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Maarschalkerweerd

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[54] **FLUID TREATMENT SYSTEM AND PROCESS**

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[*] Notice: This patent is subject to a terminal disclaimer.

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§ 371 Date: **Oct. 17, 1994**

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PCT Pub. Date: **Sep. 15, 1994**

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Issued: **Dec. 31, 1996**
Appl. No.: **08/318,858**
Filed: **Oct. 17, 1994**

U.S. Applications:

[63] Continuation-in-part of application No. 08/026,772, Mar. 5, 1993, Pat. No. 5,418,370.

[51] **Int. Cl.**[7] **B01J 19/12**; C02F 1/32

[52] **U.S. Cl.** **422/186.3**; 422/24; 422/906

[58] **Field of Search** 422/186.3, 24, 422/906

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Primary Examiner—Daniel J. Jenkins
Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper & Scinto

[57] **ABSTRACT**

A fluid treatment system includes one or more radiation sources arranged in an irradiation zone with a treatment zone through which fluid to be treated passes and is irradiated. The radiation zone has a closed cross section to maintain the fluid within a predetermined maximum distance form he radiation source. Preferably, the irradiation zone comprises a reduced cross-sectional area perpendicular to the direction of fluid flow and thus the fluid flow velocity is increased through the irradiation zone.

104 Claims, 8 Drawing Sheets

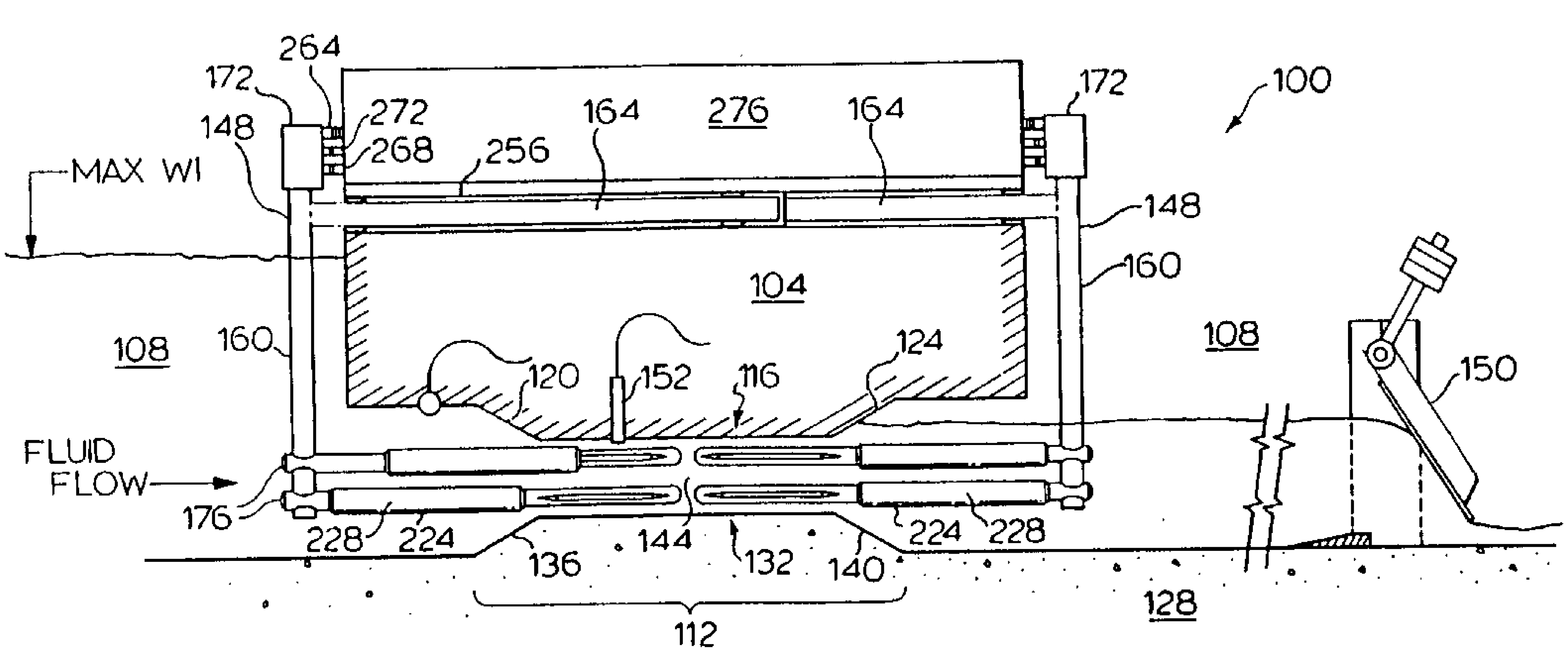

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FIG. 1
PRIOR ART

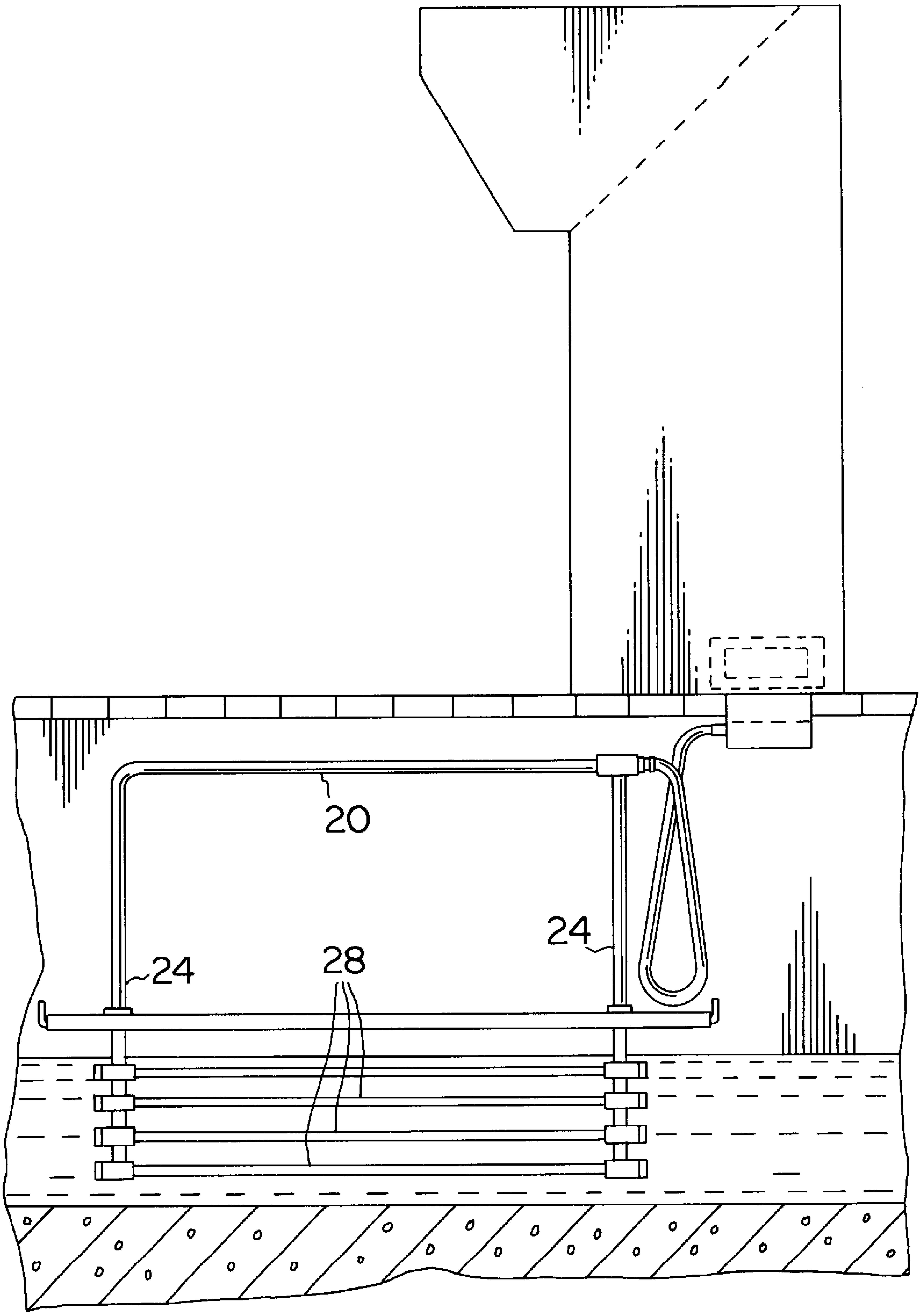


FIG.2
PRIOR ART

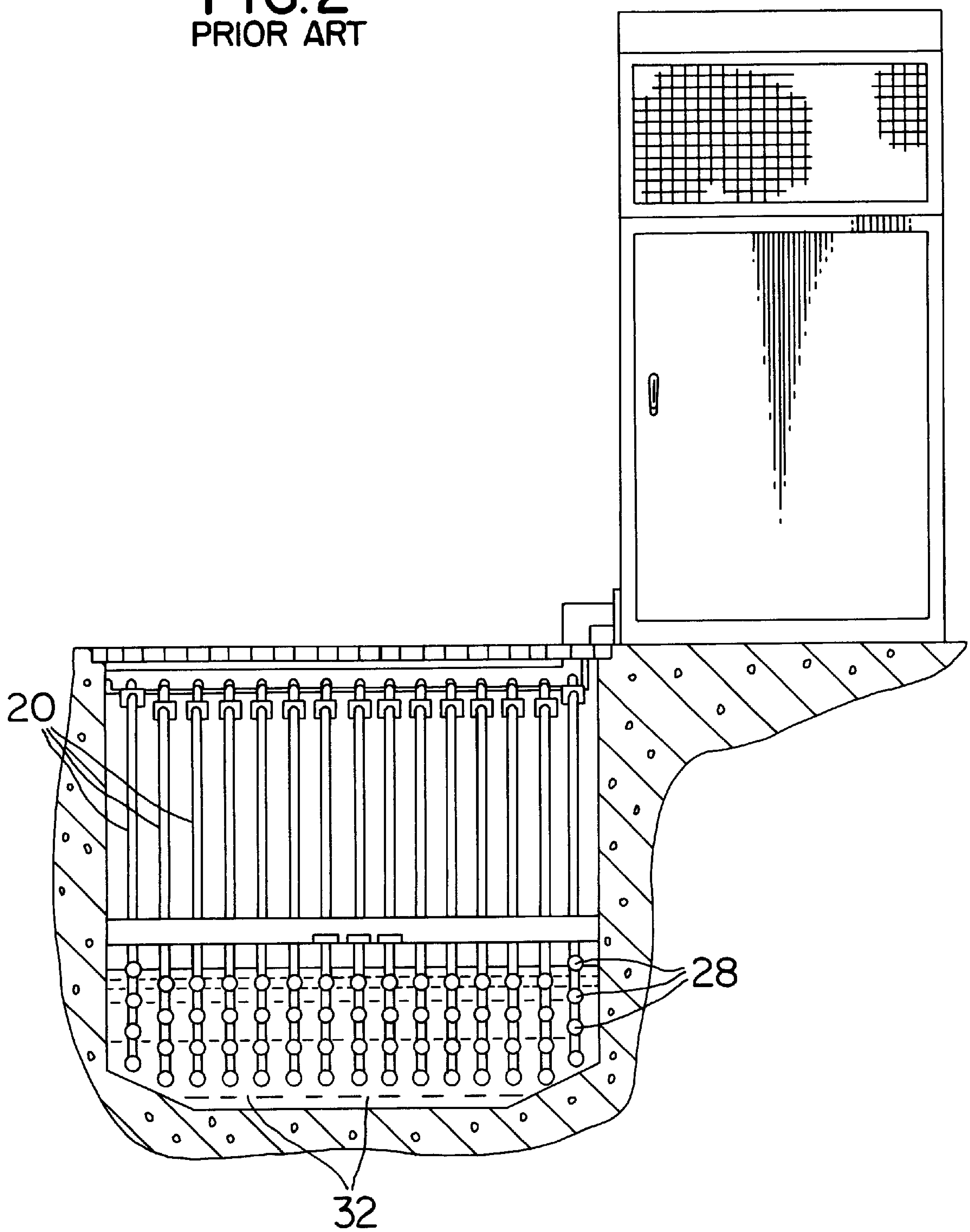
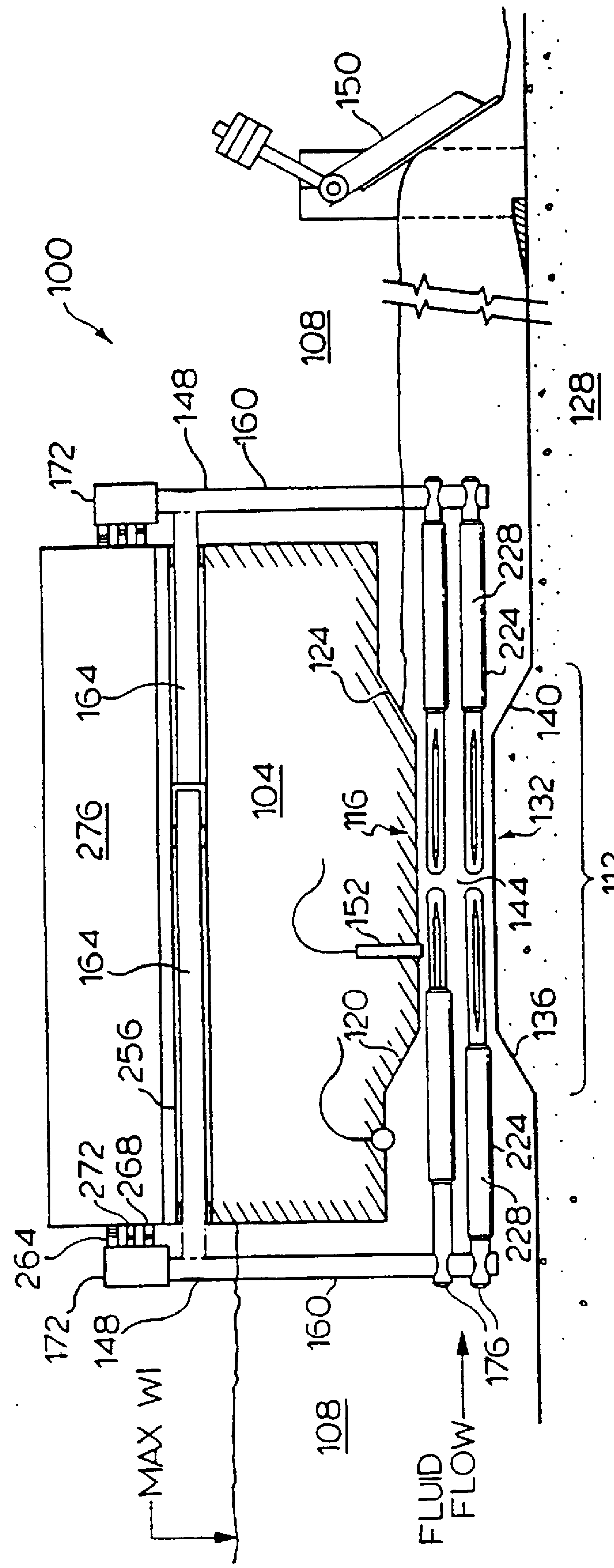


FIG. 3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132
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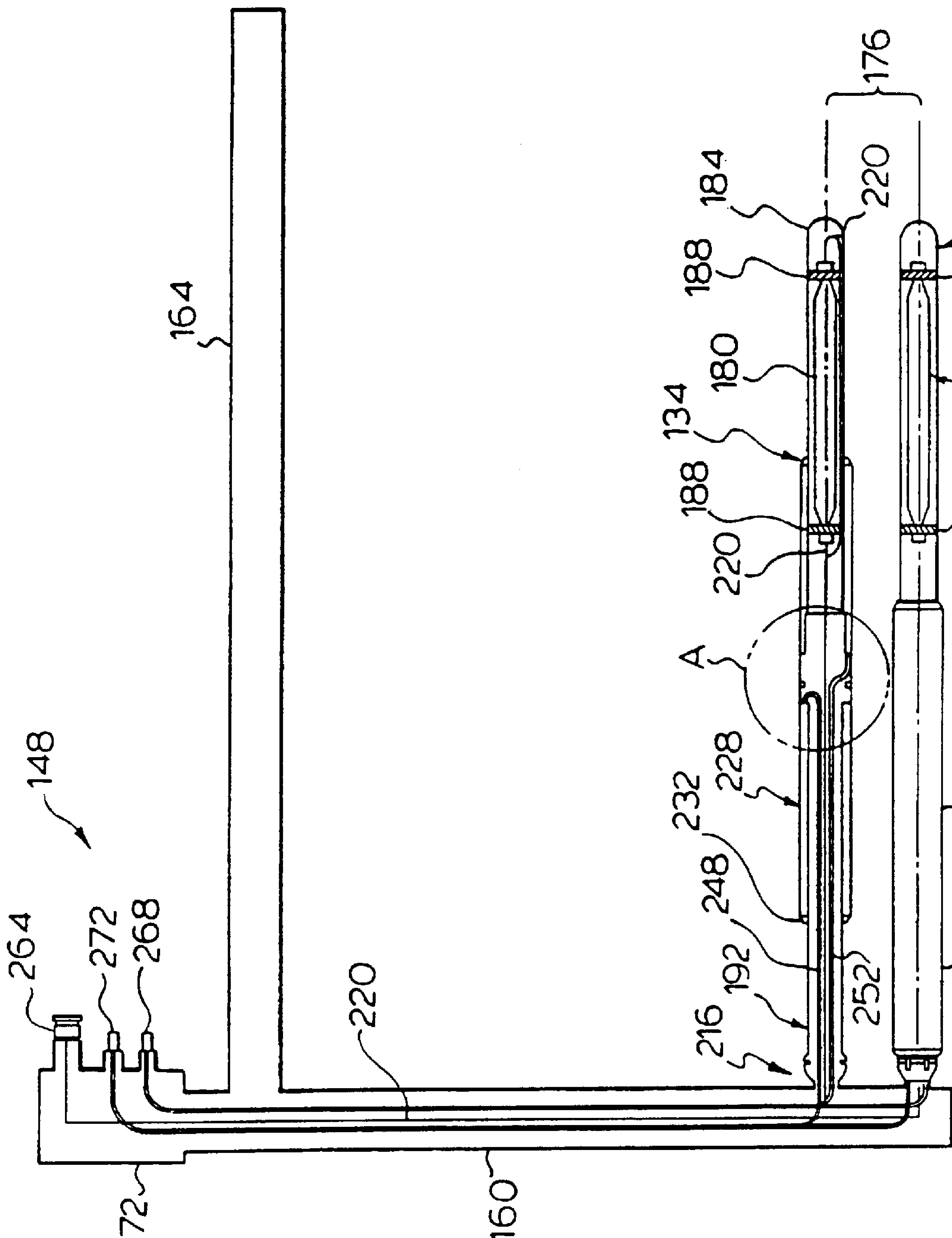
112
176
MAX WI
FLUID FLOW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180
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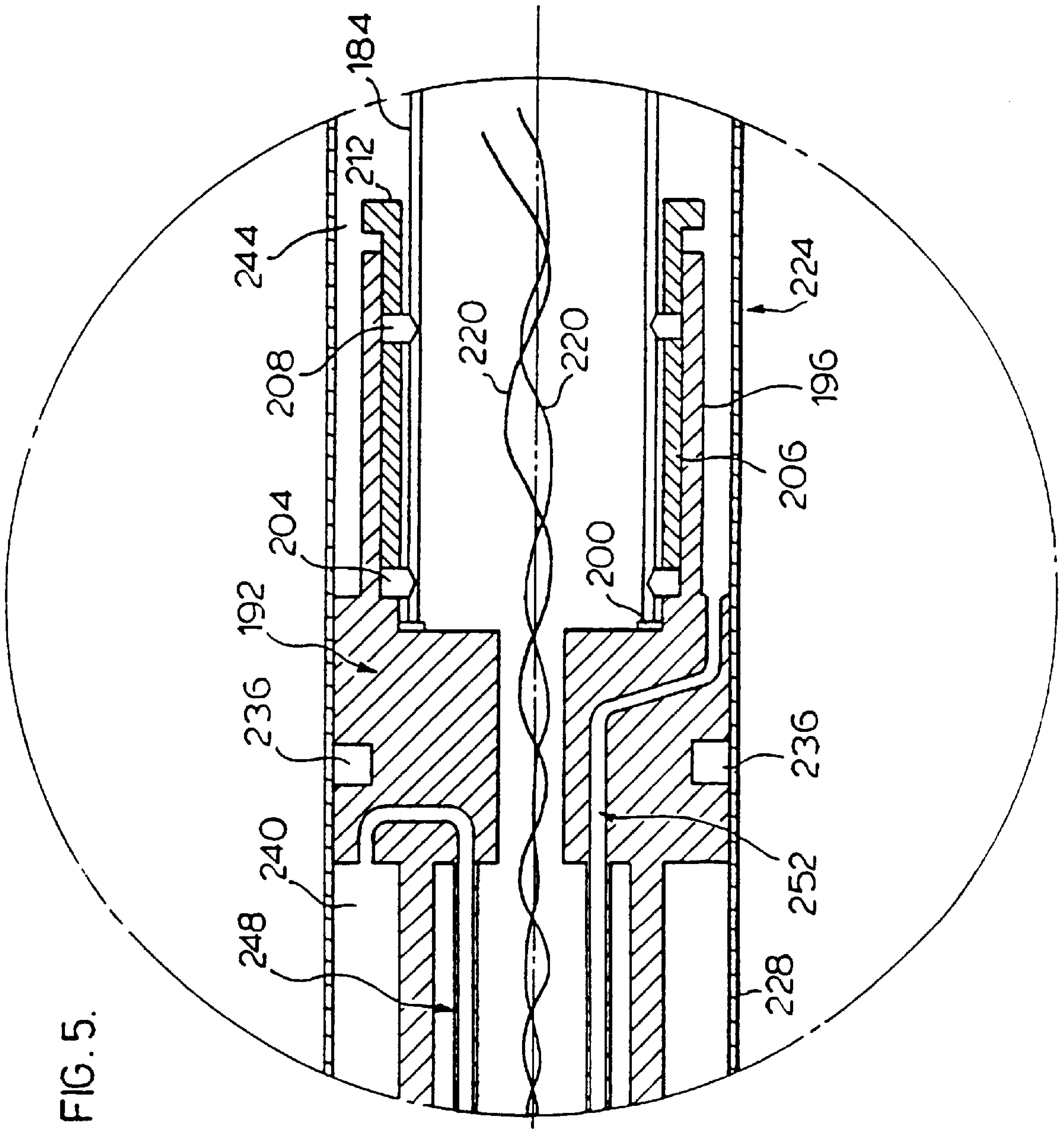
224
228

