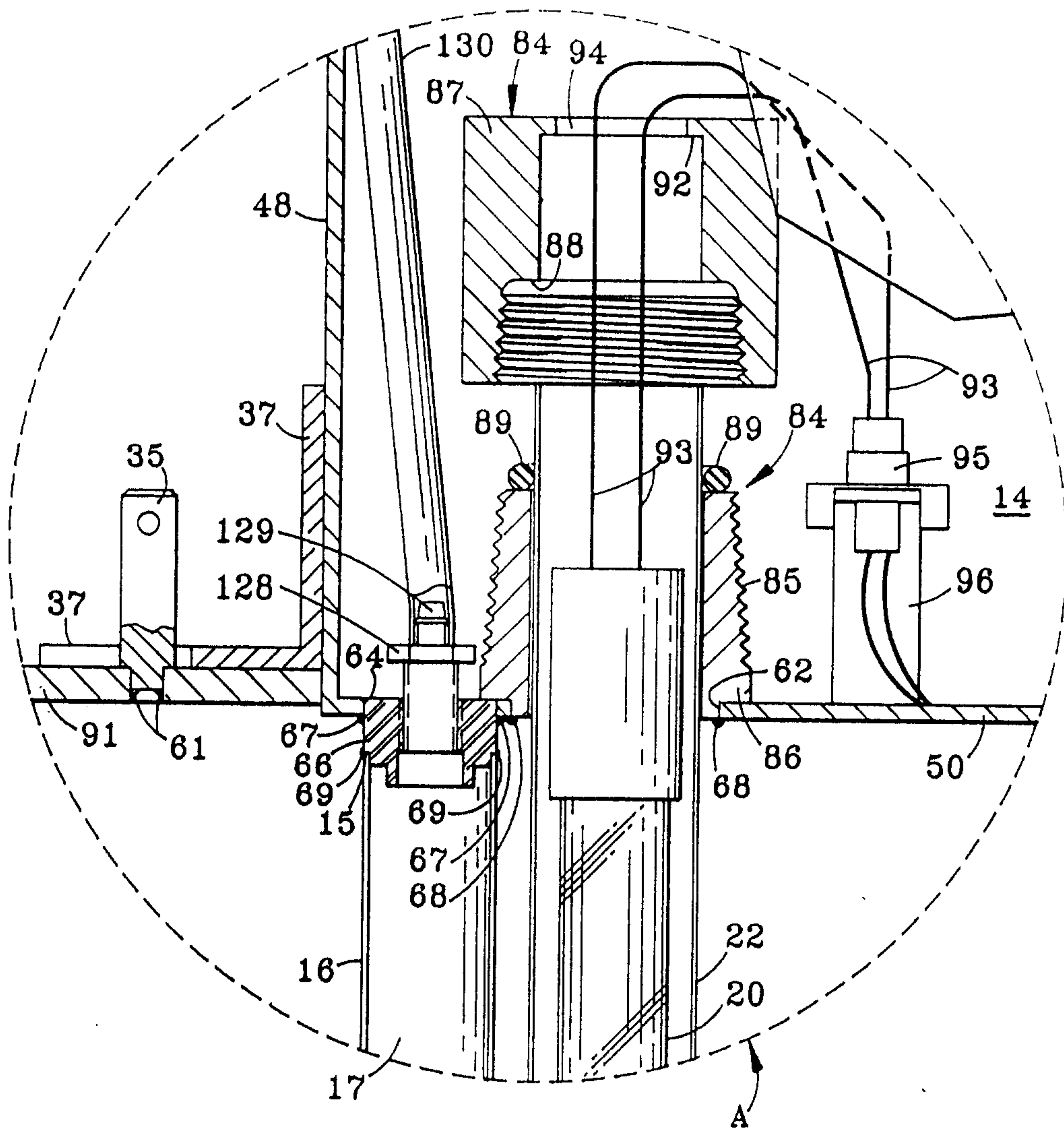


FIG. 5

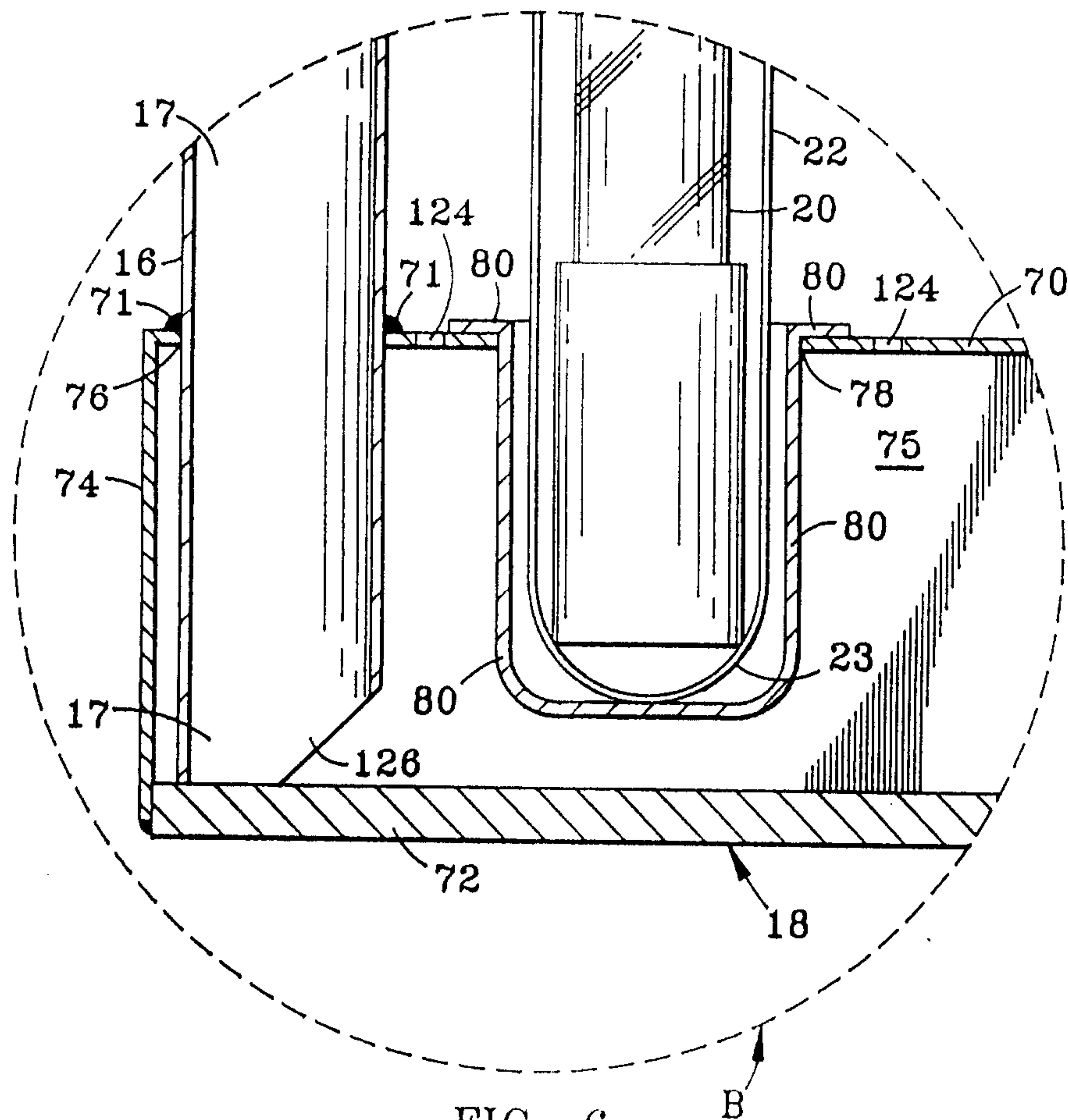


FIG. 6

