United States Patent

[11] **3,566,105**

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[54] **SYSTEM FOR ULTRAVIOLET IRRADIATION OF FLUIDS WITH FAIL SAFE MONITORING MEANS**
8 Claims, 15 Drawing Figs.

[52] **U.S. Cl.** **250/43,** 250/83.3
[51] **Int. Cl.** **G01n 21/26**
[50] **Field of Search** 250/43, 45, 83.3UV

[56] **References Cited**
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3,182,193 5/1965 Ellner et al. 250/43X

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ABSTRACT: System for the purification and/or sterilizing of liquids by the application of ultraviolet (U-V) ray-emission means. The system includes a monitor for measuring the output of the ultraviolet source and at preset intervals activates various devices for rendering the system fail-safe.

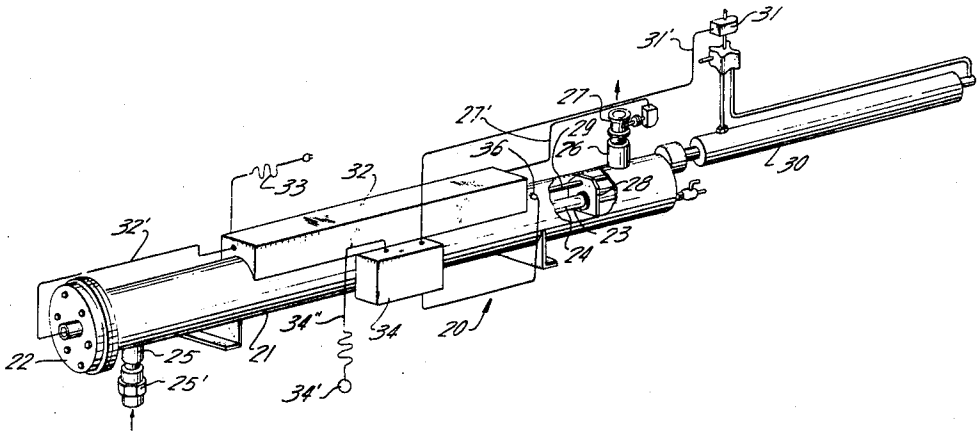


FIG. 1

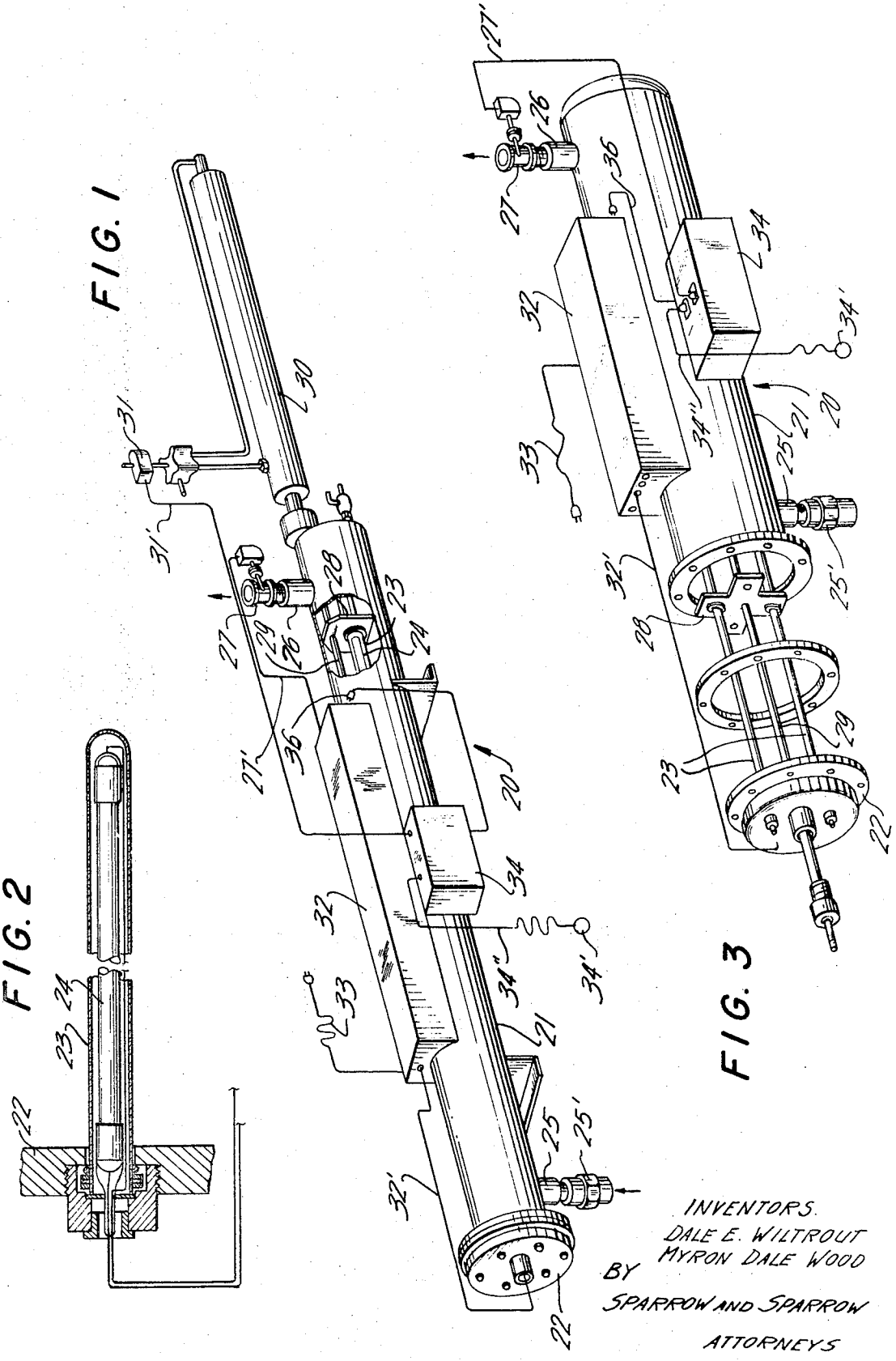


FIG. 2

FIG. 3

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FIG. 4

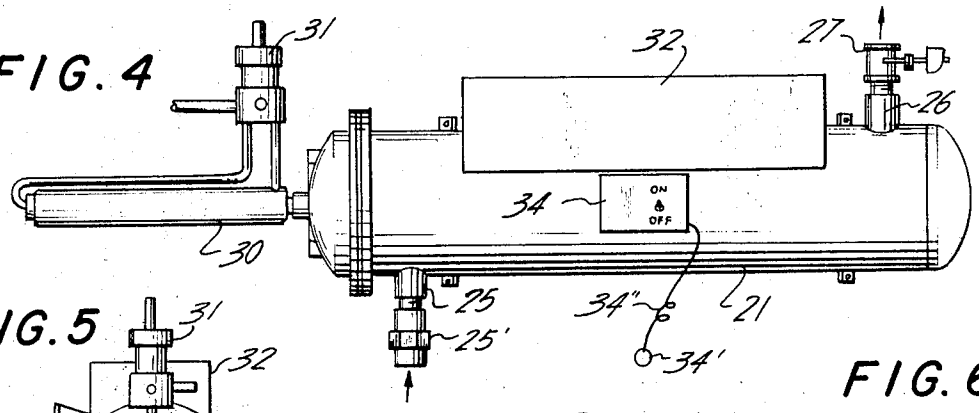


FIG. 5

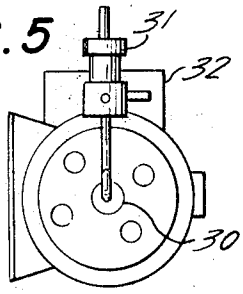
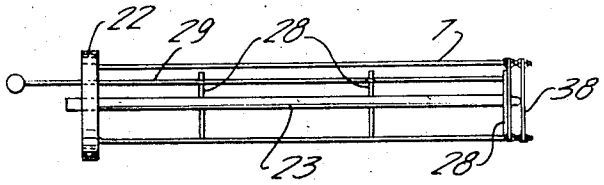