FIG. 4.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212
244
208
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204
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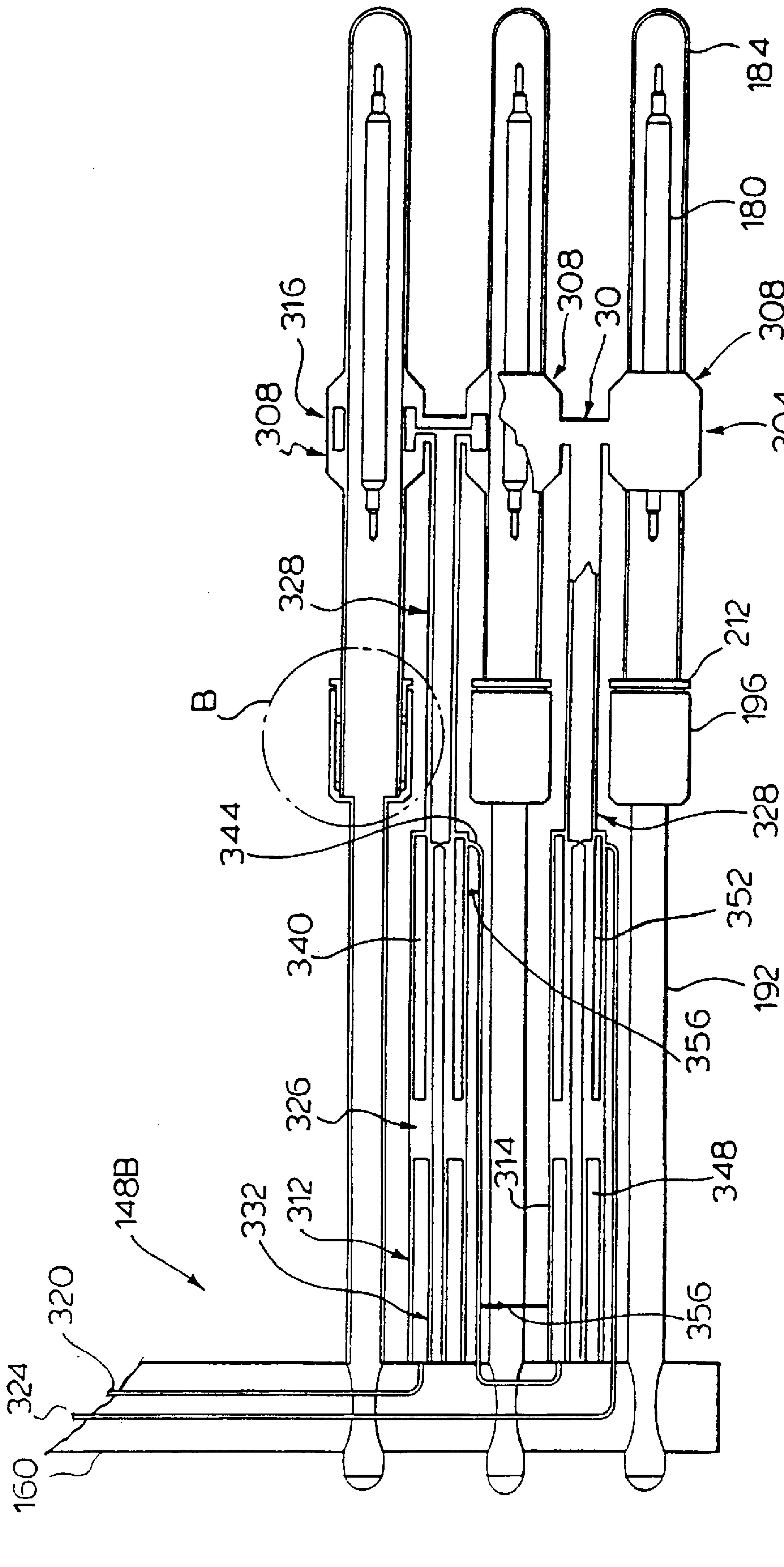
FIG. 5.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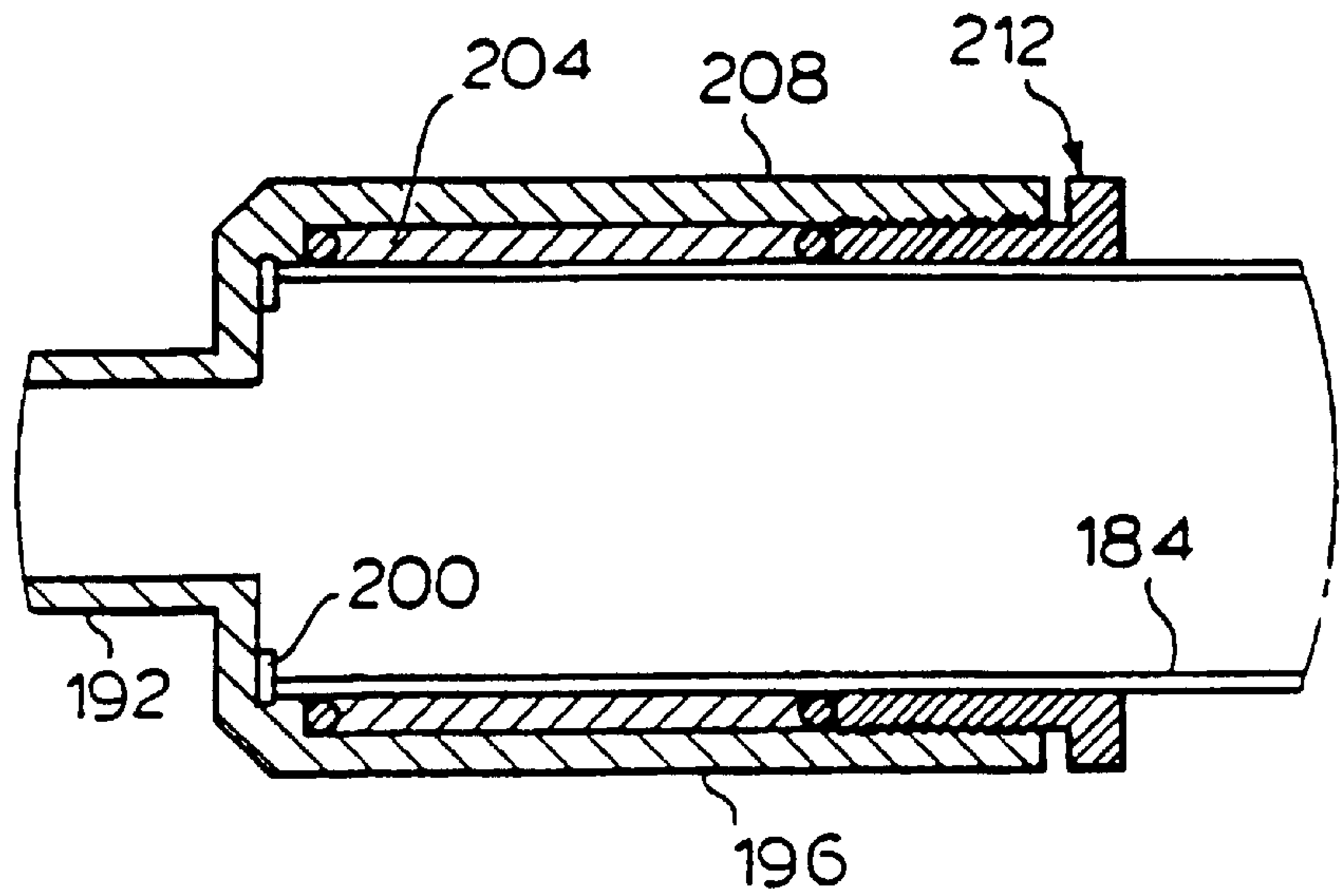
320
324
160

FIG. 6.

FIG. 7.


204
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184
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192
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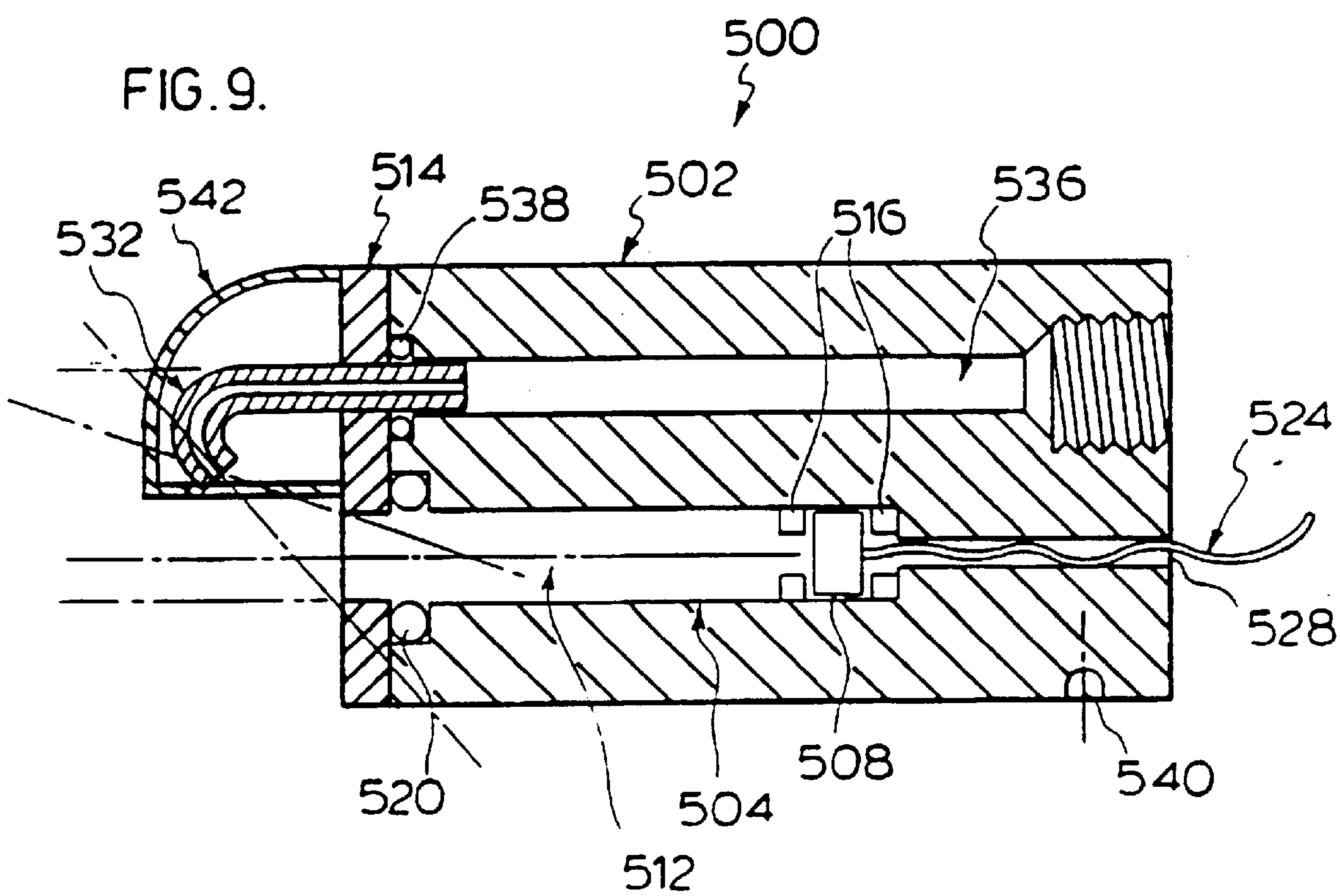
FIG. 9.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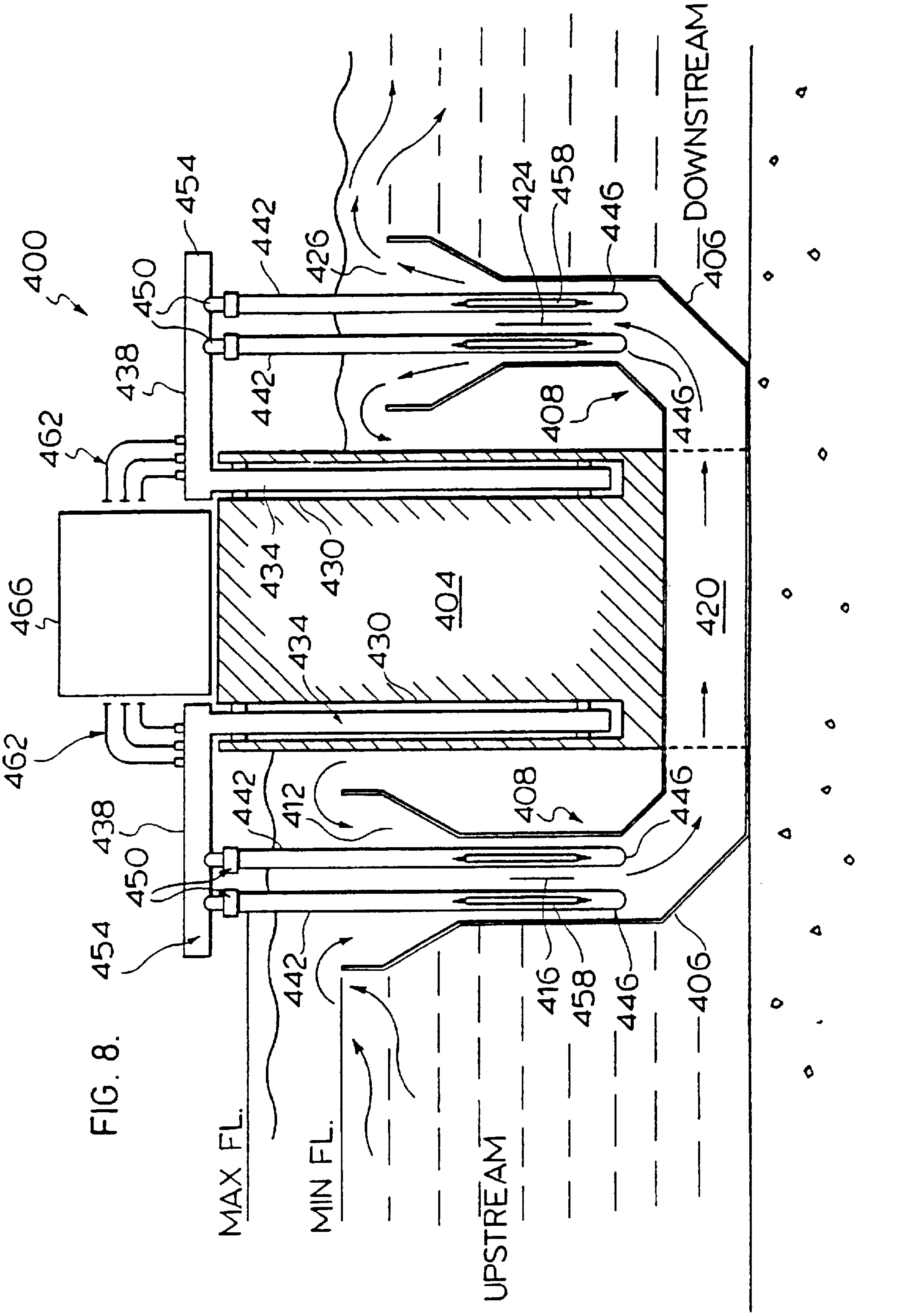
400
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434
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404
420
408
412
416
458
446
406
424
426
MAX FL.
MIN FL.
UPSTREAM
DOWNSTREAM