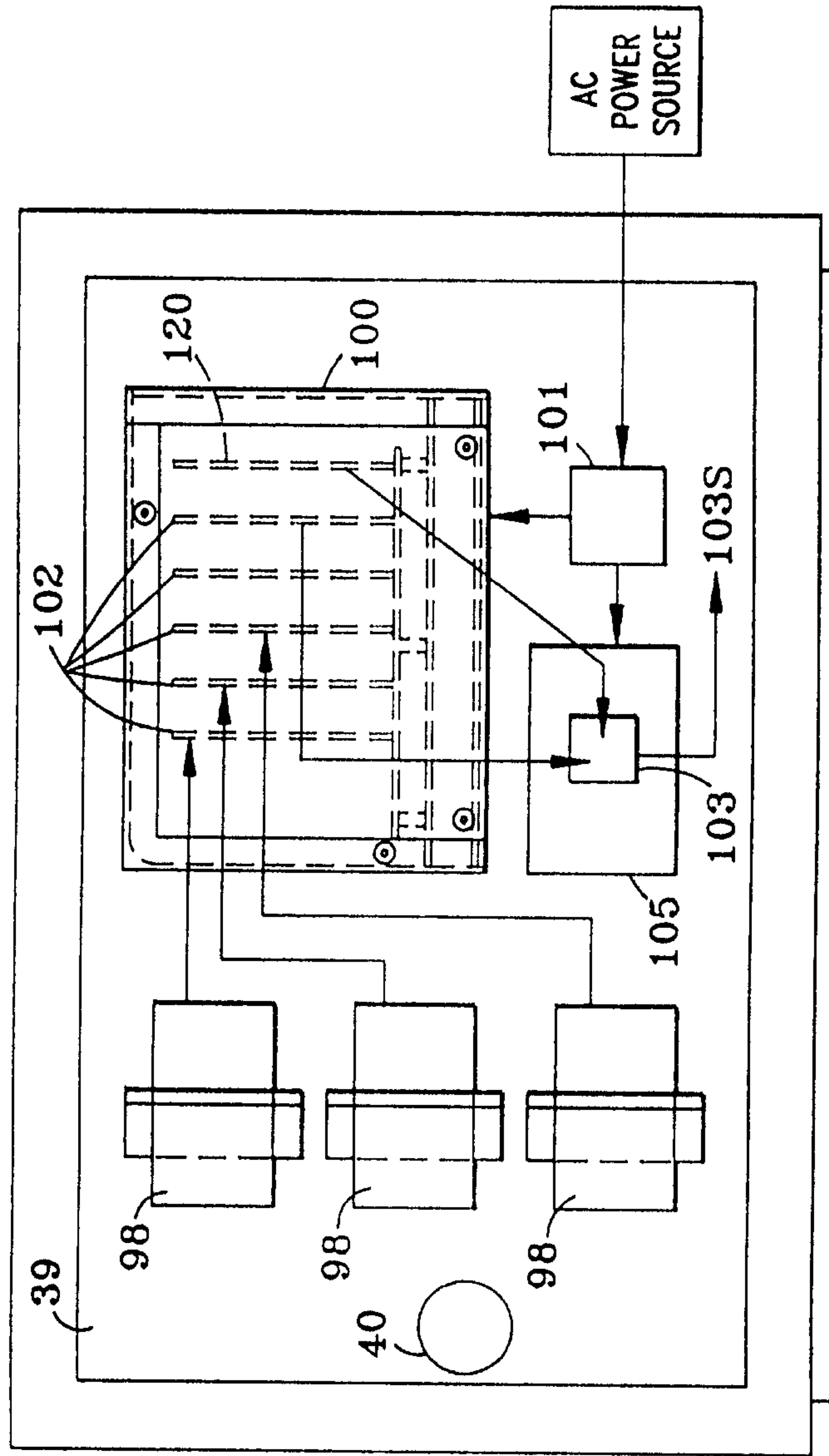


FIG. 7

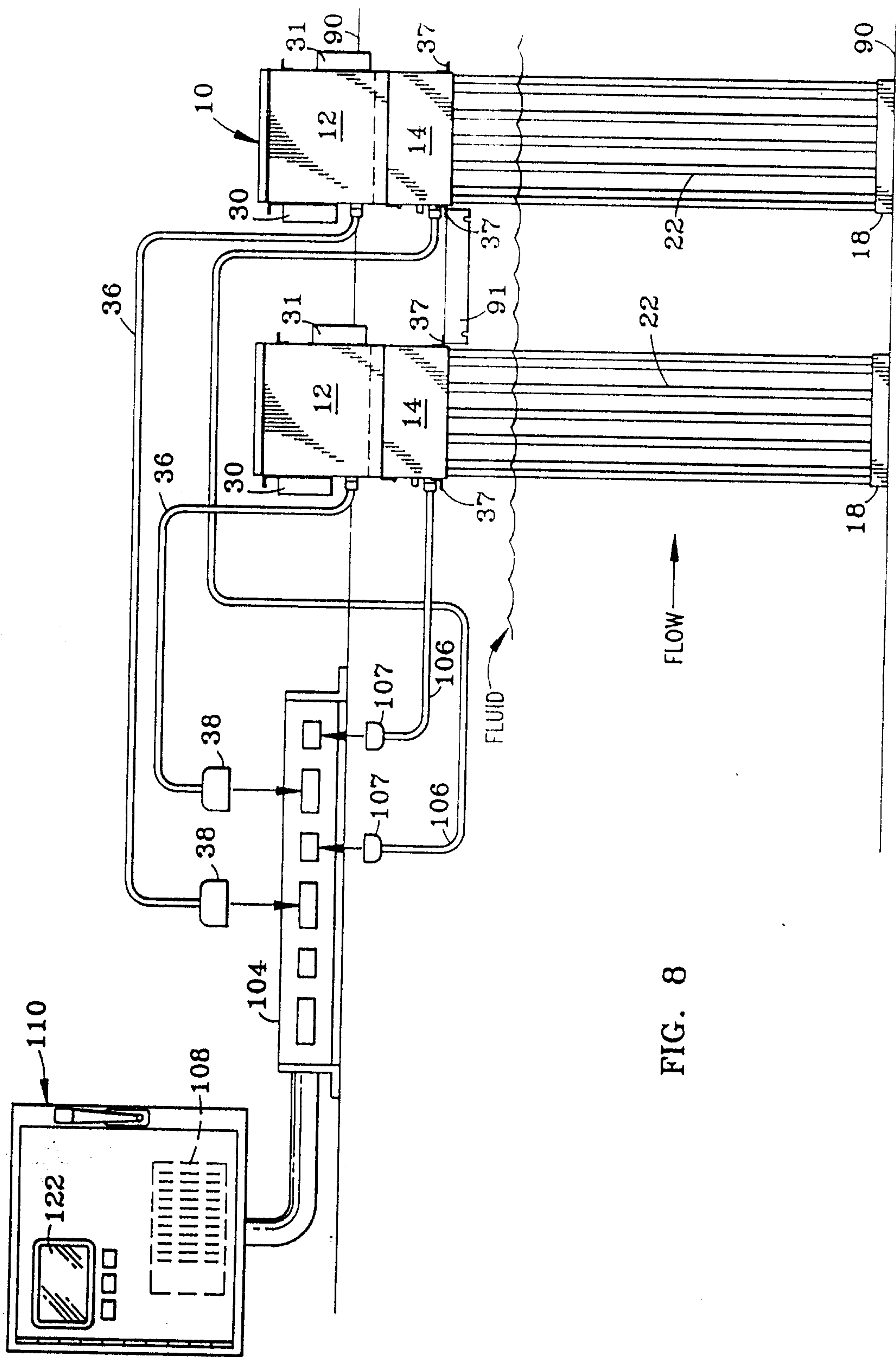
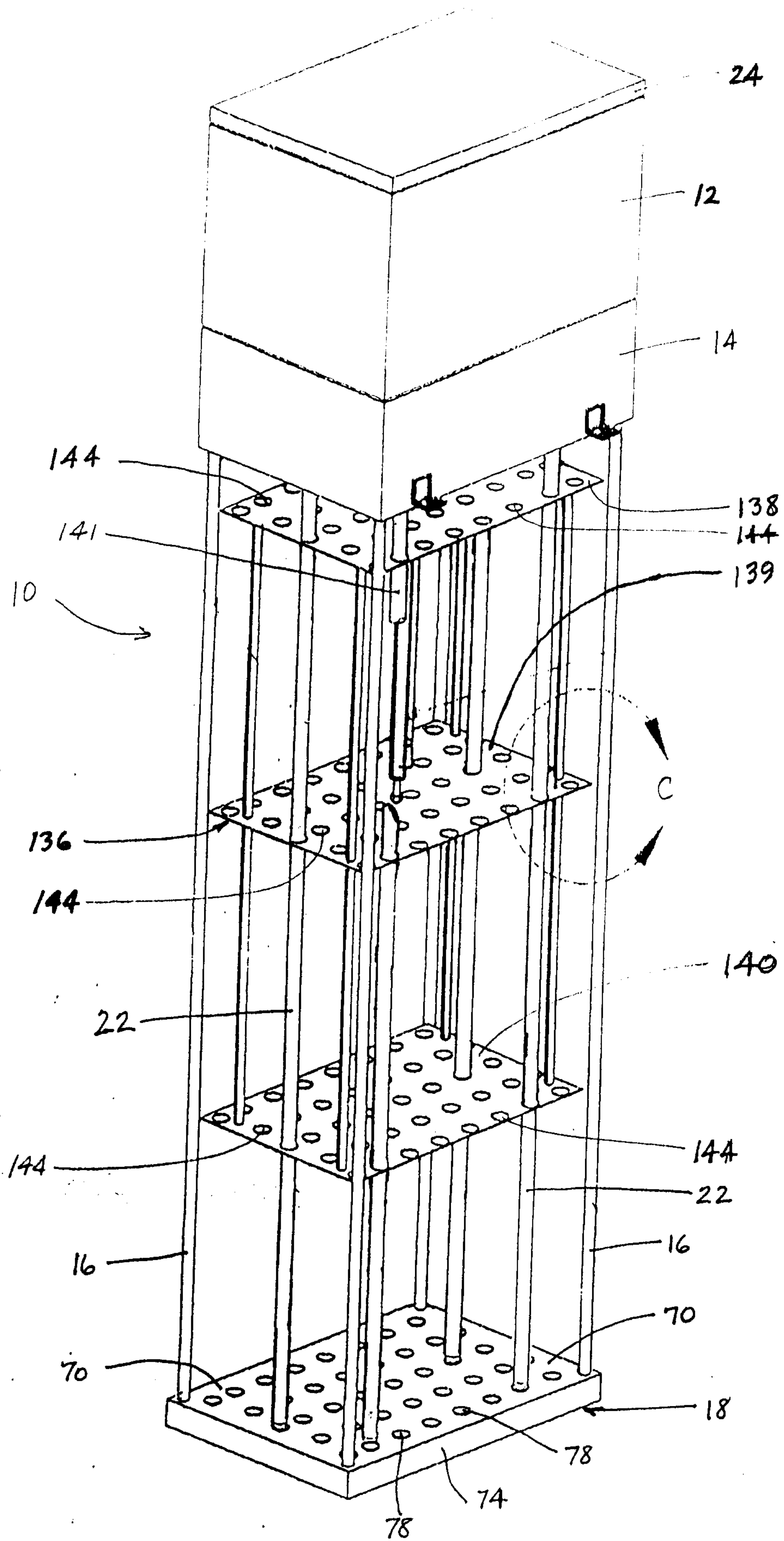