FIG. 6



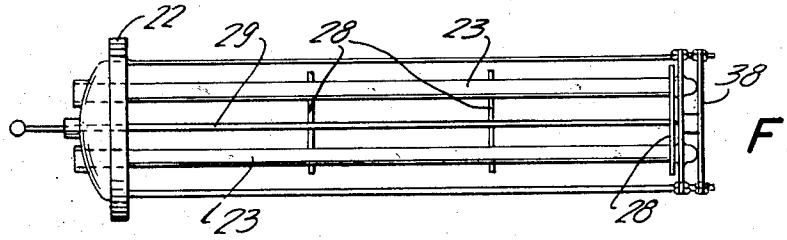


FIG. 7

FIG. 8

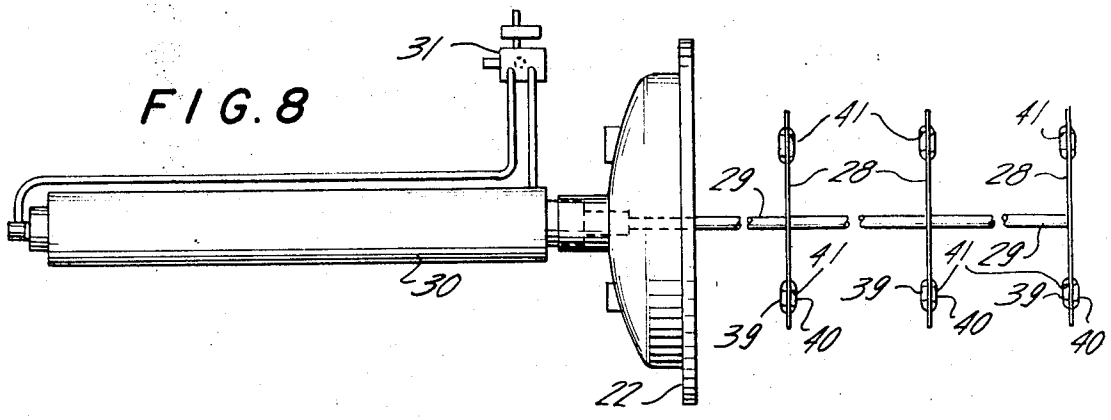


FIG. 9

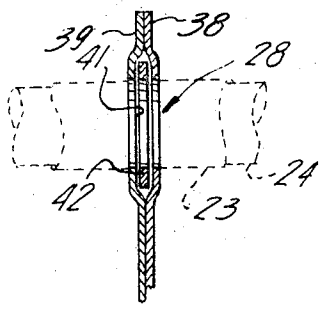
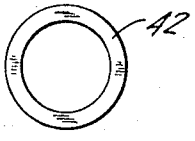
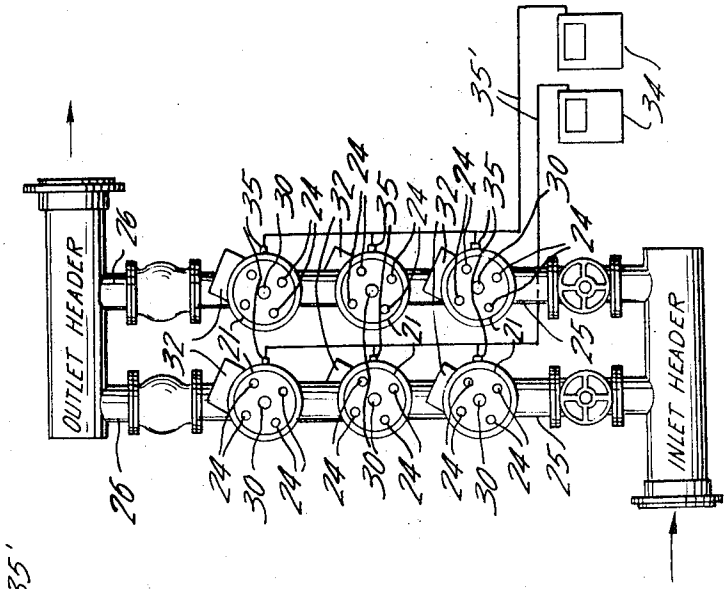