FIG. 8.

FLUID TREATMENT SYSTEM AND PROCESS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This application is a 371 of PCT/CA94/00125 filed 4 Mar. 1994 an is a continuation-in-part of Ser. No. 08/026,572, filed Mar. 5, 1993, now U.S. Pat. No. 5,418,370.

TECHNICAL FIELD

The present invention relates to a method of treating fluid by providing a gravity fed flow of fluid to an irradiation zone comprising at least one radiation source and having a closed cross-section which confines the flow of fluid within a predefined maximum distance from the at least one radiation source.

The present invention also relates to a novel method of cleaning a radiation source assembly located within a fluid flow wherein the exterior of the source is swept by a cleaning member containing an appropriate cleaning fluid.

The present invention also relates to a novel system for treating fluid by exposing it to radiation. Specifically, the present invention relates to a novel gravity fed system for treating fluids comprising a treatment zone which includes a irradiation zone configured to provide a fixed fluid geometry relative to the radiation sources.

The present invention also relates to a novel radiation source module for use in a fluid treatment system. Specifically, the module includes one or more radiation source assemblies connected to a support member and the support member is designed to permit insertion and extraction of the module from the treatment system while the system is in use. The module is designed such that the radiation source assembly is prevented from contacting surfaces within the treatment zone of the system while being installed or removed.

The present invention also relates to a novel cleaning apparatus for fluid treatment systems. Specifically, the cleaning apparatus includes one or more cleaning members which may be swept over the exterior of radiation source assemblies within the fluid treatment system, the cleaning members containing a suitable cleaning fluid which contacts the exterior of the radiation source assembly and loosens and/or removes materials fouling the exterior of the radiation source assembly.

BACKGROUND ART

Fluid treatment systems are known. For example, U.S. Pat. Nos. 4,482,809, 4,872,980 and 5,006,244 (assigned to the assignee of the present invention), the contents of each of which are hereby incorporated by reference, all describe gravity fed fluid treatment systems which employ ultraviolet (UV) radiation.

Such systems include an array of UV lamp frames which include several UV lamps each of which are mounted within sleeves extending between two support arms of the frames. The frames are immersed into the fluid to be treated which is then irradiated as required. The amount of radiation to which the fluid is exposed is determined by the proximity of the fluid to the lamps, the output wattage of the lamps and the fluid's flow rate past the lamps. One or more UV sensors may be employed to monitor the UV output of the lamps and the fluid level is typically controlled, to some extent, downstream of the treatment device by means of level gates or the like. Since, at higher flow [rams] *rates*, accurate fluid level control is difficult to achieve in gravity fed systems, fluctuations in fluid level are inevitable. Such fluctuations could lead to non-uniform irradiation in the treated fluid.

However, disadvantages exist with the above-described systems. Depending upon the quality of the fluid which is being treated, the sleeves surrounding the UV lamps periodically become fouled with foreign materials, inhibiting their ability to transmit UV radiation to the fluid. When fouled, at intervals which may be determined from historical operating data or by the measurements from the UV sensors, the sleeves must be manually cleaned to remove the fouling materials.

If the UV lamp frames are employed in an open, channel-like system, one or more of the frames may be removed while the system continues to operate, and the removed frames may be immersed in a bath of suitable acidic cleaning solution which is air-agitated to remove fouling materials. Of course, surplus or redundant sources of UV radiation must be provided (usually by including extra UV lamp frames) to ensure adequate irradiation of the fluid being treated while one or more of the frames has been removed for cleaning. Of course, this required surplus UV capacity adds to the expense of installing the treatment system.

Further, a cleaning vessel containing cleaning solution into which UV lamp frames may be placed must also be provided and maintained. Depending upon the number of frames to be cleaned at one time and the frequency at which they require cleaning, this can also significantly add to the expense of installing, maintaining and operating the treatment system.

If the frames are in a closed system, removal of the frames from the fluid for cleaning is usually impractical. In this case, the sleeves must be cleaned by suspending treatment of the fluid, shutting inlet and outlet valves to the treatment enclosure and filling the entire treatment enclosure with the acidic cleaning solution and air-agitating the fluid to remove the fouling materials. Cleaning such closed systems suffers from the disadvantages that the treatment system must be stopped while cleaning proceeds and that a large quantity of cleaning solution must be employed to fill the treatment enclosure. An additional problem exists in that handling large quantities of acidic cleaning fluid is hazardous and disposing of large quantities of used cleaning fluid is difficult and/or expensive. Of course open flow systems suffer from these two problems, albeit to a lesser degree.

Indeed, it is the belief of the present inventor that, once installed, one of the largest maintenance costs associated with prior art fluid treatment systems is often the cost of cleaning of the sleeves about the radiation sources.

Another disadvantage with the above-described prior art systems is the output of the UV lamps. Unfortunately, the UV lamps in the prior art systems were required to be about five feet in length to provide the necessary wattage of UV radiation. Accordingly, the UV lamps were relatively fragile and required support at each end of the lamp. This increased the capital cost of the system.

Further, due to the somewhat limited output wattage of the UV lamps in the prior art systems, a great number of lamps were often required. For example, certain prior art installations employ over 9,000 lamps. Such a high number of lamps adds to the above-mentioned costs in cleaning lamps as well as the cost of maintaining (replacing) the lamps.

DISCLOSURE OF THE INVENTION

It is an object of the present invention to provide a novel method of treating a fluid by irradiation which obviates or mitigates at least one of the above-mentioned disadvantages of the prior art.

It is a further object of the present invention to provide a novel fluid treatment system which obviates or mitigates at least one of the above-mentioned disadvantages of the prior art.

According to one aspect of the present invention, there is provided a method of treating a fluid comprising the steps of:

(i) providing a gravity fed flow of fluid to a fluid inlet;

(ii) feeding the flow of fluid from the fluid inlet to an irradiation zone comprising at least one radiation source and having a closed cross-section;

(iii) confining the flow of fluid within a predefined maximum distance from the at least one radiation source;

(iv) exposing the flow of fluid to radiation from the radiation source; and

(v) feeding the flow of fluid from step (iv) to a fluid outlet.

According to another aspect of the present invention, there is provided a method of removal of fouling materials from a radiation source in situ in a fluid treatment system, comprising the steps of:

(i) providing a supply of a cleaning fluid to a cleaning chamber;

(ii) moving the cleaning chamber into contact with at least a portion of the radiation source for a predetermined time period, the cleaning chamber maintaining the cleaning fluid in contact with the portion; and

(iii) removing the cleaning chamber from contact with the portion of the radiation source after the predetermined time period.

According to another aspect of the present invention, there is provided a gravity fed fluid treatment system comprising a fluid inlet, a fluid outlet, and an irradiation zone disposed between the fluid inlet and fluid outlet, the irradiation zone (i) including at least one radiation source and, (ii) having a closed cross-section to confine fluid to be treated within a predefined maximum distance from the at least one radiation source assembly.

Preferably, the irradiation zone is disposed within a fluid treatment zone including an inlet transition region and an outlet transition region. The inlet transition region receives the fluid flow from the fluid inlet and increases its velocity prior to entry thereof into the irradiation zone. The outlet transition region receives the fluid flow from the irradiation zone and decreases the velocity of the fluid flow prior to its entry into the fluid outlet. Thus, the fluid flow velocity is only elevated within the irradiation zone to reduce hydraulic head loss of the fluid flow through the system. It will be appreciated by those of skill in the art that one or both of the inlet transition region and the outlet transition region may comprise a tapered section (described in more detail hereinbelow). Alternatively, a "bell-mouth" shaped inlet and outlet may be utilized. In either case, the underlying result is a reduction in hydraulic head loss.

According to another aspect of the present invention, there is provided a radiation source module for use in a fluid treatment system comprising: a support member, at least one radiation source assembly extending from said support member; and fastening means to affix the radiation source module in the fluid treatment system.

According to yet another aspect of the present invention, there is provided a cleaning apparatus for a radiation source assembly in a fluid treatment system, comprising: a cleaning sleeve engaging a portion of the exterior said radiation source assembly and movable between a retracted position wherein a first portion of said radiation source is exposed to a flow of fluid to be treated and an extended position wherein said first portion of said radiation source assembly is completely or partially covered by said cleaning sleeve, said cleaning sleeve including a chamber in contact with said first portion of said radiation source assembly and being supplied with a cleaning solution suitable to remove undesired materials from said first portion.

According to another aspect of the invention, there is provided a radiation sensor assembly comprising: a sensor housing; a radiation transmissive means within said housing and including a portion to be exposed to a radiation source; a radiation sensor receiving radiation from said transmissive means; and means to remove materials fouling said portion.