FIG. 8

**FIGURE 9**

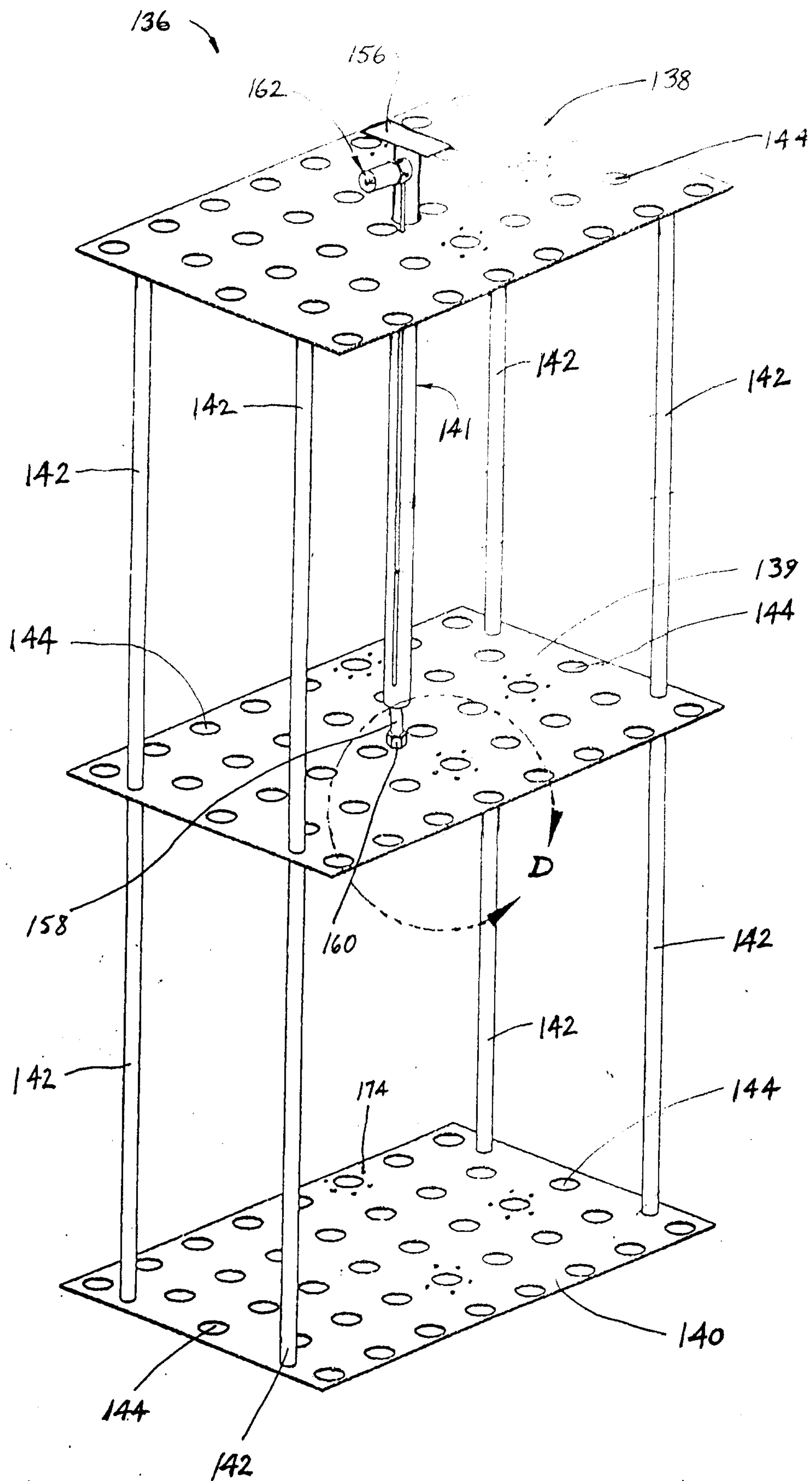


FIGURE 10

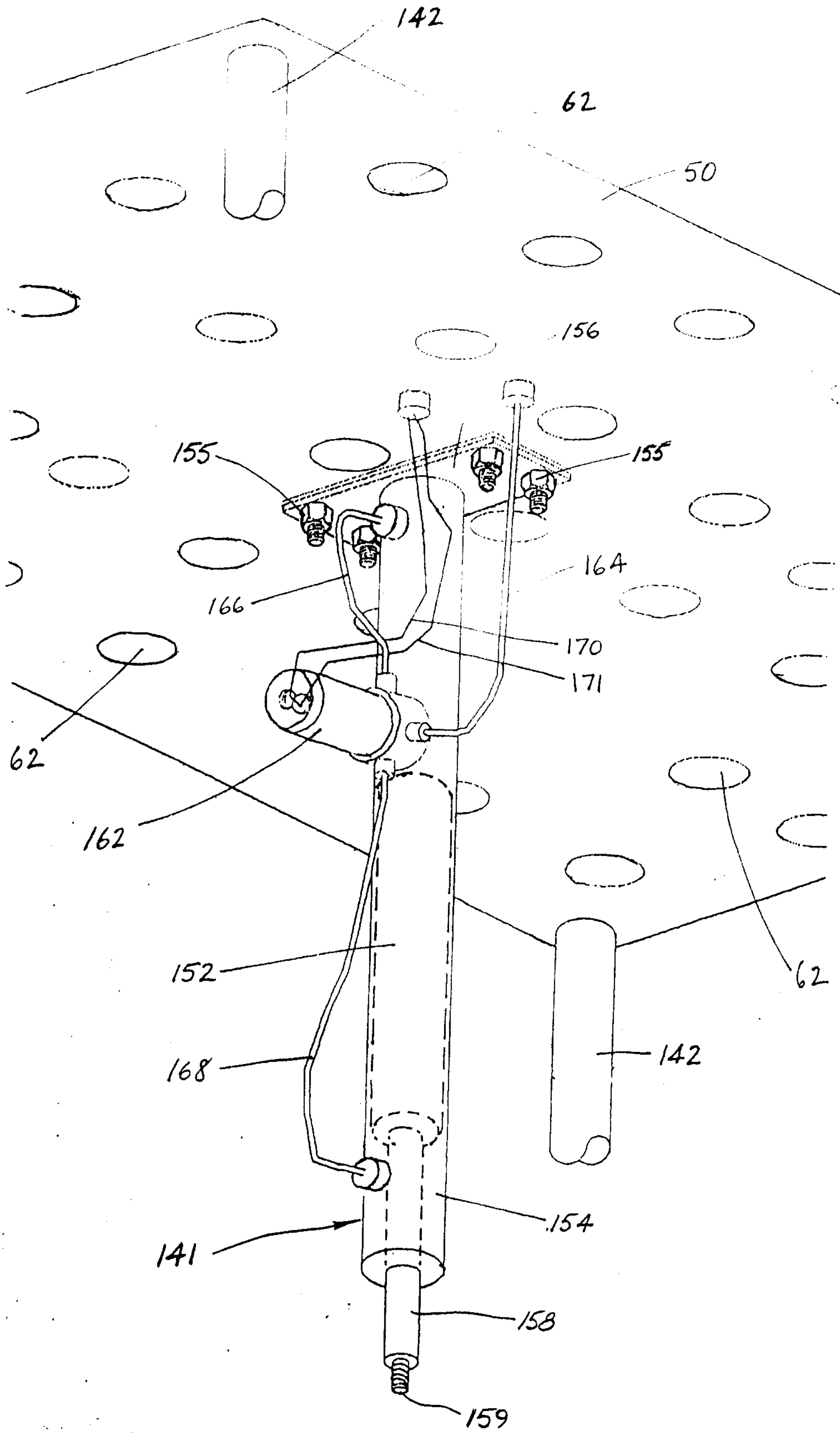


FIGURE 11

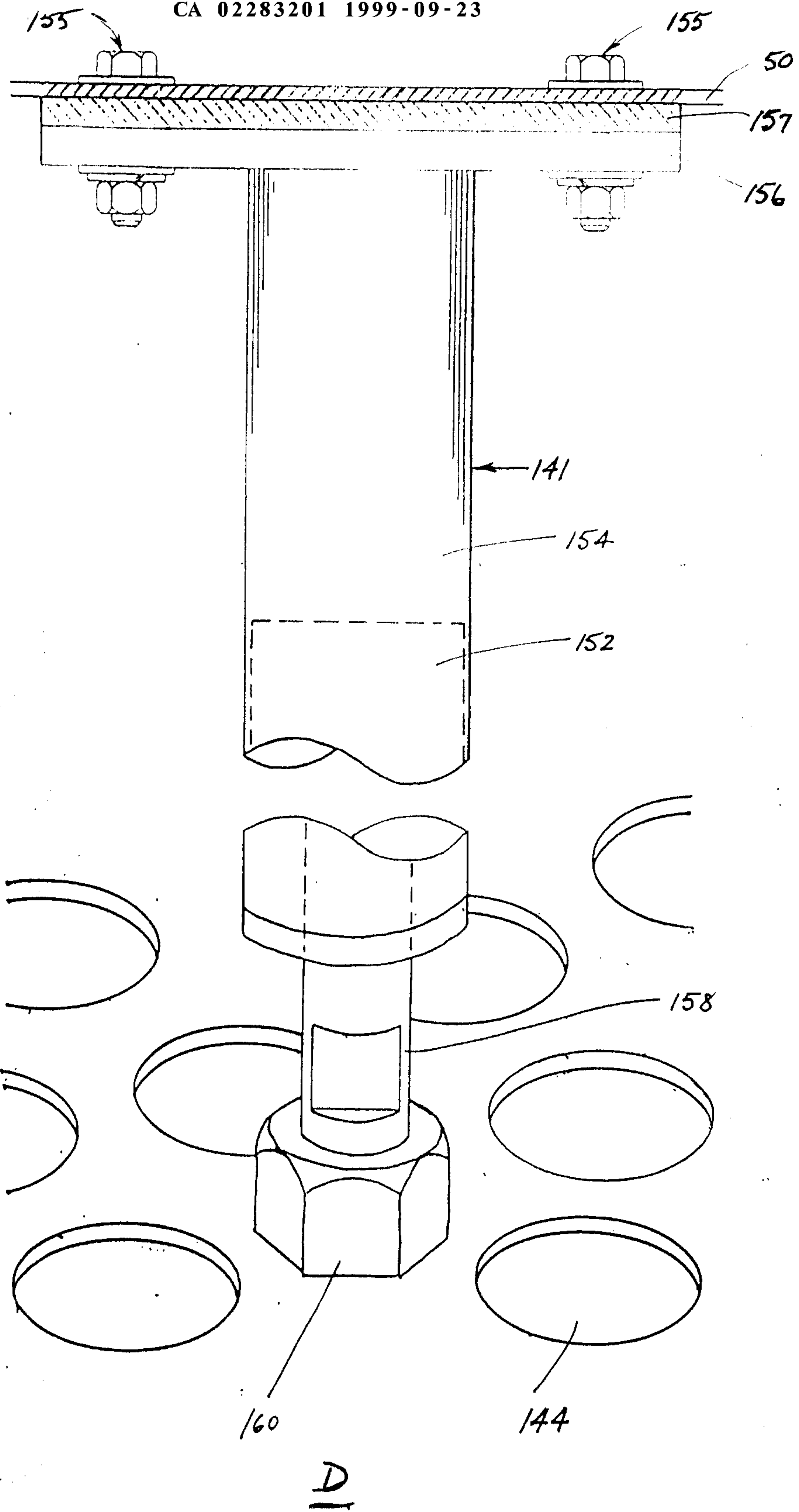
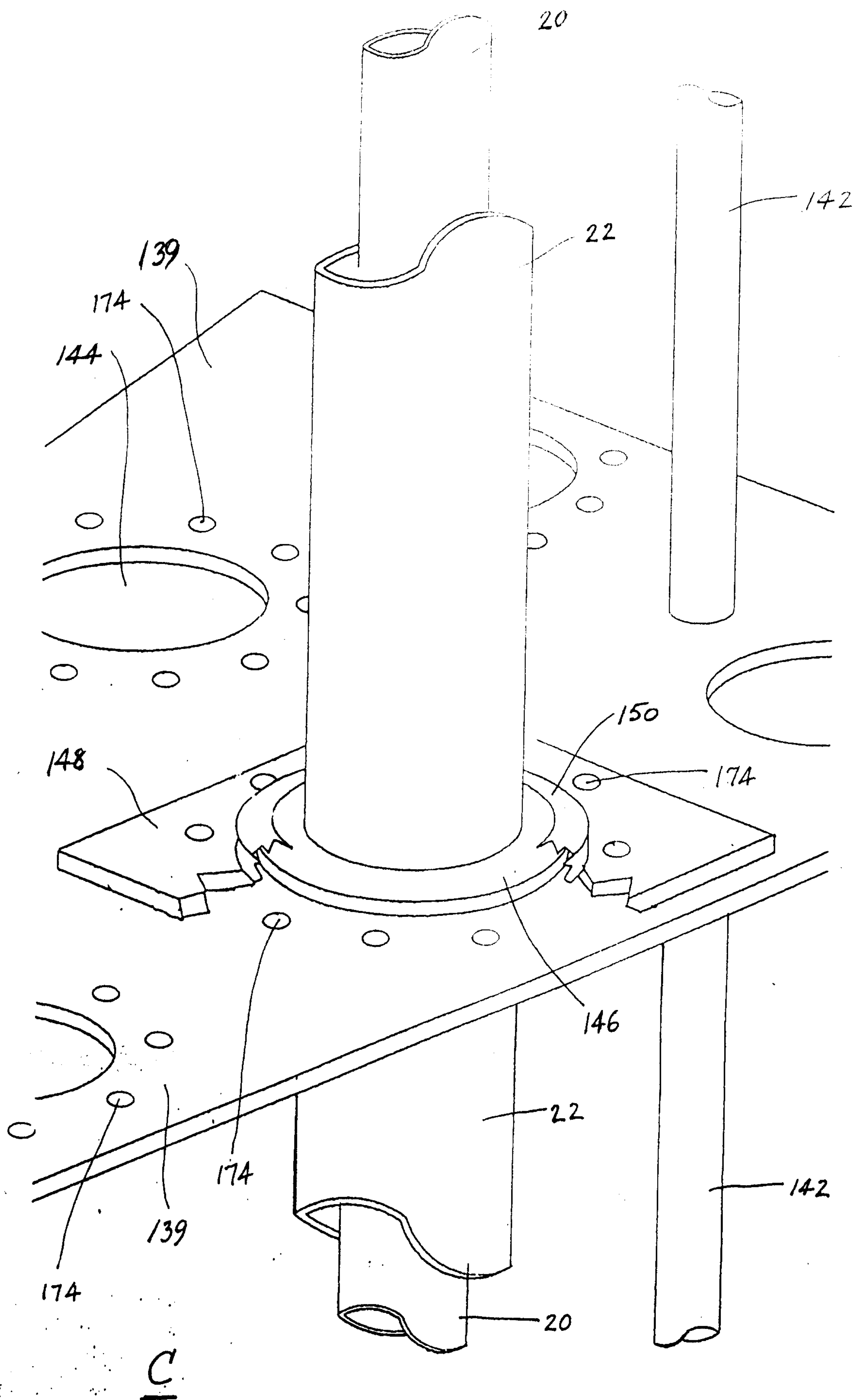