FIG. 10



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FIG. 12



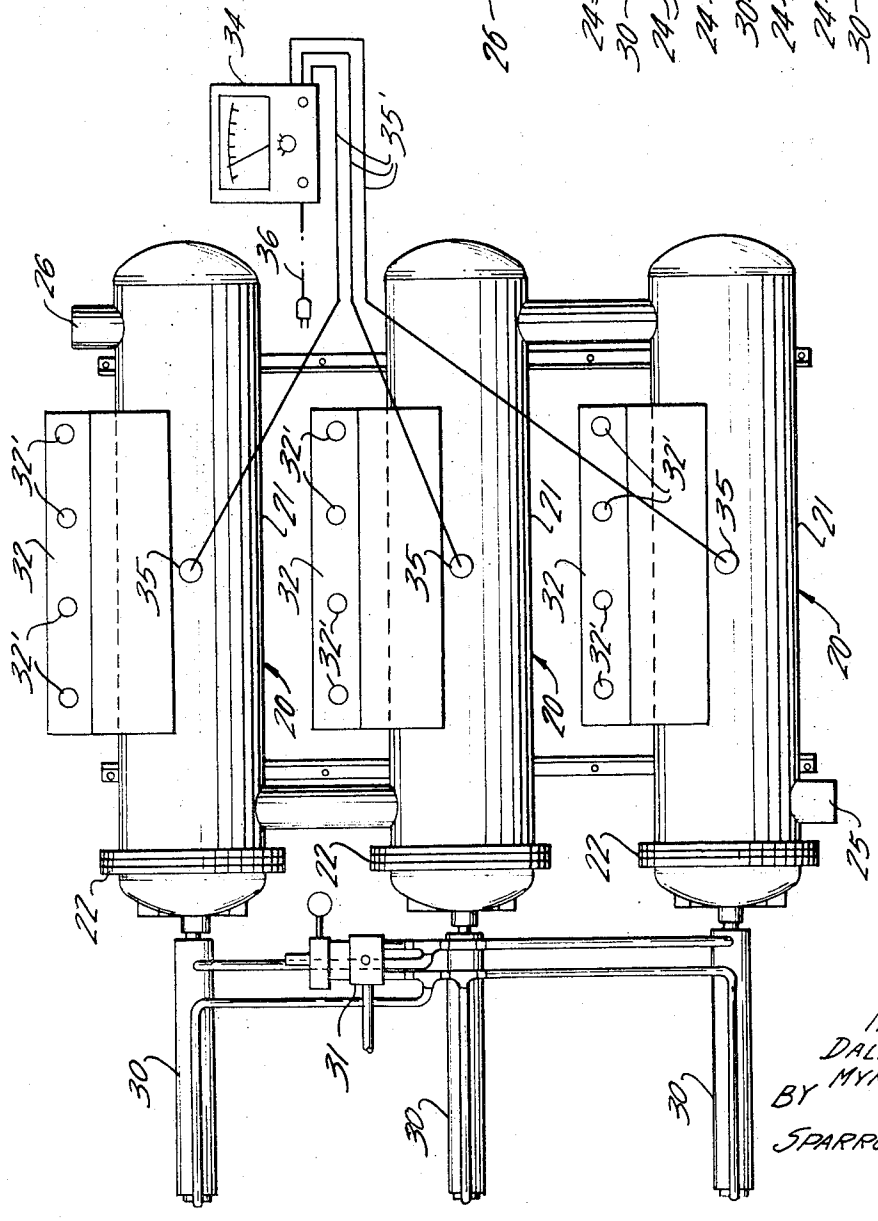


FIG. 11

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FIG. 13

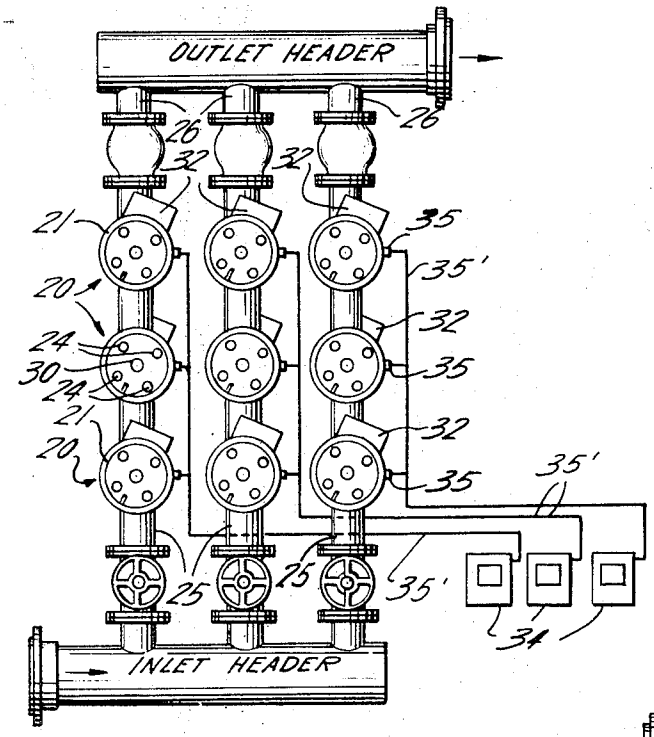
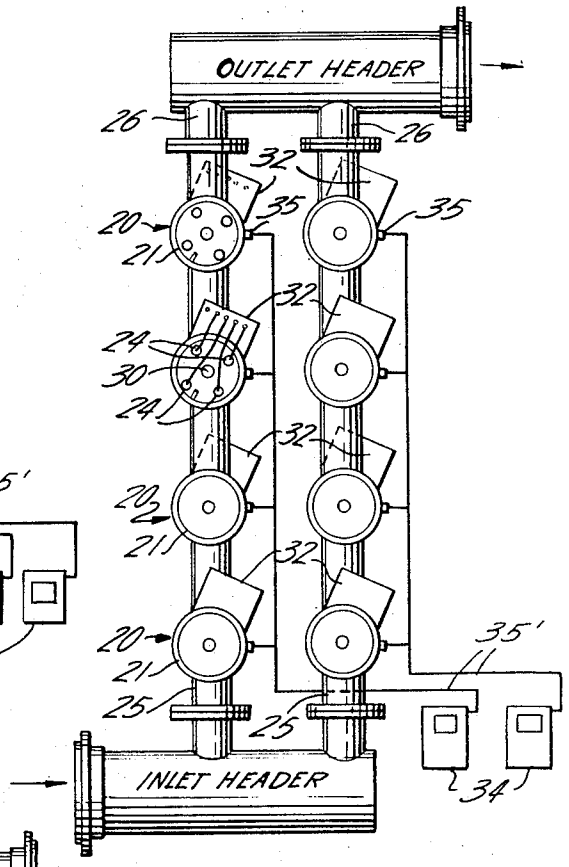