As used herein, the term "gravity fed" encompasses systems wherein the hydraulic head of the fluid is obtained from changes in the altitude of the fluid. It will be understood that such systems comprise both systems which are naturally gravity fed and systems wherein the altitude of the fluid is altered via pumps or other mechanical means to provide a gravity feed.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will be described with reference to the accompanying drawings, in which:

FIG. **1** illustrates a side section of a prior an fluid treatment device;

FIG. **2** illustrates an end section of the prior an fluid treatment device of FIG. **1**;

FIG. **3** illustrates a side section of a first embodiment of a horizontal fluid treatment system in accordance with the present invention;

FIG. **4** illustrates a radiation source module for use with the system of FIG. **3**;

FIG. **5** illustrates an expanded view of the area indicated at A in FIG. **4**;

FIG. **6** illustrates a portion of another embodiment of a radiation source module for use with the system of FIG. **3**;

FIG. **7** illustrates an expanded view of the area indicated at B in FIG. **6**;

FIG. **8** illustrates a side section of a second embodiment of a vertical fluid treatment system in accordance with the present invention; and

FIG. **9** illustrates a radiation sensor assembly.

BEST MODE FOR CARRYING OUT THE INVENTION

For clarity, a brief description of a prior art fluid treatment device will be presented before discussing the present invention. FIGS. **1** and **2** show a prior art treatment device as described in U.S. Pat. No. 4,482,809. The device includes a plurality of radiation source modules **20**, each including a pair of frame legs **24** with UV lamp assemblies **28** extending therebetween. As best shown in FIG. **2**, a plurality of lamp modules **20** are arranged across a treatment canal **32** with a maximum spacing between lamp modules **20** which is designed to ensure that the fluid to be treated is irradiated with at least a predetermined minimum dosage of UV radiation.

While this system has been successful, as discussed above it suffers from disadvantages in that the arrangement of the lamp modules **20** makes maintenance of the device relatively labour intensive. Specifically, replacing lamps or cleaning the sleeves surrounding the lamps is time consuming and expensive. Also, for treatment to continue when a lamp module is removed, it is necessary to provide redundant lamp modules to ensure that the fluid still receives the predefined minimum dosage of radiation increasing the cost of the system. Further, depending on the quality of the fluid and its flow rate, significant numbers of lamps and sleeves may be required per unit of fluid treated. Another disadvantage of this prior art system is the difficulty in controlling fluid level relative to lamp modules **20** at higher flow rates.

Accordingly, while the above-described prior an systems have been successful, the present inventor has been concerned with improving fluid treatment systems to overcome some of these disadvantages. The present invention will now be described with reference to the remaining Figures.

Referring now to FIG. **3**, a fluid treatment system in accordance with the present invention is indicated generally at **100**. The system **100** includes a main body **104** which is installed across an open fluid canal **108** such that the all of the fluid flow through canal **108** is directed through a treatment zone **112**. Main body **104** may be precast concrete, stainless steel or any other material suitable for use with the fluid to be treated and which is resistant to the type of radiation employed.

The lower surface of main body **104** includes a central section **116** which extends downward with leading and trailing inclined sections **120** and **124**, respectively. A corresponding upraised central section **132** is located on a base **128** of canal **108** beneath central section **116** and includes leading and trailing inclined sections **136** and **140**, respectively. Central section **132** may be part of main body **104** or may be part of base **128** (as illustrated).

As can be clearly seen in FIG. **3**, sections **116** and **132** form a narrowed irradiation zone **144**, while sections **120** and **136** form a tapered inlet transition region and sections **124** and **140** form a tapered outlet transition region.

As will be apparent, irradiation zone **144** presents a closed cross-section to the fluid to be treated. This provides a fixed geometry of the fluid relative to irradiation sources (described hereinafter) to ensure that the fluid is exposed to the predefined minimum radiation from the irradiation sources. Those of skill in the art will appreciate that the inner walls of irradiation zone **144** could be designed and configured to substantially follow the contours of the portions of radiation source modules **148** disposed therein in order to maximize treatment efficiency at the farthest points from the radiation source.

At least one of the upstream and downstream faces of main body **104** includes one or more radiation source modules **148** mounted thereto. Depending on the fluid to be treated, the number of modules **148** provided may be varied from a single upstream module **148** to two or more modules **148** across both the upstream and downstream faces of main body **104**.

Preferably, main body **104** further includes a radiation sensor **152** which extends into irradiation zone **144** and a fluid level sensor **156** which monitors the level of fluid in the inlet side of treatment zone **112**. As is known to those of skill in the art, if the level of fluid in the system falls below fluid level sensor **156**, an alarm or shutdown of the radiation sources will occur, as appropriate. A standard fluid levelling gate **150** is also provided downstream of main body **104** to maintain a minimum fluid level in treatment zone **112**.

As best shown in FIGS. **4** and **5**, each radiation source module **148** includes a radiation source support leg **160**, a horizontal support and guide member **164** (optional), a connector box **172** and one or more radiation source assemblies **176** adjacent the lower extremity of support leg **160**. Each radiation source assembly **176** includes a high intensity radiation source **180** which is mounted within a hollow sleeve **184** by two annular inserts **188**. Of course, it will be apparent to those of skill in the art that in some circumstances radiation sources assemblies **176** will not require a sleeve and radiation source **180** may be placed directly in the fluid to be treated.

Each sleeve **184** is closed at the end distal support leg **160** and is hermetically joined to a mounting tube **192** connected to support leg **160**. The hermetic seal between sleeve **184** and mounting tube **192** is accomplished by inserting the open end of sleeve **184** into a mount **196** which is hermetically fastened to the end of mounting tube **192**. A rubber washer-type stopper **200** is provided at the base of mount **196** to prevent sleeve **184** from breaking due to it directly contacting housing **196** as it is inserted. A pair of O-ring seals **204**, **208** are placed about the exterior of sleeve **184** with an annular spacer **206** between them.

After sleeve **184**, O-ring seals **204**, **208** and annular spacer **206** are inserted into mount **196**, an annular threaded screw **212** is placed about the exterior of sleeve **184** and is pressed into contact with mount **196**. The threads on screw **212** engage complementary threads on the interior of mount **196** and screw **212** is tightened to compress rubber stopper **200** and O-ring seals **204** and **208**, thus providing the desired hermetic seal.

The opposite end of each mounting tube **192** is also threaded and is mated to a screw mount **216** which is in turn welded to support leg **160**. The connections between mounting tube **192** and screw mount **216** and between screw mount **216** and support leg **160** are also hermetic thus preventing the ingress of fluid into the hollow interior of mounting tube **192** or support leg **160**.

Each radiation source **180** is connected between a pair of electrical supply conductors **220** which run from connector box **172** to radiation source **180** through the inside of support leg **160** and mounting tube **192**.

As best shown in FIGS. **4** and **5**, a cleaning assembly **224** is also included on each radiation source assembly **176** and mounting tube **192**. Each cleaning assembly **224** comprises a cylindrical sleeve **228** which acts as a double-action cylinder. Cylindrical sleeve **228** includes an annular seal **232**, **234** at each end of the sleeve. Seal **232**, which is adjacent support leg **160**, engages the exterior surface of mounting tube **192** while seal **234**, which is distal support leg **160**, engages the exterior surface of radiation source assemblies **176**.

The exterior of mount **196** includes a groove in which an O-ring seal **236** is placed. O-ring seal **236** engages the inner surface of cylindrical sleeve **228** and divides the interior of cylindrical sleeve **228** into two chambers **240** and **244**. Chamber **240** is connected to conduit **248** and chamber **244** is connected to conduit **252**. Each of conduits **248** and **252** run from connector box **172**, through the interior of support leg **160** and through the interior of mounting tube **192**, to mount **196** where they connect to chambers **240** and **244**, respectively.

As will be readily understood by those of skill in the art, by supplying pressurized hydraulic oil, air or any suitable fluid to chamber **240** through conduit **248**, cylindrical sleeve **228** will be urged toward support leg **160** and will force fluid out of chamber **244** and into conduit **252**. Similarly, by supplying pressurized fluid to chamber **244** through conduit **252**, cylindrical sleeve **228** will be urged toward sleeve **184** and will force fluid out of chamber **240** and into conduit **248**.

Conduit **252** is connected to a supply of an appropriate cleaning solution, such as an acidic solution, and conduit **248** is connected to a supply of any suitable fluid, such as air. Thus, when it is desired to clean the exterior of sleeve **184**, pressurized cleaning solution is supplied to chamber **244** while fluid is removed from chamber **240**. Cylindrical sleeve **228** is thus forced to an extended position distal from support leg **160** and, as cylindrical sleeve **228** moves to its extended position, seal **234** could also sweep loose foreign materials from sleeve **184**.

When the cylindrical sleeve **228** is in its extended position, the cleaning solution in chamber **244** is brought into contact with the exterior of radiation assemblies **176**, which forms the interior wall of chamber **244**, and the cleaning solution chemically decomposes and/or removes the remaining foreign materials which are fouling radiation assemblies **176**. After a preselected cleaning period, fluid is forced into chamber **240**, the pressure on the cleaning solution is removed from chamber **244** thus forcing cylindrical sleeve **228** to a retracted position adjacent support leg **160**. As cylindrical sleeve **228** is retracted, seal **234** again could sweep loosened foreign materials from the surface of radiation assemblies **176**.

As will be understood by those of skill in the art, the above-described cleaning assembly **224** may be operated on a regular timed interval, for example once a day or, where the quality of the fluid being treated varies, in response to variations in the readings obtained from radiation sensor **152**.

Each radiation source module **148** can be mounted to main body **104** by horizontal support member **164** which has a predefined cross-sectional shape and which is received in a complementary-shaped bore **256** in main body **104**. The predefined shape is selected to allow easy insertion of horizontal support member **164** into bore **256** while preventing rotation of horizontal support member **164** within bore **256**.

As can been seen in FIGS. **3** and **4**, the length of horizontal support member **164** is selected such that horizontal support member **164** extends from support leg **160** to a greater extent than does radiation source assembly **176**. In this manner, radiation source assembly **176** is maintained well clear of the inlet or outlet transition regions as the radiation source module **148** is being installed. This arrangement mimimizes the possibility of damage occurring to the radiation source assembly **176** from impacting it against other objects while installing radiation source module **148** and this is especially true if fluid is flowing through system **100**. Due to the resulting required length of horizontal supports **164**, bores **256** are horizontally staggered on opposite faces of main body **104**.

When horizontal support member **164** is fully seated within bore **256**, electrical power connectors **264**, cleaning solution connectors **268** and fluid connectors **272** on connection box **172** are brought into engagement with complementary connectors on an enclosure **276**. The engagement of connectors **264** and **272** with the complementary connectors on enclosure **276** also serves to maintain horizontal support member **164** within bore **256**. Enclosure **276** may conveniently contain ballasts to supply electrical power for radiation sources **180** and pumps and storage vessels (not shown) for cleaning fluid and pressurized fluid for cleaning assemblies **224**.

Recent improvements in radiation source technology have now made radiation sources of greater intensity available and devices which are filamentless are available. In comparison, prior art UV lamps employed in fluid treatment systems had rated outputs in the order of 1 watt per inch and were five feet in length.

As these greater intensity radiation sources emit more radiation, fewer radiation sources are needed to treat a given amount of fluid. As is known to those of skill in the art, the dosage of radiation received by the fluid is the product of the radiation intensity and the exposure time. The intensity of the radiation varies with the square of the distance the radiation passes through, but the exposure time varies linearly with the fluid flow velocity. Accordingly, it is desired to maintain the fluid to be treated as close as possible to the radiation sources. This requires either many low intensity radiation sources arranged within a large treatment area or fewer high intensity radiation sources arranged within a smaller treatment area For reasons of efficiency, minimizing expense and for mitigating the above-mentioned requirement of accurately controlling fluid level, the latter alternative has been adopted by the present inventor as described above. Irradiation zone **144** is designed to present a closed cross-section to the fluid flow thereby ensuring that the fluid to be treated passes within a predetermined maximum distance of a minimum number of high intensity radiation sources **180**. The flow rate of fluid through irradiation zone **144** can be increased so that an acceptable rate of fluid treatment is maintained with a minimum number of high intensity radiation sources.