FIGURE 12

**FIGURE 13**

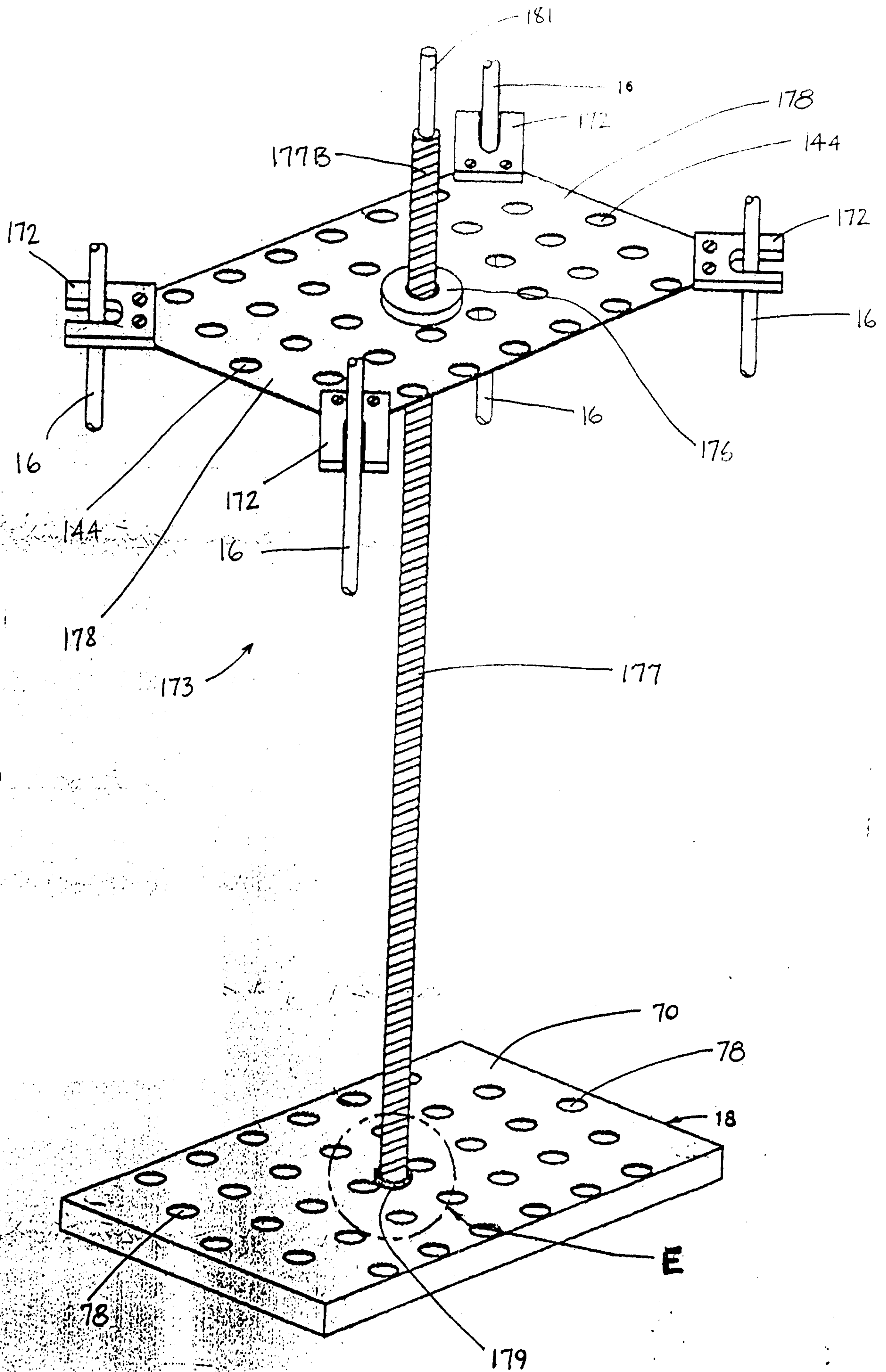
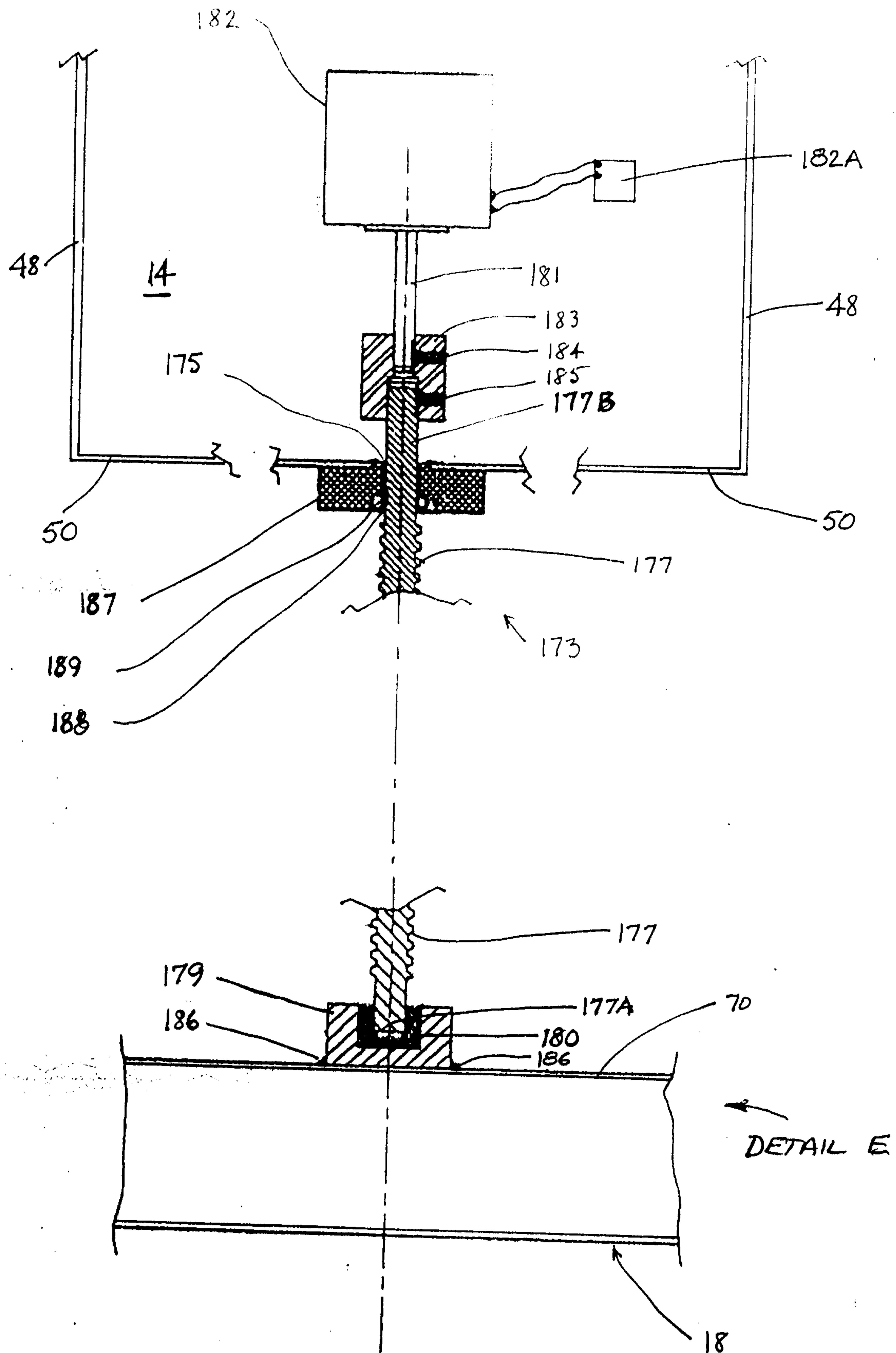