FIG. 15



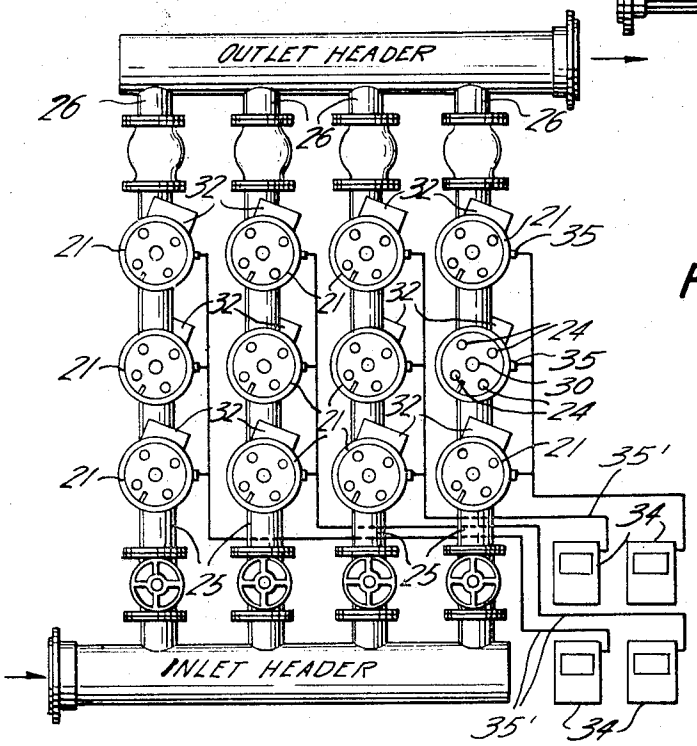


FIG. 14

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SYSTEM FOR ULTRAVIOLET IRRADIATION OF FLUIDS WITH FAIL SAFE MONITORING MEANS

BACKGROUND OF THE INVENTION

The invention relates to a system for the purification and sterilization of liquids, particularly drinking water, utilizing ultraviolet ray-emission in the wave length area of 2537 angstrom units.

It is known that certain rays of predetermined wave length have remarkable bactericidal, sterilizing, purifying, germicidal and other chemical actinic powers. By reason of the power of destroying, reducing and inhibiting the growth and number of bacteria, yeasts, molds, algae, virus and other microorganisms or other undesirable germs, light rays of short wave length, preferably at the ultraviolet end of the spectrum, have been used for the sterilization and purification of liquids and fluids.

Among the possible contingencies and/or failures which might arise under any ultraviolet purification system may be mentioned (a) lamp jacket coating and resultant loss of ultraviolet intensity, (b) lamp depreciation or failure, (c) internal circuit failure, (d) line voltage drop or external circuit failure and (e) the unexpected existence of liquid containing characteristics other than that for which a system has been designed.

A basic ultraviolet liquid purifier receives nonpurified liquid into one end of a chamber, usually cylindrical, the passage of this liquid being directed over, around and across one or more ultraviolet lamps, ultraviolet irradiation energy being imparted from the lamp or lamps to the liquid in sufficient quantities and over sufficient duration to kill bacteriological microorganisms in accordance with the rated capacity. Although a single sterilizing or purifying lamp may be used, the operating unit or system may comprise a bank of germicidal lamps, the germicidal or purifying effect increasing proportionally with any increase in the number of lamps and the latter being determined by the nature, dimensions and contour of the liquid or fluid holding container. The purified liquid is discharged from the sterilization chamber through a pipe or conduit, thus making the same available for its intended use.

The purpose of the present invention is to overcome the deficiences of devices and systems of the prior art and design water treatment systems that will fulfill and secure requirements of drinking water standards with reference to its purification and disinfection without changing the chemical and physical characteristics of the water.

SUMMARY OF THE INVENTION

The invention consists in the novel parts, construction arrangements, combinations of parts and improvements as may be shown and described in connection with the apparatus herein disclosed by way of examples only and as illustrative of preferred embodiments. Objects and advantages of the invention will be set forth in part hereafter and in part will be obvious herefrom as may be learned by practicing the invention, the same being realized and attained by means of the instrumentalities and combinations pointed out in the appended claims.

The principal object of the present invention is to eliminate bacteriological and other deleterious microorganisms from liquids or fluids and to insure safe, continuous, constant and efficient performance of the device by improved means.

A further object of the present invention is to provide improved systems embodying the use of the ultraviolet process as a means of disinfecting water to meet the bacteriological requirements of public health drinking water standards.