Thus, the present system has been designed to minimize the size of irradiation zone **144** while elevating the fluid flow velocity to obtain the desired rate of treatment. Thus, the flow rate through irradiation zone **144** is higher than in prior an treatment devices which are typically designed to operate at flow rates of 2 feet per second or less. In contrast, the present system may be operated at a flow rate through irradiation zone **144** of up to 12 feet per second.

As is known to those of skill in the art, pressure head losses through a fluid conduit are a function of the square of the fluid flow velocity. Thus, high flow velocities result in increased head loss and may result in unacceptable fluctuations in the fluid level in the treatment system. Accordingly, the present system may be provided with inlets and outlets having large cross-sections to minimize head losses and to facilitate insertion and removal of radiation source modules as will be discussed below. The actual irradiation zone **144** is a relatively short length of reduced cross-section and is connected to the inlets and outlets by respective transition regions. In this manner, a desired relatively high flow rate through the irradiation zone **144** may be accomplished and hydraulic head losses minimized.

Other advantages provided by the present invention include simplified maintenance, as the radiation source assemblies may be cleaned of fouling materials in situ, and relatively easy removal of radiation source modules for maintenance or radiation source replacement. Further, the capability of in situ cleaning minimizes or eliminates the requirement for otherwise redundant radiation sources to be provided to replace those removed for cleaning and it is contemplated that the elevated velocity of the fluid through the irradiation zone will reduce the mount of fouling materials which adhere to the radiation sources.

Another embodiment of a radiation source module **148**B and a cleaning assembly **300** is shown in FIGS. **6** and **7** wherein like components of the previous embodiment are identified with like reference numerals. As most clearly shown in FIG. **7**, sleeve **184** is hermetically scaled to mounting tube **192** at housing **196** in a manner very similar to the embodiment shown in FIG. **5**. However, in this embodiment cleaning assembly **300** comprises a web **304** of cleaning rings **308** and a pair of double-action cylinders **312,314**. Each cleaning ring **308** includes an annular chamber **316** adjacent the surface of sleeve **184** and cleaning rings **308** are swept over sleeves **184** by the movement of cylinders **312,314** between retracted and extended positions.

As with the embodiment shown in FIG. **4**, conduits **320** and **324** run from connector box **172** (not shown) through support leg **160** to cylinders **312** and **314** respectively. When fluid is supplied under pressure through conduit **320** to cylinder **312**, the cylinder's piston rod **328** is forced out to its extended position. As will be understood by those of skill in the art, as piston rod **328** is extended by the supply of fluid to the chamber **332** on one side of the piston **336**, fluid is forced out of the chamber **340** on the second side of the piston **336** and passes through connector link **344** to chamber **348** of cylinder **314** forcing its piston rod **328** to also extend and the fluid in chamber **352** to be forced into conduit **324**.

In order to ensure that piston rods **328** travel synchronously, cylinders **312** and **314** are designed such that the volume of fluid displaced per unit of stroke of piston **336** in cylinder **312** is equal to the volume of fluid received per unit of stroke of piston **336** in cylinder **314**. As will be understood by those of skill in the art, this is accomplished by selecting appropriate diameters for each of the two cylinders or the cylinder rods. As will be further understood by those of skill in the art, an one way compensator valve **356** is employed at the end of the extended stroke of the pistons **336** to further compensate for the any difference in the total volume of fluid which may result between chambers **332** and **352** and between chambers **348** and **340**.

In a similar fashion, to retract piston rods **328**, pressurized fluid is supplied to conduit **324** and a second compensator valve **356** is employed to compensate for the any difference in the total volume of fluid which may result between chambers **332** and **352** and between chambers **348** and **340** at the end of the retraction stroke.

It is contemplated that annular chambers **316** will be filled with a predetermined quantity of suitable cleaning fluid which could be changed at appropriate maintenance intervals, such as when servicing the radiation sources. Alternatively, annular chambers **316** could be supplied with cleaning solution via conduits run through the hollow center of piston rods **328**. Another alternative is to provide annular chambers **316** in a sealed configuration to contain cleaning fluid which can be replaced when necessary. Further, the cleaning solution could be circulated through hollow piston rods **328**, chamber **332** and annular chambers **316**. By providing appropriate baffling means (not shown) within annular chambers **316**, the cleaning fluid could enter through the lowermost hollow piston rod **328**, circulate through cleaning rings **308** and exit through uppermost hollow piston rod **328**.

While FIGS. **4**, **5** and **6** illustrate specific embodiments of the aspect of the invention relating to cleaning apparatus for a radiation source assembly, other designs will be apparent to those of skill in the an without departing from the spirit of the invention.

For example, it is possible to employ a single, double-action cylinder in combination with a hollow cylinder rod that is very rigidly mounted through its cylinder rods on a plurality (e.g. 2 or 4) of cleaning rings **308**. Further, it is possible to pump cleaning fluid (e.g. water) through hollow piston rods toward and into annular chambers **316** while moving the cylinder back and forth. If annular chambers **316** were outfit with suitable spray nozzles or the like, it would possible to apply a spray or jet stream across the surface of the irradiation chamber thereby facilitating cleaning of sleeve **184** of the radiation source.

Another design modification involves prefilling annular chambers **316** with a suitable cleaning fluid and modifying the chambers to provide a closed wiping assembly. This would allow for the use of various translation means to move the annular chambers **316** back and forth over sleeve **184** of the radiation source. For example, it is possible to utilize a double-acting, single cylinder that merely translates annular chambers **316** back and forth over sleeve **184** of radiation source. Of course it will be apparent to those of skill in the art that the annular chambers should be mounted rigidly to the translation means to avoid jamming of the entire assembly resulting in damage to sleeve **184**.

As will be further apparent to those skilled in the art, in the embodiments described above, it is possible to reverse relative movement between the radiation source and the cleaning mechanism. Thus, the cleaning mechanism could be mounted rigidly with the treatment zone in the present or any other system, and the radiation source would be translated back and forth with respect thereto.

Another preferred embodiment of the present invention is shown in FIG. **8**. In this embodiment a treatment system **400** includes a main body **404** with a lower surface which, with a base wall **406**, defines a treatment zone **408**. Treatment zone **408** comprises an inlet transition region **412**, a first irradiation zone **416**, an intermediate zone **420**, a second irradiation zone **424** and a tapered outlet zone **426**. As is apparent from the Figure, outlet zone **426** is lower than inlet zone **412** to provide some additional hydraulic head to the fluid being treated to offset that lost as the fluid flows through the treatment system. It will be apparent to those of skill in the art that, in this configuration, the requirement for level controlling gates and the like is removed as the treatment zone **408** also performs this function through the positioning of its inlet and outlet.

Main body **404** could also include bores **430** to receive vertical support members **434** of radiation source modules **438**. Radiation source modules **438** are similar to the above described radiation source modules **148** but are configured for vertical positioning of the radiation source assemblies **442**. Radiation source assemblies **442** include sleeves **446** which are connected to mount stubs **450**. Of course, as mentioned above, it will be understood that in some circumstances the radiation source assemblies **442** will not require a sleeve and may instead be placed directly in the fluid to be treated.

As mount stubs **450** are located above the maximum level of fluid in treatment system **400**, the connection to sleeves **446** need not be hermetically sealed and may be accomplished in any convenient fashion. Of course, as the connection point between sleeves and mount stubs **450** is above the level of fluid within the system, the interior of sleeves **446** will not be exposed to fluid.

Mount stubs **450** are in turn connected to support arms **454** which are attached to vertical support members **434**. Radiation sources **458** are located within sleeves **446** and are connected between electrical supply lines (not shown) which are run from connectors **462**, through hollow support arms **454** and mount stubs **450** and into sleeve **446**. Connectors **462** connect with complementary connectors on enclosure **466** which may include a suitable power supply and/or control means for proper operation of the radiation sources **180** and cleaning supply systems, if installed.

In this embodiment, service of on source modules **438** is accomplished by lifting the radiation source modules **438** vertically to remove them from the fluid flow. While not illustrated in FIG. **8**, it is contemplated that in some circumstances the cleaning assemblies described above will be desired and it will be apparent to those of skill in the art that either of the cleaning assembly embodiments described herein, or their equivalents, can be favourably employed with this embodiment of the present invention. Alternatively, it is contemplated that when the sleeves **446** require cleaning, a radiation source module may simply be removed by lifting it vertically.

As described above, fluid treatment systems typically include a radiation sensor **152** to monitor the intensity of radiation within an irradiation zone. These sensors include a radiation transmissive window behind which the sensor proper is mounted and the window is inserted into the fluid flow. Of course, as with radiation source assemblies **176** (**442**), this window becomes fouled over time.

FIG. **9** illustrates radiation sensor assembly **500** in accordance with another aspect of the present invention. Sensor assembly **500** includes a cylindrical body **502** in which a bore **504** is formed. A radiation sensor element **508** is located at the interior wall of bore **504** adjacent to a rod **512** which is radiation transmissive and which extends from a front face plate **514** attached to body **502**. Sensor element **508** is hermetically sealed from fluid by O-rings **516** which are adjacent sensor element **508** and by O-ring **520** which surrounds rod **512** at the connection point between front face plate **514** and body **502**. The electrical leads **524** from sensor element **508** exit the rear of body **502** through bore **528**.

Since the exposed end of rod **512** will become fouled over time, face plate **514** also includes a cleaning jet **532**. Cleaning jet **532** is hermetically connected to bore **536** with O-ring **538**, through body **502**, which is in turn connected to a supply of pressurized cleaning fluid (not shown) such as an acidic solution, water or air.

When pressurized cleaning fluid is pumped applied to bore **536**, cleaning jet **532** directs the cleaning fluid onto the exposed surfaces of rod **512** to remove fouling materials. To prevent damage to cleaning jet **532**, rod **512** and to streamline fluid flow, a shroud is also provided.

Radiation sensor assembly **500** may be mounted in a sleeve connected to the treatment zone of a fluid treatment system as will be apparent to those of skill in the art. Radiation sensor assembly **500** can be maintained within such a sleeve by a set screw (not shown) which is received in keyway **540**. Of course, as is known by those of skill in the art, for accurate results it is desired that rod **512** be orientated substantially perpendicular to the radiation sources **180** being monitored.

It is contemplated that in normal use, radiation sensor assembly **500** will be cleaned by supplying a predetermined amount of cleaning solution or water at predefined time intervals, to cleaning jet **532**.

It should be understood that, while exemplary embodiments of the present invention have been described herein, the present invention is not limited to these exemplary embodiments and that variations and other alternatives may occur to those of skill in the art without departing from the intended scope of the invention as defined by the attached claims.

What is claimed is:

1. A gravity fed fluid treatment system comprising a fluid inlet, a fluid outlet, an irradiation zone disposed between the fluid inlet and fluid outlet, and at least one radiation source assembly comprising at least one radiation source and a support therefor, the at least one radiation source being elongate and having a longitudinal axis substantially parallel to the direction of fluid flow through the irradiation zone and being fully submersed in fluid flow through the irradiation zone, the support being disposed upstream or downstream of the irradiation zone, the irradiation zone having a closed cross-section to confine fluid to be treated within a predefined maximum distance from the at least one radiation source, said closed cross-section being less than a cross-section of said fluid inlet.

2. A system according to claim **1**, wherein said support has a longitudinal axis which is disposed in the fluid inlet substantially perpendicular to the fluid flow.

3. A fluid treatment system according to claim **1** wherein the cross-sectional area of said irradiation zone is less than the cross-sectional area of said fluid inlet and the cross-sectional area of said fluid outlet.

4. A fluid treatment system according to claim **3** wherein the cross-sectional area of said irradiation zone is less than the cross-sectional area of the fluid inlet and said irradiation zone is disposed in a treatment zone including a transition region connecting said fluid inlet to said irradiation zone, said transition region reducing pressure loss in said fluid between said inlet and said irradiation zone.

5. A fluid treatment system according to claim **3** wherein the cross-sectional area of said irradiation zone is less than the cross-sectional area of the fluid outlet and said irradiation zone is disposed in a treatment zone including a transition region connecting said fluid outlet to said irradiation zone, said transition region reducing pressure loss in said fluid between said outlet and said irradiation zone.