FIGURE 14



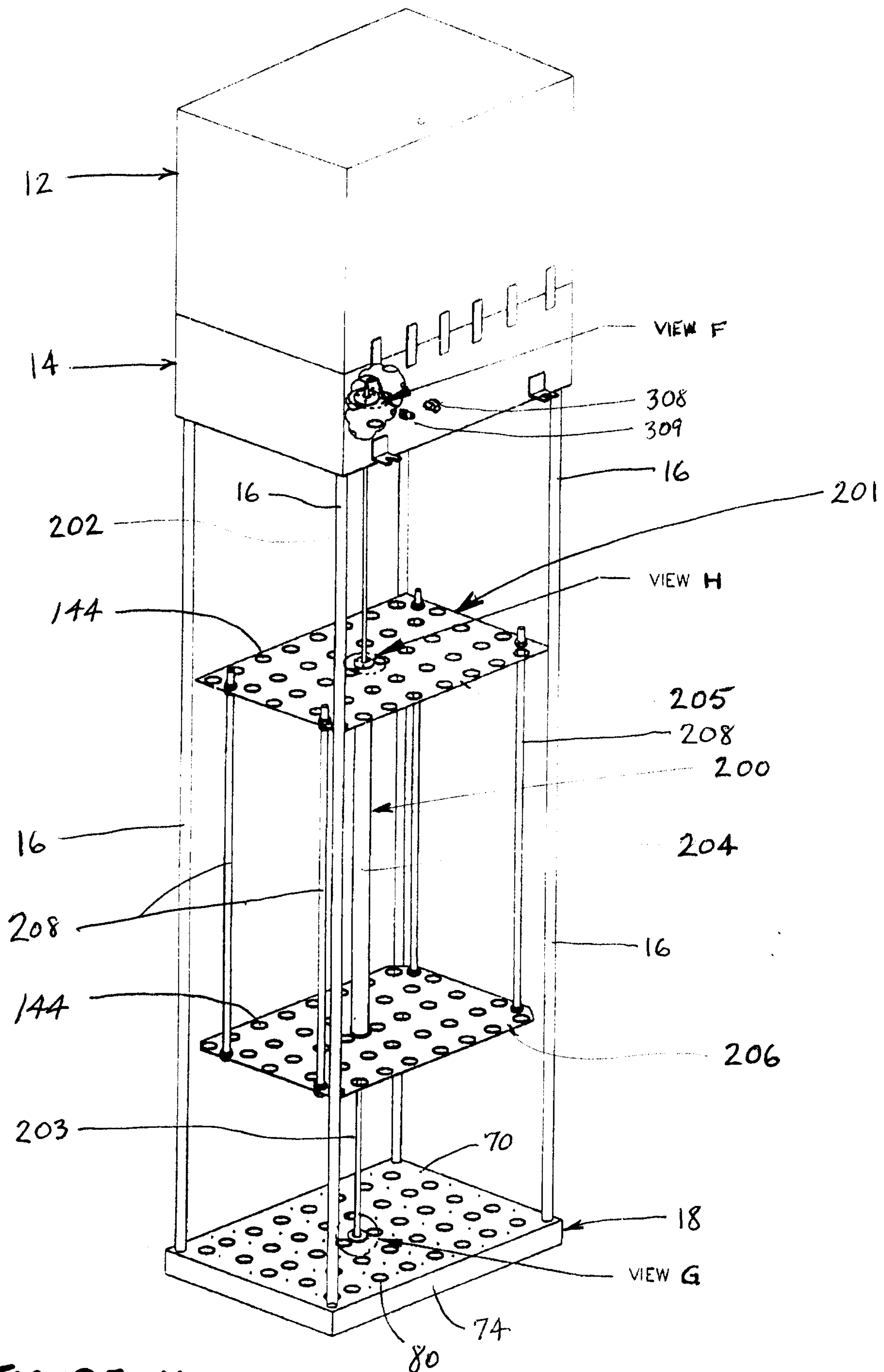


FIGURE 16

VIEW H

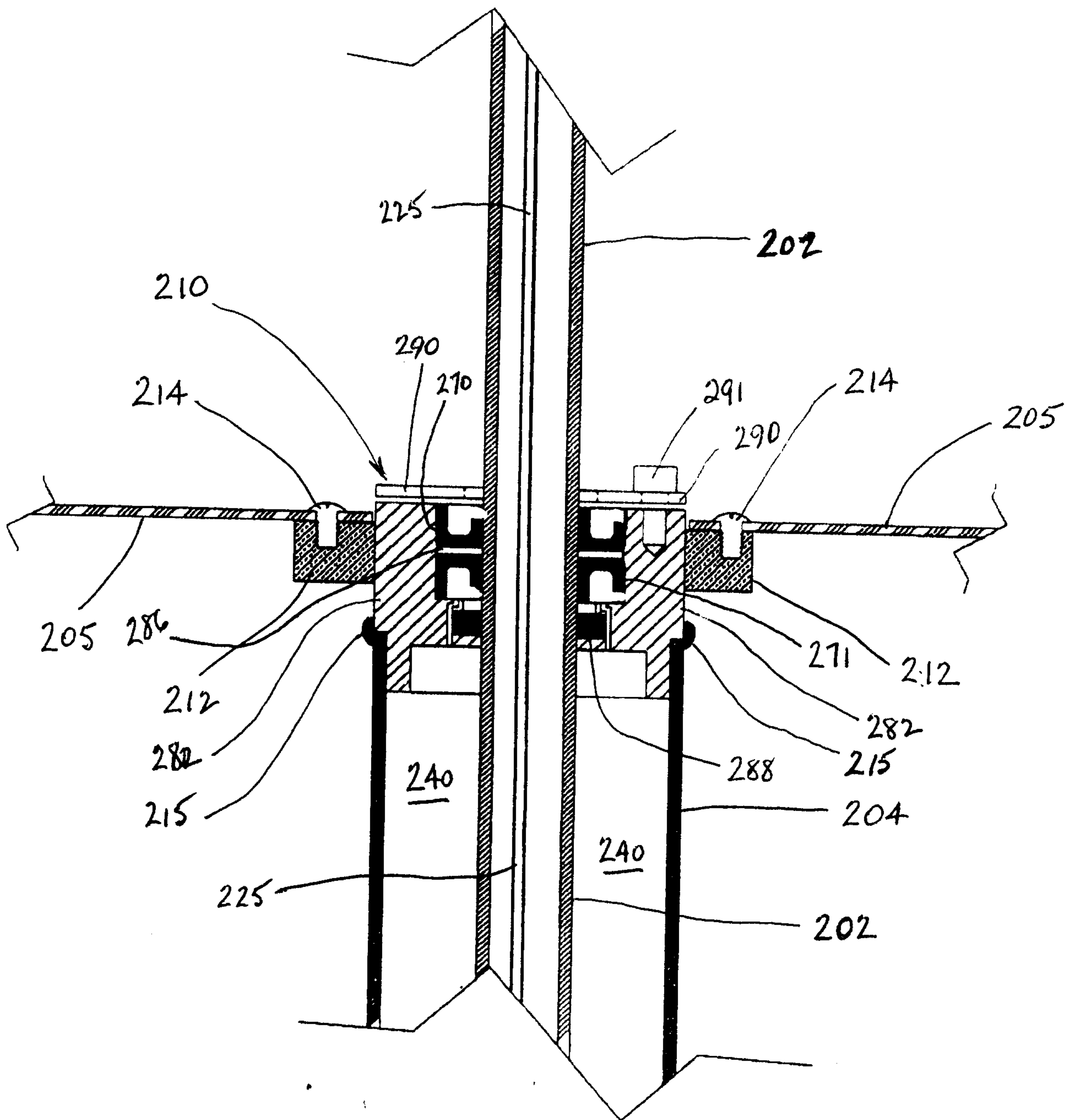


FIGURE 18