The system according to the invention incorporates monitoring of the intensity of the ultraviolet source. When the intensity of the source falls below a preset level the monitor shuts off the supply of liquid and activates an alarm to denote a malfunction. The monitor may also activate a device which wipes the jacket containing the ultraviolet source.

In the system according to the present invention, a continuous flow of liquid such as, for example, drinking water, may be purified as well as liquid in a storage tank or vessel. Individual units may be ganged to increase the efficiency and capacity of the system. The system also employs novel wiping means in the wiper apparatus, and may incorporate a flow or time delay mechanism to permit a tube warmup period before water flows from the unit.

It is therefore a further object of the present invention to design a system to purify certain liquids within specific standards and requirements as determined by the user, the system being monitored by ultraviolet irradiation measuring means such as a meter which activates an electronic circuit and subsequently safety devices such as, automatic wiper means, automatic warning signals (visual and/or audible), automatic flow control and automatic flow shutoff.

Another object of the present invention is to provide in combination contrivances or devices in a purifying and/or sterilizing system for continuously monitoring the operation of the system and immediately communicating certain automatic alarms in the event that this system falters or ceases to perform in accordance with its intended purposes.

A further object of the present invention is to provide a purification system designed to monitor instantaneously and continuously ultraviolet radiation imparted to the liquid to be purified at all times, such as in the event that contingencies arise, they will be immediately monitored and subsequently various safety devices will be automatically implemented by direct and automatic communication from the monitoring device.

Yet another object of the present invention is to provide such implements as may be necessary or required for maintaining the irradiation values for the purification of the liquid or fluid to be treated at a safe constant level.

Furthermore, it is an object of the present invention to provide in a purifying and/or sterilizing system instruments and automatically operating devices for controlling the flow of the liquid or fluid to be purified in such manner that a constantly safe, monitored and efficient result will be obtained.

Various further and more specific purposes, features and advantages will clearly appear from the detailed description given below taken in connection with the accompanying drawings which form part of this specification and schematically illustrate merely by way of examples embodiments of the devices of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following description and in the claims, parts will be identified by specific names for convenience, but such names are intended to be as generic in their application to similar parts as the art will permit. Like reference characters denote like or similar but not necessarily identically constructed parts in the drawings, illustrating preferred embodiments by which the invention may be realized.

In the drawings:

FIG. 1 illustrates in isometric projection, a complete ultraviolet ray-emission liquid purifying unit, partly cut away;

FIG. 2 shows, section, an ultraviolet ray-emission lamp in its jacket of quartz or high silica glass or other material with similar optical characteristics;

FIG. 3 shows in isometric projection, an exploded view of a multiple ultraviolet ray-emission purifying unit;

FIGS. 4 and 5 are respectively longitudinal and end views of ultraviolet liquid purifier similar to FIG. 3 with automatic wiper equipment attached;

FIG. 6 is a view of an ultraviolet lamp assembly for a tank;

FIG. 7 shows a unit for a tank, incorporating a plurality of ultraviolet ray-emission lamps;

FIG. 8 is a view of an automatic wiper assembly for a unit shown in FIG. 4;

FIG. 9 shows a section of one of the wiper elements of FIG. 8 in an enlarged scale;

FIG. 10 shows the wiper ring used in FIG. 9;

FIG. 11 is a view of a water purifier consisting of three multiple lamp units, shown in FIG. 3, arranged in series;

FIG. 12 shows a water purifier consisting of two parallel lines of three multiple lamp units shown in FIG. 3, arranged in series;

FIG. 13 shows a water purifier consisting of three parallel lines of three multiple lamp units shown in FIG. 5 arranged in series;

FIG. 14 shows a water purifier consisting of four parallel lines of three multiple lamp units shown in FIG. 5, arranged in series; and

FIG. 15 shows a liquid purifier consisting of two parallel lines of four multiple lamp units, shown in FIG. 5, arranged in series