6. A fluid treatment system according to claim **2** wherein the cross-sectional area of said irradiation zone is less than the cross-sectional areas of said fluid inlet and said fluid outlet, said irradiation zone being disposed in a treatment zone including first and second transition regions, said first transition region connecting said fluid inlet to said irradiation zone and said second transition region connecting said irradiation zone to said fluid outlet, said first and second transition regions reducing pressure loss in said fluid between said fluid inlet and said irradiation zone and between said irradiation zone and said fluid outlet, respectively.

7. A fluid treatment system according to claim **6** wherein said at least one radiation source assembly comprises at least one ultraviolet lamp and a support therefor.

8. A fluid treatment system according to claim **7** wherein said *at least one* radiation source assembly includes a sleeve about a portion of the exterior of each **[**of**]** said at least one ultraviolet lamp.

9. A fluid treatment system according to claim **[6]** *1* wherein said longitudinal axis is substantially vertical and said **[**first transition region**]** *system* alters a substantially horizontal fluid flow through said fluid inlet to a substantially vertical fluid flow through said irradiation zone.

10. A fluid treatment system according to claim **9** wherein said **[**second transition region**]** *system* alters said substantially vertical fluid flow through said **[**first**]** irradiation zone to a substantially horizontal fluid flow through said fluid outlet.

11. A fluid treatment system according to claim **7**, wherein said longitudinal axis *of said at least one radiation source* is substantially horizontal.

12. A fluid treatment system according to claim **1** further including cleaning means to remove undesired materials from the exterior of said at least one radiation source assembly.

13. A fluid treatment system according to claim **12**, wherein said cleaning means comprises a cleaning sleeve surrounding said at least one radiation source assembly, said cleaning sleeve being movable between a retracted position wherein a first portion of said at least one radiation source assembly is exposed to said fluid flow and an extended position wherein said first portion of said at least one radiation source *assembly* is covered by said cleaning sleeve.

14. A fluid treatment system according to claim **13** wherein said cleaning sleeve includes a chamber surrounding and in contact with the exterior of said at least one radiation source assembly, said chamber being supplied with a cleaning solution suitable to remove undesired materials from the exterior of said at least one radiation source assembly.

15. A fluid treatment system according to claim **14** wherein said cleaning sleeve includes a seal between the exterior surface of said at least one radiation source assembly and said cleaning sleeve, said seal removing a portion of said undesired materials from the exterior of said at least one radiation source assembly when said cleaning sleeve is moved between said retracted and extended positions.

16. A fluid treatment system according to claim **14** wherein said supply of said cleaning solution is pressurized to said cleaning sleeve and said cleaning sleeve is extended to said extended position by said pressure.

17. A fluid treatment system according to claim **16** wherein said cleaning sleeve is retracted to said retracted position by the removal of said pressurized cleaning solution from said cleaning sleeve.

18. A fluid treatment system according to claim **6** including a first radiation source assembly located upstream of and extending into said irradiation zone and a second radiation source assembly located downstream of and extending into said irradiation zone.

19. A radiation source module for use in a fluid treatment system comprising:

a first support member;

at least one radiation source assembly extending from said first support member; and

a second support member extending from said first support member,

wherein said at least one radiation source assembly extends from said first support member substantially parallel to said second member, said second support member extending from said first support member and having a free end to affix the radiation source module in the fluid treatment system.

20. A radiation source module according to claim **19** wherein said second support member extends from said first support member to a greater extent than said at least one radiation source assembly.

21. A radiation source module according to claim **19** wherein said at least one radiation source assembly comprises an ultraviolet source.

22. A radiation source module according to claim **[20]** *21* wherein said radiation source assembly further comprises a sleeve about said ultraviolet source to provide an insulating gap between said ultraviolet source and fluid passing therearound.

23. A radiation source module according to claim **19** wherein said *first* support member includes conduit means through which an electrical power supply is provided to said radiation source assembly.

24. A radiation source module according to claim **21** wherein at least two of said ultraviolet sources are connected to each first support member.

25. A cleaning apparatus for a radiation source assembly in a fluid treatment system, comprising:

a cleaning sleeve engaging a portion of the exterior said radiation source assembly and movable between a retracted position wherein a first portion of said radiation source is exposed to a flow of fluid to be treated and an extended position wherein said first portion of said radiation source assembly is completely or partially covered by said cleaning sleeve, said cleaning sleeve including a chamber in contact with said first portion of said radiation source assembly and being supplied with a cleaning solution suitable to remove undesired materials from said first portion.

26. A cleaning apparatus according to claim **25** further comprising at least one seal between the exterior surface of said radiation source assembly and said cleaning sleeve, said at least one seal removing a portion of said undesired materials from the exterior of said radiation source assembly when said cleaning sleeve is moved between said retracted and extended positions.

27. A cleaning apparatus according to claim **25** wherein said supply of said cleaning solution is pressurized to said cleaning sleeve.

28. A cleaning apparatus according to claim **27** wherein said cleaning sleeve is retracted to said retracted position by the removal of said pressurized cleaning solution from said cleaning sleeve.

29. A cleaning apparatus according to claim **25** wherein said cleaning sleeve engages a portion the exterior of at least two radiation source assemblies.

30. A cleaning apparatus according to claim **29** wherein said cleaning sleeve is connected to at least one means to move said cleaning sleeve between said retracted and extended positions.

31. A cleaning apparatus according to claim **30** wherein said at least one means to move is hydraulically operated.

32. A cleaning apparatus according to claim **30** wherein said at least one means to move is pneumatically operated.

33. A method of treating a fluid with at least one radiation source assembly comprising at least one radiation source and a support therefor, the method comprising the steps of:

(i) providing a gravity fed flow of fluid from a fluid inlet to a fluid outlet, and irradiation zone being disposed between said inlet and said outlet;

(ii) disposing the at least one radiation source assembly within said irradiation zone such that the at least one radiation source has a longitudinal axis which is substantially parallel to the flow of fluid and the support is upstream or downstream of the irradiation zone;

(iii) confining the flow of fluid such that it is within a predefined maximum distance from and fully submerses the at least one radiation source, said confining **[**source**]** *step* including the step of confining the flow of fluid in a closed cross-section which is smaller than a cross-section of the fluid inlet;

(iv) exposing the flow of fluid to radiation from the radiation source; and

(v) feeding the flow of fluid from step (iv) to a fluid outlet.

34. A method according to claim **33**, wherein said disposing step includes the step of disposing the radiation source assembly support such that its longitudinal axis is disposed in the fluid inlet and is substantially perpendicular to the fluid flow.

35. A method according to claim **33** wherein the flow of fluid is at a first velocity in said fluid inlet, a second velocity in said irradiation zone and a third velocity in said fluid outlet.

36. A method according to claim **35** wherein said second velocity is greater than at least one of said first velocity and said third velocity.

37. A method according to claim **35** wherein said second velocity is greater than both of said first velocity and said third velocity.

38. A method according to claim **37** wherein said third velocity is substantially equal to said first velocity.

39. A method according to claim **37** wherein prior to step (ii), the fluid flow is **[**admired**]** *admitted* to a transition zone which increases the velocity thereof.

40. A method according to claim **37** wherein prior to step (v), the fluid flow is admitted to a transition zone which decreases the velocity thereof.

41. A method of removal of fouling materials from a radiation source in situ in a fluid treatment system using a cleaning apparatus comprising a cleaning sleeve engaging a portion of the exterior said radiation source assembly and movable between a retracted position wherein a first portion of said radiation source is exposed to a flow of fluid to be treated and an extended position wherein said first portion of said radiation source assembly is completely or partially covered by said cleaning sleeve, said cleaning sleeve including a chamber in contact with said first portion of said radiation source assembly, comprising the steps of:

(i) providing a supply of a cleaning fluid to a cleaning chamber;

(ii) moving said cleaning chamber to said extended position;

(iii) maintaining said cleaning fluid in contact with said portion;

(iv) allowing said cleaning fluid to facilitate removal of fouling materials from the radiation source; and

(v) moving said cleaning chamber to said retracted position.

42. A method according to claim **41** wherein said cleaning chamber includes a seal member in slidable engagement with said portion and sweeping said portion to further remove fouling materials when said cleaning chamber is moved to at least one of said extended position and said retracted position.

43. A method according to claim **41** wherein said cleaning chamber simultaneously contacts a like portion of at least two radiation sources.

44. A method according to claim **41** wherein said cleaning chamber is substantially continuously pressurized by said cleaning fluid and contains inward spray means to remove the fouling materials from the radiation source.

45. A method according to claim **41** wherein said cleaning chamber is kept stationary and the radiation source is moved relative thereto to remove the fouling materials from the radiation source.

46. A method according to claim **41** wherein said cleaning chamber further comprises scouring means to increase rubbing against said radiation source while in contact with the cleaning chamber.

47. A gravity fed fluid treatment system suitable for installation in an open fluid canal, said system comprising a fluid inlet, a fluid outlet, an irradiation zone disposed between the fluid inlet and the fluid outlet, and at least one radiation source assembly comprising at least one radiation source and a support therefor, the at least one radiation source being elongate and having a longitudinal axis substantially parallel to the direction of fluid flow through the irradiation zone and being fully submersed in fluid flow through the irradiation zone, the support being disposed upstream or downstream of the irradiation zone, the irradiation zone having a closed cross-section to confine fluid to be treated within a predefined maximum distance from the at least one radiation source, said closed cross-section being less than a cross-section of the open fluid canal upstream of said irradiation zone.

48. A gravity fed fluid treatment system suitable for installation in an open fluid canal, said system comprising:

a fluid inlet;

a fluid outlet;

an irradiation zone disposed between the fluid inlet and the fluid outlet; and

at least one radiation source assembly comprising at least one radiation source and a support therefor, the at least one radiation source being elongate and having a longitudinal axis substantially parallel to the direction of fluid flow through the irradiation zone and being fully submersed in fluid flow through the irradiation zone,

the support being disposed upstream or downstream of the irradiation zone,

the irradiation zone having a closed cross-section to confine fluid to be treated within a predefined maximum distance from the at least one radiation source,

wherein said closed cross-section causes the velocity of fluid flow therein to be higher than a velocity of fluid flow in the open fluid canal upstream of said irradiation zone.

49. A system according to claim 48, wherein said support comprises a vertically-extending member partially submersed in a fluid flow area having a fluid flow velocity which is less than the fluid flow velocity of the closed cross-section.

50. A system according to claim 49, wherein the vertically-extending member is movable to remove the at least one radiation source from the irradiation zone.

51. A system according to claim 49, wherein the at least one radiation source is supported by a single vertically-extending member.

52. A system according to claim 48, wherein said closed cross-section has inner walls which are configured to follow contours of the at least one radiation source.

53. Apparatus for irradiating fluid in an open fluid canal of a gravity-fed fluid treatment system, comprising:

an irradiation zone disposed in the open fluid canal and having a closed cross-section for confining the fluid flow, such that a fluid flow velocity in the irradiation zone is higher than a fluid flow velocity upstream of the irradiation zone in the open fluid canal;

a plurality of elongate ultraviolet lamps disposed in the irradiation zone with their longest axes substantially parallel to the direction of fluid flow therethrough;

a plurality of supports for holding said plurality of ultraviolet lamps in the closed cross-section irradiation zone, said plurality of supports being positioned upstream of the irradiation zone in the open fluid canal, each support being movable with respect to the irradiation zone so that the ultraviolet lamps may be removed from the irradiation zone;

a plurality of protective sleeves respectively disposed to cover the plurality of ultraviolet lamps;

a plurality of sleeve cleaners, each disposed around an outer surface of a corresponding sleeve; and

driving apparatus which drives the plurality of sleeve cleaners along the plurality of sleeves to clean the sleeves.