VIEW G

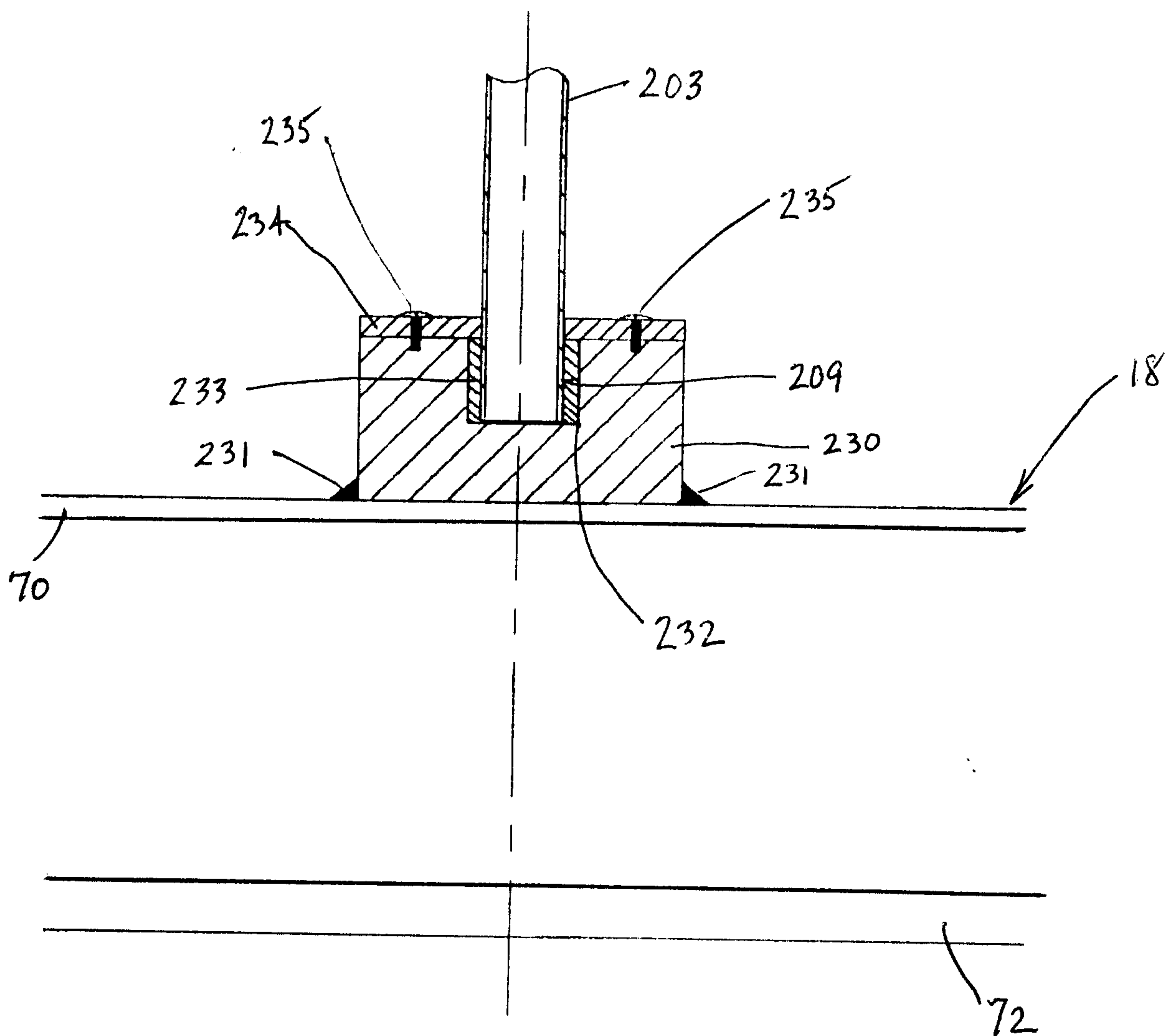
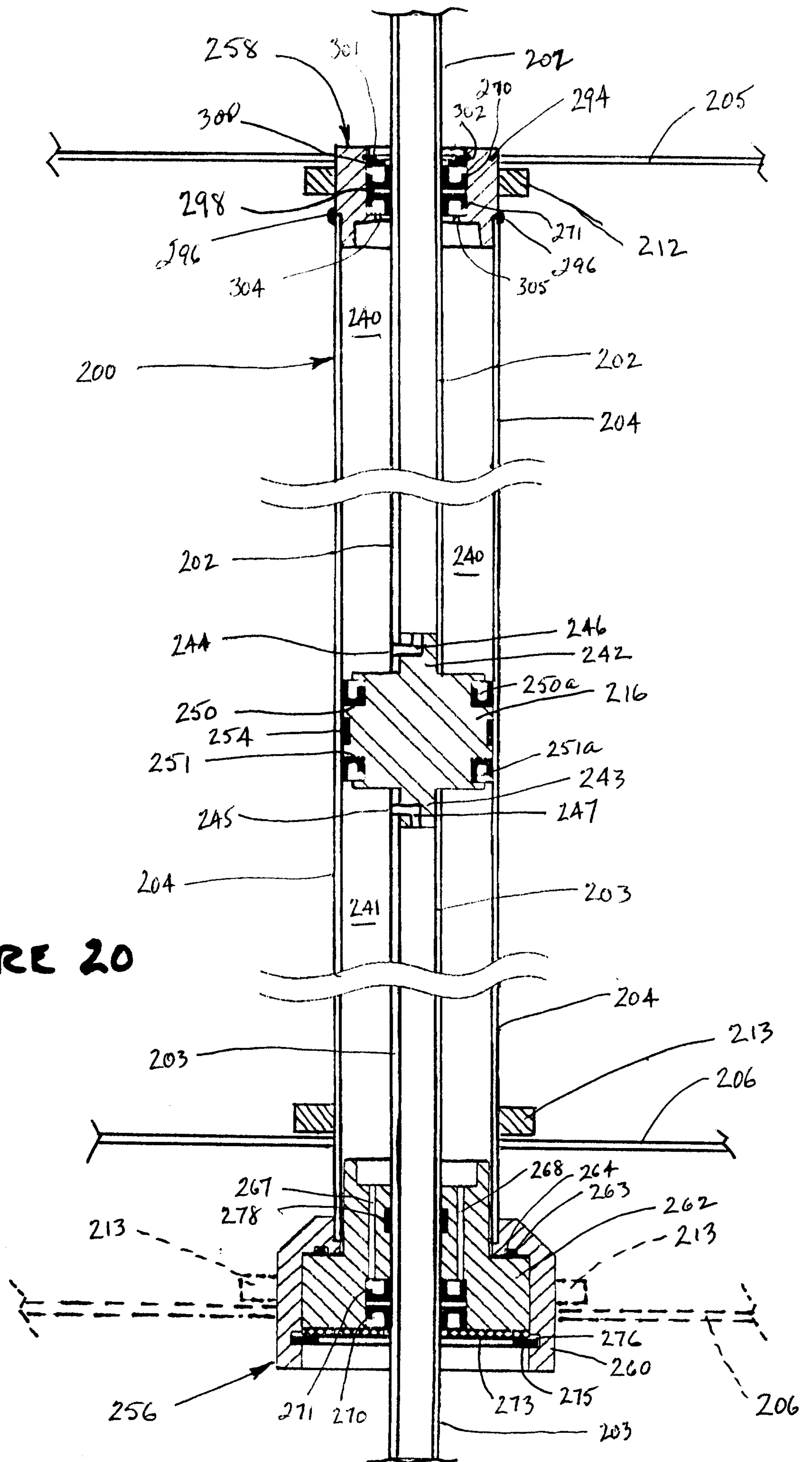
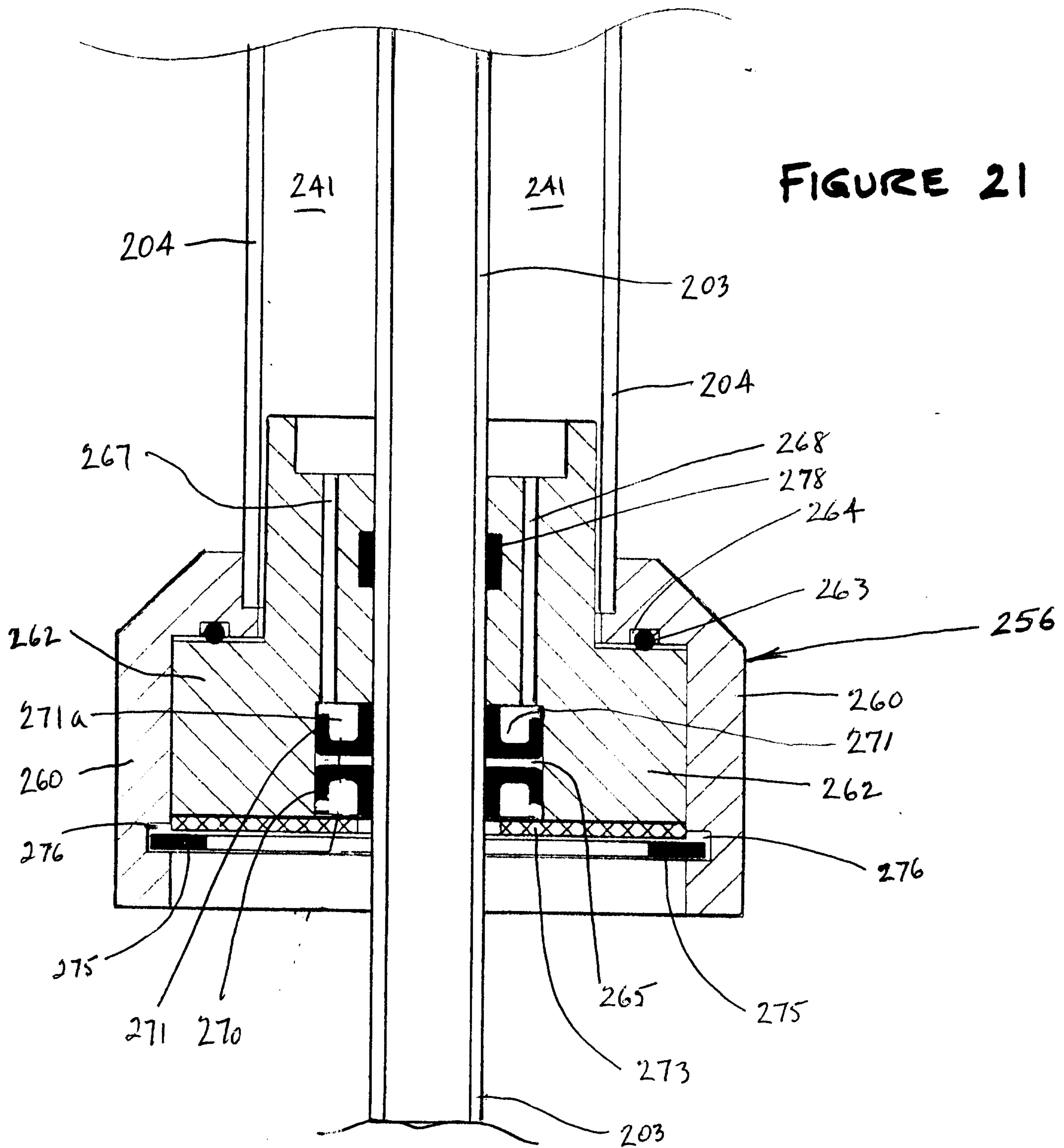