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in more detail to the drawings illustrating embodiments by which the invention may be realized, there is disclosed in FIG. 1 one example of a complete liquid purifying unit or system, designated by the general numeral 20. It consists basically of a housing or container 21 comprising the ultraviolet radiation chamber, which is closed on both ends, one of which by a flange plate 22. In container 21 and held in plate 22, is a jacket 23 of quartz or quartzlike material of high silica glass with similar optical characteristics, in which a high intensity ultraviolet lamp 24 is positioned. Jacket 23 is adapted to transmit ultraviolet rays emitted from lamp 24. Lamp 24 emits ultraviolet rays of a wave-length of substantially 2537 angstrom units. Container 21 has an inlet tube 25 with a flow control valve 25' connected thereto, and an outlet tube 26. A solenoid valve 27 is located at the outlet tube for controlling or shutting of the flow of the liquid passing through container 21 purified by the ultraviolet rays. A wiper 28 is longitudinally movably positioned on quartz tube jacket 23. Wiper 28 is fastened on a rod 29; generally there are several wipers spaced apart from one another, on rod 29 but only one is shown on FIG. 1. Rod 29 is coupled with the piston of a fluid or similar power motor, such as, for example, a hydraulic cylinder 30 which has a solenoid control valve 31 for double-action movement. Mounted on container 21 is a power pack or supply 32 which contains the necessary transformers for ultraviolet lamp 24, cable connection 33 for connecting the purifier to AC line voltage, and power supply elements for air cylinder 30, for valve 31 through cable 31' and for automatic shut-off valve 27 through cable 27'. Installed in the outer wall of ultraviolet purifier container 21 through a center port communicating with the inside thereof, is a fail-safe monitor unit 34 positioned and connected perpendicular to ultraviolet lamp 24, for example monitors disclosed in our pending U.S. Pat. applications Ser. Nos. 652,141 and 668,432 filed respectively Jul. 10, 1967 and Sept. 18, 1967. The fail-safe monitor 34 combines substantially 2537 angstrom units ultraviolet sensing and visual readout with automatic operation of outlet solenoid shutoff valve 27 and activation of visual and audio alarm means 34' and provides flow or time delay means during startup cooperating with valve 27 to permit ultraviolet lamp 24 warmup period to reach peak efficiency before the liquid flows from the unit. Monitor 34 includes a sensor which senses the germicidal ultraviolet ray emission intensity at the sight port after penetration of the fluid and accurately measures the purification performance. It further includes an accurately calibrated ultraviolet intensity meter, filtered to restrict sensitivity to the disinfection spectrum. With respect to the embodiments disclosed in FIGS. 11 through 15, the sensors 35 are shown connected by cables 35' to monitors 34. The monitor unit 34 by means of power cable 36, is plugged into the power pack or supply 32. The ultraviolet source by means of a cable or electrical harness 32' is connected to power supply 32. In safe service position, valve 27 is operative (open) and alarm means 34' is inoperative; in "fail" position, valve 27 is inoperative (closed) and alarm 34' operative. Valve 27 prevents contamination of purified service line in the event of electrical failure or decrease in ultraviolet emission below desired minimum. Automatic shutoff valve 27 permits flow into the portable water system only when at least the minimum ultraviolet dosage is applied. Power Pack 32 contains also a timer (not visible in the drawing) which actuates periodically air cylinder 30 for wiping tube or jacket 23.

The operation is as follows:

A liquid, for example water, from inlet 25 flows through chamber or container 21 and is exposed to the ultraviolet rays of the selected wavelength which is ll held to close tolerances at substantially 2537 angstrom units. These rays are highly effectively germicidal so that the liquid emanating from the unit is purified and germ-free. However, any deposits on jacket 23 would weaken the passage of the ultraviolet rays from lamp 24 and eventually prevent even the passage thereof. Therefore, the jacket is periodically wiped clean by wiper 28 controlled by the fail-safe monitor 34. Monitor 34 also guards the operation by shutting off through shutoff valve 27 the flow of the liquid if the emission of the ultraviolet rays drops below a certain level for any reason, and by operating at the same instant audible and visible alarm means indicated generally by the numeral 34'. Obviously, the wiping action on jacket 23 does not solely rely on the monitor which acts as a safety precaution. The wiping is always performed at regular intervals set by the timer in the power pack in order to keep the system automatically going. In FIG. 1, valve 27 and alarm 34' are connected to monitor 34 by cables 27' and 34'' respectively, and monitor 34 is connected to power pack 32 through cable 35.

FIGS. 3 and 4 show variations of ultraviolet liquid purifiers. Where applicable the same numerals as appear in FIG. 1 are applied in the remaining FIGS. of the drawing for similar but not identical parts.

In order to enlarge the capacity of the system, for example, by accelerating the flow through container 21, a plurality of ultraviolet lamps 24 may be arranged in container or housing 21, as indicated in FIG. 3, wherein two lamps 24 are shown (provision being made for four lamps), or in FIGS. 12—15, where four lamps 24 are arranged in each one of the containers or housings 21.

The system may be also used in storage tanks of larger capacity (tanks not being shown in the drawings). In this case, container 21 is not needed and as shown in FIGS. 6 and 7, flange plate 22 is connected by rods 37 with an end plate 38, forming substantially a cage for holding jackets 23 containing ultraviolet lamps in place. In these embodiments hand operated wipers may be employed. Wiper rod 29 carrying several wipers 28 is slidably or movably arranged in flange plate 22, and is arranged for hand operation. FIG. 6 shows such system with one ultraviolet ray-emission lamp within jacket 23, whereas FIG. 7 shows two such lamps within jackets 23.