54. Apparatus for irradiating fluid in a gravity-fed fluid treatment system, comprising:

an enclosed flow zone which physically restricts the flow of fluid therethrough as compared to a relatively less restricted flow zone upstream of said enclosed flow zone;

a plurality of elongate radiation sources disposed within the enclosed flow zone so that a longitudinal axis of each radiation source is substantially parallel to a direction of the fluid flow through said enclosed flow zone; and

a support member for holding one or more of said plurality of radiation sources in the enclosed flow zone, at least a portion of said support member being disposed outside of said enclosed flow zone,

said enclosed flow zone having inner walls which are configured to follow contours of portions of said plurality of radiation sources.

55. Apparatus according to claim 54, wherein said support member comprises a vertically-extending member disposed in a fluid flow area which has a fluid flow velocity which is less than a fluid flow velocity of the enclosed flow zone.

56. Apparatus according to claim 55, wherein the vertically-extending member is movable to remove the one or more of said plurality of radiation sources from the enclosed flow zone.

57. Apparatus according to claim 55, wherein each of said one or more of said plurality of radiation sources is supported by a single vertically-extending member.

58. A system for treating fluid in an open fluid canal of a gravity fed fluid system, comprising:

a closed cross-section irradiation zone in which the velocity of fluid flowing therethrough is higher than the velocity of fluid flowing in a zone upstream of said irradiation zone in the open fluid canal;

a plurality of ultraviolet lamps disposed in said irradiation zone parallel to a direction of fluid flow therethrough, said ultraviolet lamps for treating the fluid flowing through the closed cross-section irradiation zone; and

at least one support which holds one or more of the plurality of ultraviolet lamps in the irradiation zone, the at least one support being disposed upstream of the irradiation zone in the open fluid canal,

wherein said closed cross-section irradiation zone is defined at least in part by a main body restricting fluid flow.

59. A system according to claim 58, wherein said at least one support comprises a vertically-extending member disposed in a fluid flow area having a fluid flow velocity which is less than a fluid flow velocity of the closed cross-section irradiation zone.

60. A system according to claim 59, wherein the vertically-extending member is movable to remove the one or more of the plurality of ultraviolet lamps from the closed cross-section irradiation zone.

61. A system according to claim 59, wherein each of said one or more of the plurality of ultraviolet lamps is supported by a single vertically-extending member.

62. A system according to claim 58, wherein said closed cross-section irradiation zone has inner walls which are configured to follow contours of the plurality of ultraviolet lamps disposed in the irradiation zone.

63. A radiation module for an open-canal gravity-fed fluid treatment system having an irradiation zone, comprising:

a plurality of radiation sources for disposal in the irradiation zone and having longitudinal axes which are substantially parallel to a direction of fluid flow through the irradiation zone;

a vertically-extending support member coupled to said plurality of radiation sources such that each radiation source is supported by a single vertically-extending support member, said support member holding the plurality of radiation sources in the irradiation zone, said support member being movable with respect to the irradiation zone so that said plurality of radiation sources may be removed from the irradiation zone; and

cleaning means, movable in the direction of the longitudinal axes of the radiation sources, for cleaning outer surfaces of the radiation sources while said radiation sources are in the irradiation zone.

64. A module according to claim 63, further comprising an additional support member for coupling said support member to the fluid treatment system.

65. A module according to claim 63, wherein said plurality of radiation sources are horizontally-disposed, and wherein said vertically-extending support member comprises a vertical member.

66. A fluid treatment system for a gravity fed fluid canal through which fluid to be treated flows, comprising:

a main body installed across the fluid canal such that the main body is at least partly immersed in the fluid of said canal so as to direct the fluid to an irradiation zone;

an irradiation zone through which the fluid flows before returning to the fluid canal; and

at least one radiation source disposed in said irradiation zone to treat fluid with radiation, said at least one radiation source having its longest axis parallel to said fluid flow,

said irradiation zone having a closed cross-section to confine fluid within a predefined maximum distance from the at least one radiation source,

said irradiation zone having a cross-sectional area that is less than that of the fluid canal.

67. A system according to claim 66, further comprising a support member for supporting the at least one radiation source in the irradiation zone.

68. A system according to claim 67, wherein said support member comprises a vertically-extending member partially submersed in a fluid flow area having a fluid flow velocity which is less than a fluid flow velocity of the irradiation zone.

69. A system according to claim 68, wherein the vertically-extending member is movable to remove the at least one radiation source from the irradiation zone.

70. A system according to claim 68, wherein said at least one radiation source is supported by a single vertically-extending member.

71. A system according to claim 66, wherein said irradiation zone closed cross-section has inner walls which are configured to follow contours of the at least one radiation source disposed in the irradiation zone.

72. A system according to claim 66, wherein said at least one radiation source is mounted on a support therefor with the support being disposed in an area upstream or downstream of said irradiation zone.

73. A fluid treatment system for irradiating fluid flowing in an open fluid canal, comprising:

an irradiation zone disposed in said open fluid canal to receive the fluid flow from the open fluid canal;

said irradiation zone having a closed cross-sectional area that is smaller than the cross-sectional area of the fluid flowing in the open fluid canal;

a plurality of elongate ultraviolet lamps disposed in said irradiation zone with the longest axis of each lamp being substantially parallel to the direction of fluid flow; and

at least one vertically-extending support member for supporting said plurality of ultraviolet lamps in the irradiation zone;

each of said plurality of ultraviolet lamps being supported by a single vertically-extending support member;

said at least one vertically-extending support member being disposed in an area upstream or downstream of said irradiation zone.

74. A system according to claim 73, wherein the closed cross-section causes a fluid flow velocity in the irradiation zone to be higher than a fluid flow velocity in the open fluid canal.

75. A system according to claim 73, wherein said support member comprises a vertically-extending member partly submersed in a fluid flow area having a fluid flow velocity which is less than a fluid flow velocity in the irradiation zone closed cross-section.

76. A system according to claim 75, wherein the vertically-extending member is movable to remove the plurality of ultraviolet lamps from the irradiation zone.

77. A system according to claim 73, wherein the irradiation zone closed cross-section has inner walls configured to follow contours of the plurality of ultraviolet lamps.

78. A system according to claim 73, wherein said vertically-extending support member is movably mounted with respect to said fluid treatment system so that said ultraviolet lamps may be moved into and out of said irradiation zone.

79. A system according to claim 73, wherein each said ultraviolet lamp is located within a sleeve, and wherein said system further includes a cleaning member disposed about said sleeve and which is reciprocally movable from a retracted position to an extended position to clean the surface of said sleeve.

80. A radiation source module for an open fluid treatment system which includes a fluid inlet, and a fluid outlet, comprising:

a vertically-extending support member for disposal in the fluid;

a plurality of elongated radiation source assemblies extending from said support member,

each of said radiation source assemblies being supported by a single vertically-extending support member; and

another support member disposed outside of the fluid and extending from said vertically-extending support member to movably position said radiation source module in an irradiation zone in said fluid treatment system.

81. A module according to claim 80, wherein each elongated radiation source assembly includes an ultraviolet lamp, and further comprises cleaning means for cleaning each ultraviolet lamp.

82. A module according to claim 80, wherein said another support member is coupled to the fluid treatment system.

83. A module according to claim 80, wherein said vertically-extending support member comprises a vertical member.

84. A module according to claim 80, wherein said vertically-extending support member is movable with respect to the irradiation zone so as to extract said plurality of radiation source assemblies from the irradiation zone.

85. A method of treating a fluid in an open canal system, comprising the steps of:

(i) providing a gravity fed flow of fluid at a first velocity in the open canal;

(ii) feeding the flow of fluid from the open canal through an elongate irradiation zone at a second velocity which is greater than the first velocity, the elongate irradiation zone having a closed cross-section and having disposed therein an elongate radiation source having a longitudinal axis substantially parallel to the flow of fluid, the elongate radiation source being connected to a support disposed in an area upstream or downstream of the irradiation zone;

(iii) confining the flow of fluid at the second velocity within a redefined maximum distance from the at least one radiation source;

(iv) exposing the flow of fluid at the second velocity to radiation from the radiation source; and

(v) feeding the flow of fluid from step (iv) to the open canal downstream of the irradiation zone.

86. A fluid treatment method for a gravity fed fluid flow, comprising the steps of:

disposing a main body across an open fluid canal such that the main body is at least partly immersed in the fluid of said canal;

directing fluid flow to an irradiation zone through which the fluid flows before returning to the fluid canal;

disposing at least one radiation source in said irradiation zone, said at least one radiation source having its longest axis parallel to said fluid flow;

irradiating the fluid flow with the at least one radiation source in the irradiation zone;

providing said irradiation zone with a closed cross-section to confine fluid within a predefined maximum distance from the at least one radiation source; and

providing said irradiation zone with a cross-sectional area that is less than that of the fluid canal.

87. A radiation source module for use in a fluid treatment system comprising:

a single vertically-extending support member;

a plurality of radiation source assemblies extending from the support member, the plurality of radiation source assemblies each comprising at least one radiation source, the at least one radiation source being elongate with its longitudinal axis substantially parallel to a direction of fluid flow, the plurality of radiation source assemblies being supported by the single vertically-extending support member; and

fastening means to affix the radiation source module in the fluid treatment system.

88. A gravity fed fluid treatment system for an open canal, comprising:

an array of radiation sources disposed in an elongate irradiation zone having a closed cross-section which provides a fixed geometry to restrict fluid flow through the irradiation zone as compared to a flow in the open canal, the array of radiation sources being disposed substantially parallel to the fluid flow;

a fluid inlet upstream of the irradiation zone;

a fluid outlet downstream of the irradiation zone; and

at least one vertically-extending support for the array of radiation sources, the at least one vertically-extending support being partly submersed in the fluid flow upstream or downstream of the irradiation zone.

89. A gravity fed fluid treatment system comprising:

an open canal for receiving a fluid flow;

an array of elongate radiation sources disposed substantially parallel to the fluid flow;

an elongate irradiation zone surrounding the array of radiation sources and having a closed cross-section to (i) restrict the fluid flow within a predetermined maximum distance from the array of radiation sources and (ii) to increase a fluid flow velocity in the irradiation zone with respect to a fluid flow velocity in the open canal; and

at least one support for the array of radiation sources disposed in the open canal upstream or downstream of the irradiation zone.

90. A system according to claim 1 wherein said at least one radiation source comprises a high intensity ultraviolet lamp.

91. A module according to claim 19, wherein said at least one radiation source assembly comprises a high intensity ultraviolet lamp.

92. A method according to claim 33, wherein said disposing step includes the step of disposing a radiation source which comprises a high intensity ultraviolet lamp.

93. A system according to claim 47, wherein said at least one radiation source comprises a high intensity ultraviolet lamp.

94. A system according to claim 48, wherein said at least one radiation source comprises a high intensity ultraviolet lamp.

95. Apparatus according to claim 53, wherein each of said plurality of ultraviolet lamps comprises a high intensity ultraviolet lamp.

96. Apparatus according to claim 54, wherein each of said plurality of elongated radiation sources comprises a high intensity ultraviolet lamp.

97. A system according to claim 58, wherein each of said plurality of ultraviolet lamps comprises a high intensity ultraviolet lamp.

98. A module according to claim 63, wherein each of said plurality of radiation sources comprises a high intensity ultraviolet lamp.

99. A system according to claim 66, wherein said at least one radiation source comprises a high intensity ultraviolet lamp.

100. A system according to claim 73, wherein each of said plurality of elongated ultraviolet lamps comprises a high intensity ultraviolet lamp.

101. A module according to claim 80, wherein each of said plurality of elongated radiation source assemblies comprises a high intensity ultraviolet lamp.

102. A module according to claim 87, wherein said at least one radiation source comprises a high intensity ultraviolet lamp.

103. A system according to claim 88, wherein each of the radiation sources comprises a high intensity ultraviolet lamp.

104. A system according to claim 89, wherein each elongate radiation source comprises a high intensity ultraviolet lamp.

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