FIGURE 19





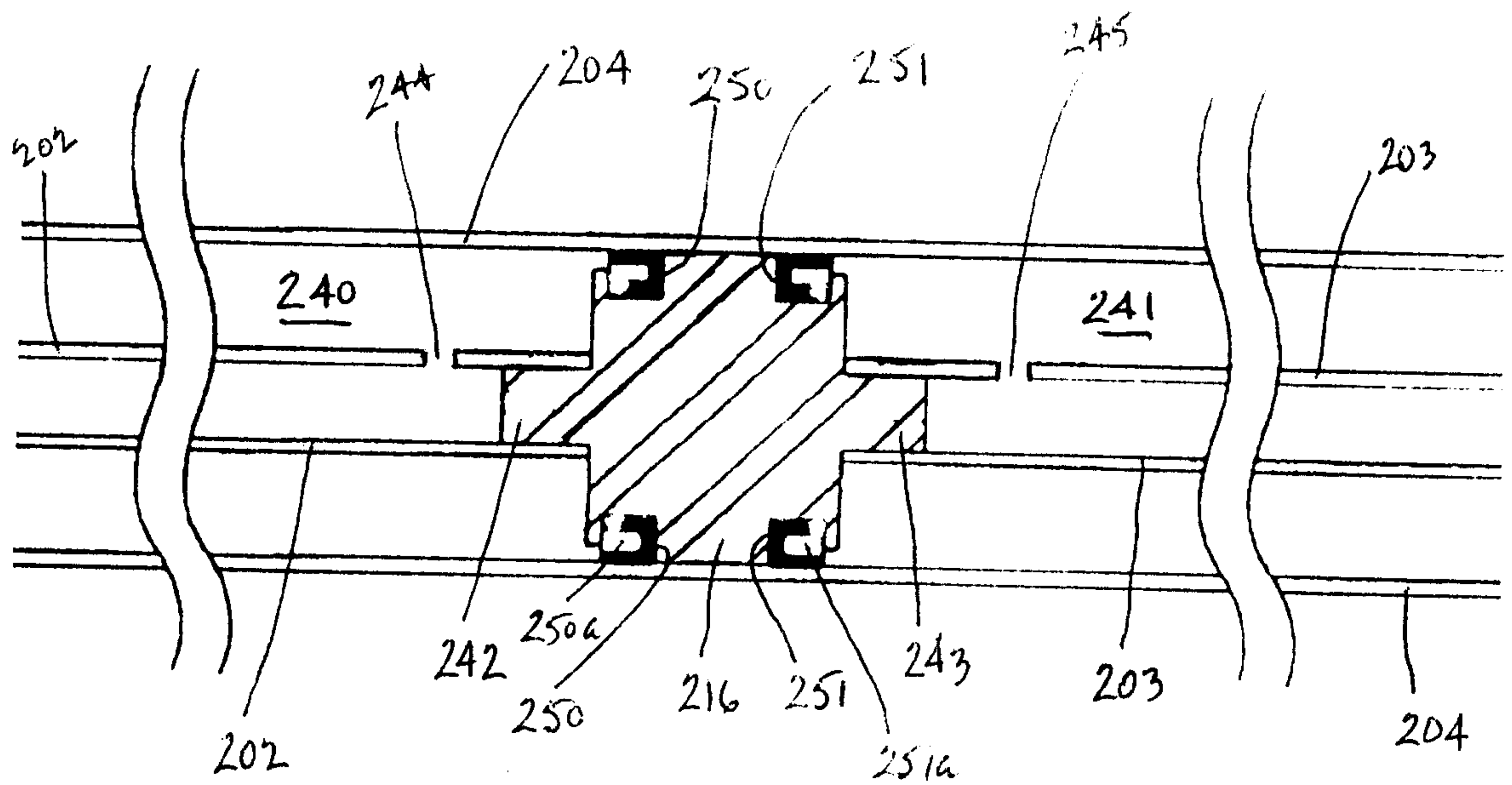


FIGURE 22

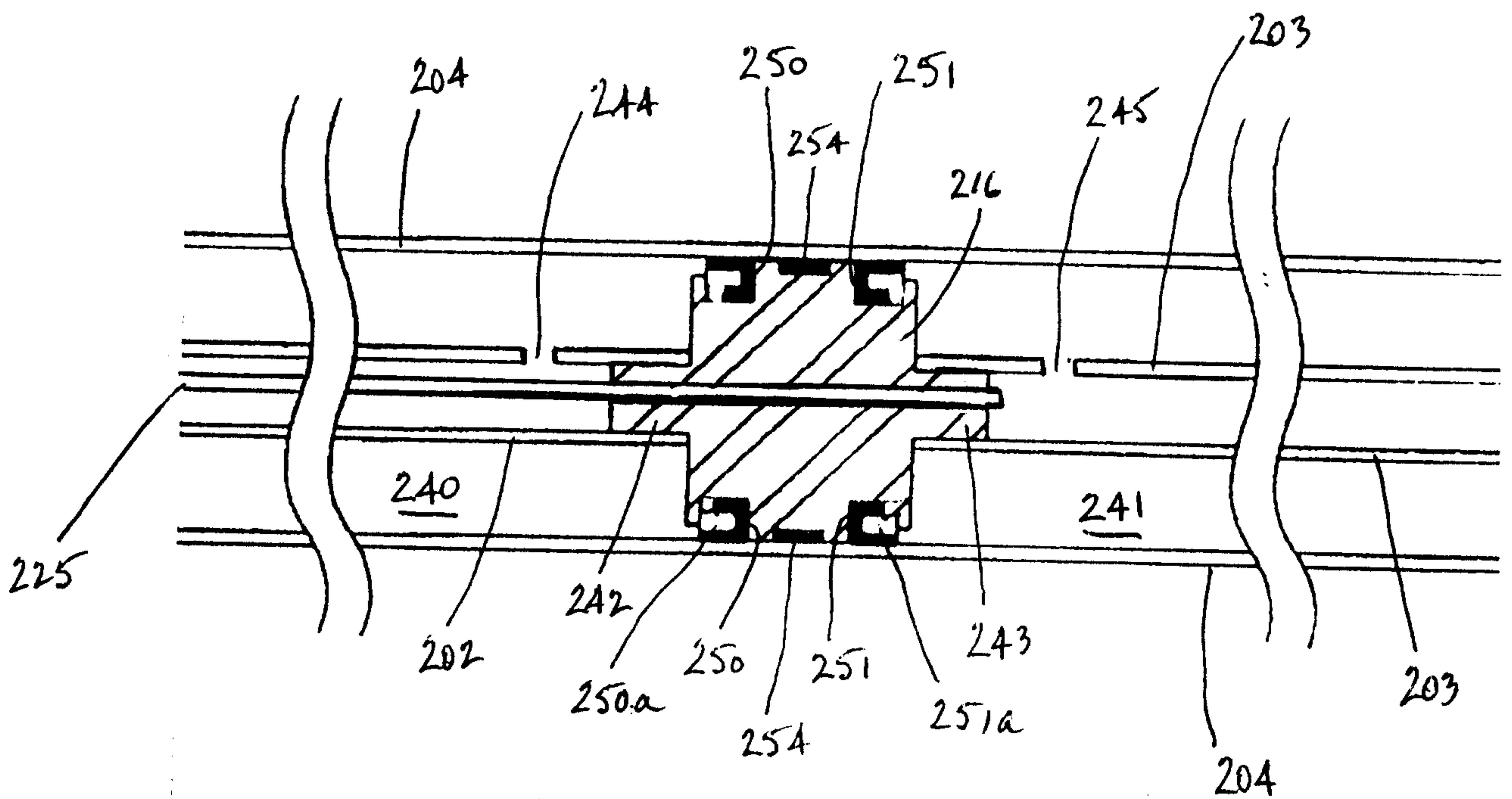


FIGURE 23

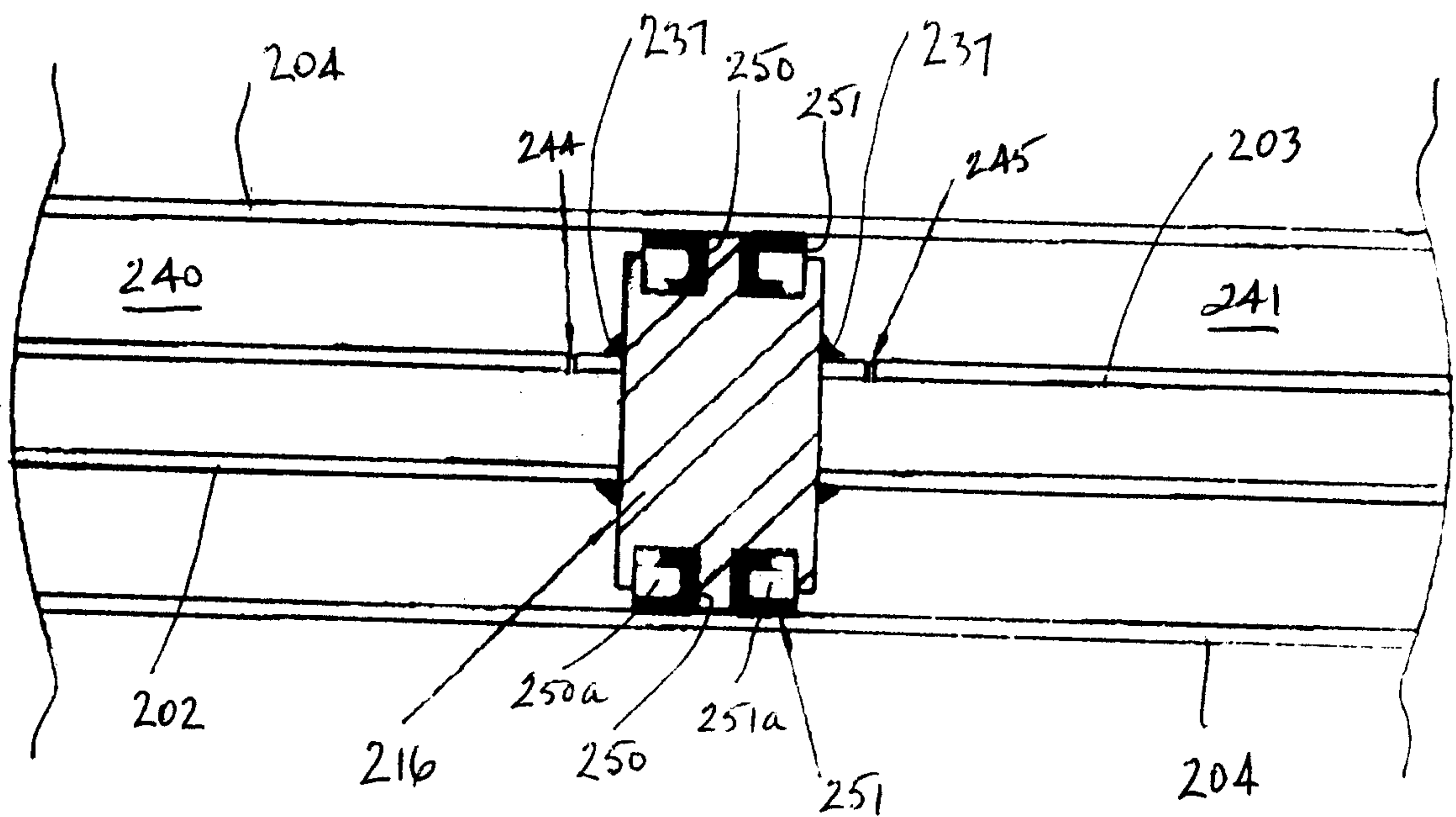


FIGURE 24

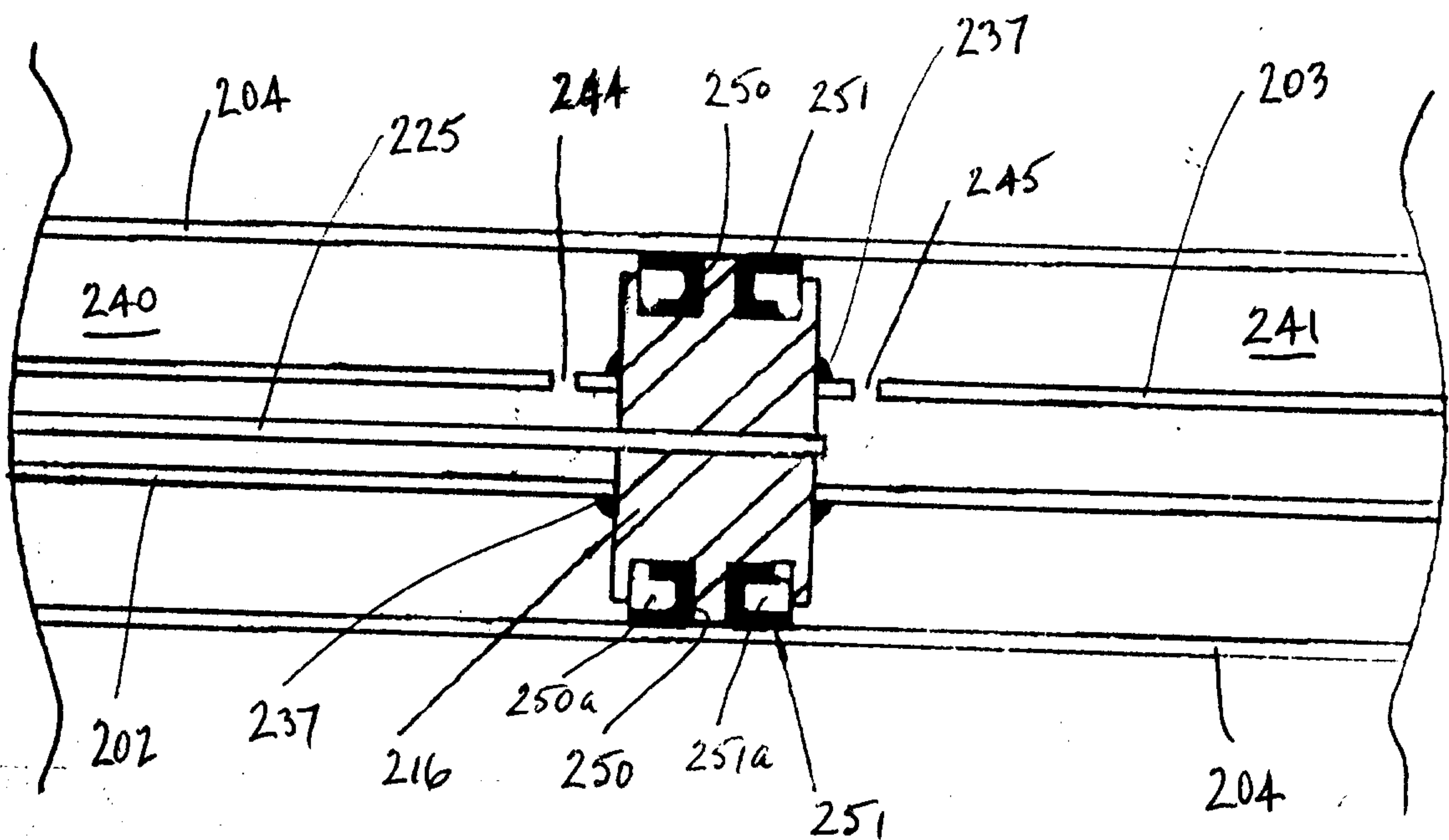


FIGURE 25

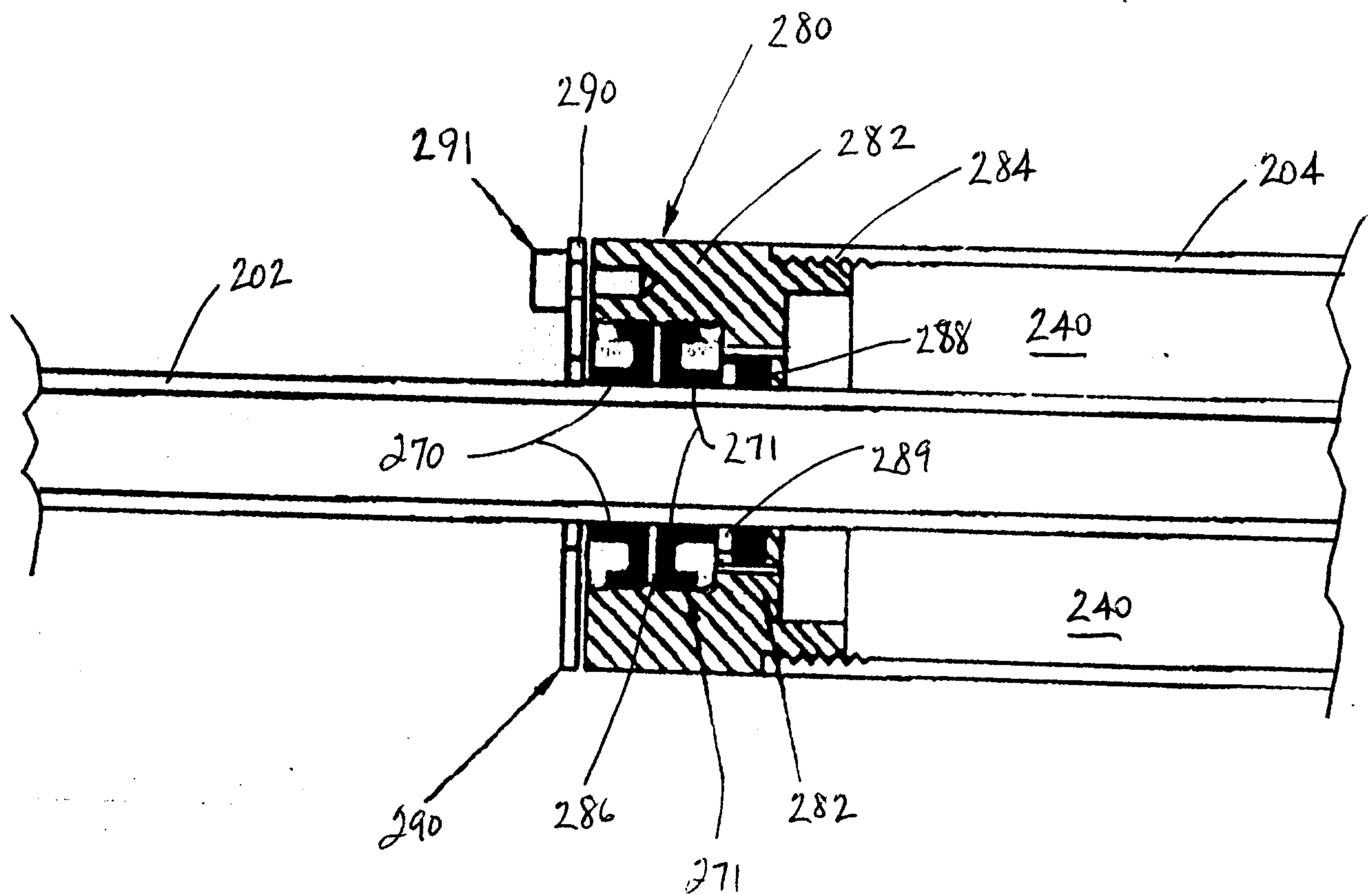


FIGURE 26

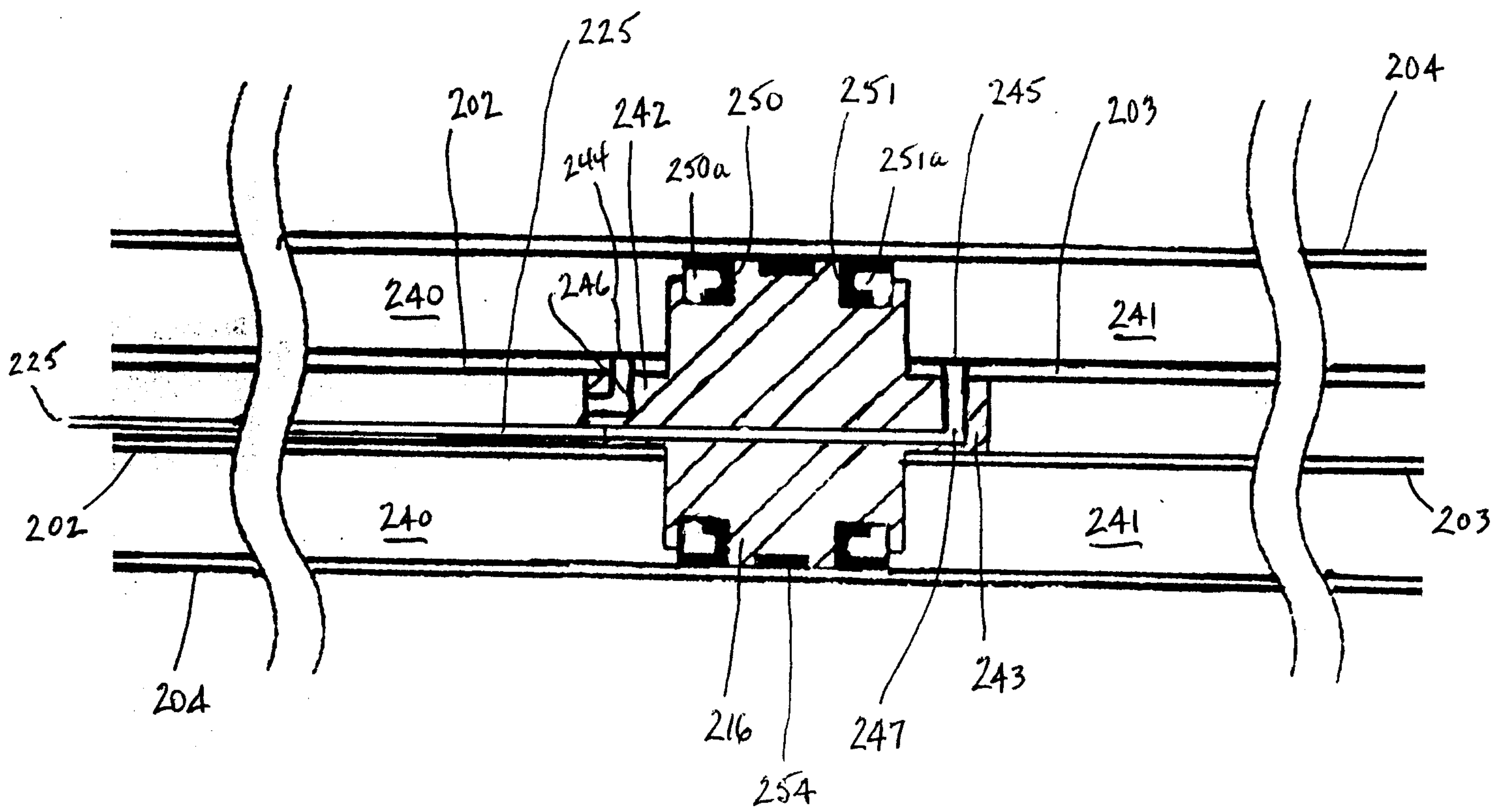


FIGURE 27