It is obvious that the tank systems may be equipped with similar fail-safe monitors 34 with sensor elements as heretofore mentioned.

A preferred wiper mechanism is shown in more detail in FIGS. 8, 9 and 10. The wiper 28 consists of two formed discs 39, 40 which are spot welded together leaving cavities 41 in which wiper rings 42 are placed. Ring 42 preferably consists of a chemically inert plastic, which also is unaffected by ultraviolet rays, such as, for example, polyurethane. Rings 42 fit closely over envelopes or jackets 23 enclosing lamps 24 so that they can wipe jackets 23 clean from all organic or inorganic deposits which may settle on the surfaces thereof during the operation of the system.

FIG. 11 shows a typical liquid purifying system consisting of three units 20 which are arranged in series. Each one of the units has its own power pack or supply 32 with pilot lights 32' and wiper cylinder 30, but the system needs only one fail-safe monitor 34. It is obvious that such a system can operate successfully at a higher speed of flow of liquid. Therefore, containers 21 are arranged for a higher pressure of the liquid.

Further system arrangements for still larger quantities of liquids to be continuously purified are shown in FIG. 12—15 wherein FIG. 12 shows a system consisting of a bank or two se-

ries of three purifiers 20 each, which are arranged parallel to one another so that the capacity of the system shown in FIG. 11 is doubled. Another system arrangement is shown in FIG. 13 with a bank of three series of three units each put together in parallel relationship to one another, and FIG. 14 shows an arrangement of a bank of four parallel series of three units each, which has twice the capacity of the system shown in FIG. 12. System arrangements of this kind are used for drinking water purification for communities, which render better tasting water than conventional chlorination, due to the ozonation of the water by the effect of ultraviolet rays.

For stronger purification which may be required in the case of a badly polluted water, the arrangement shown in FIG. 15 may be used. In this case four units 20 are set in series with two series arranged parallel to one another. It is understood that other multiple arrangements may be made, for larger quantities of liquids, particularly water, without deviating from the principle and from the efficiency of the system. It is preferable that the plurality of series of purifiers 20 arranged or connected in parallel have a common inlet header and a common outlet header.

From the foregoing it is evident that the present invention provides water or other liquid purification and disinfection system through the use of ultraviolet which embodies among other things, a flow of time delay mechanism to permit a tube or lamp warmup period before water flows from the unit; automatic flow valve, accurate within expected pressure range, to restrict flow to the maximum design flow of the treatment unit; accurate calibrated ultraviolet intensity meter to measure the energy levels to which the meter is subjected, filtered to restrict its sensitivity to the disinfection spectrum, and which is installed in the wall of the disinfection chamber; automatic shutoff valve permitting flow into the potable water system only when at least the minimum ultraviolet dosage is applied, the valve adapted to be in a closed (fail-safe) position when power is not being supplied to the unit, which prevents the flow of water into the potable water system; automatic, visual and/or audible alarm system installed to warn of malfunction; and a system in which ultraviolet radiation at a level of 2537 angstrom units are applied at a required minimum microwatt-seconds per square centimeter dosage at all points throughout the distribution system.

While the invention has been described and illustrated with respect to certain preferred examples which give satisfactory results, it will be understood by those skilled in the art after understanding the invention in principle, that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is intended therefore, in the appended claims to cover all such changes and modifications.

We claim:

1. A system for purifying continuously flowing liquids, said system comprising a closed container having an inlet and an outlet, ultraviolet ray-emission means of selected wave-length and intensity in said container, an ultraviolet light transmitting jacket surrounding said ray-emission emission means, wiper means for said jacket, hydraulic means connected to said wiper means for reciprocating said wiper means at predetermined periodic time intervals, a shutoff valve located adjacent said outlet, fail-safe monitoring means having a sensor and mounted on the exterior wall of said container, said sensor communicating with the interior of said container through a port thereof, said monitoring means for measuring the output of said ray-emission emission means and for activating devices for rendering said system fail-safe, power supply means mounted on said container adapted to supply electric energy for said ray-emission means, said valve, and said fail-safe monitoring means, said system being a compact unit through mounting of said monitoring means and said power supply on said container, and a timer in said power supply means for actuating at said predetermined periodic time intervals said power supply for reciprocatingly operating said wiper means.

2. A system for purifying continuously flowing liquids according to claim 1, said monitoring means having means for controlling the shutting off of said valve when said output of said ray-emission emission means drops below a preset minimum level.

3. A system for purifying continuously flowing liquids according to claim 2, said monitor having means cooperating with said valve for permitting a warmup period of said ultraviolet ray-emission means before the liquid flows from said system.

4. A system for purifying continuously flowing liquids according to claim 3, said monitoring means also controlling the operation of said wiper means.

5. A system of purifying continuously flowing liquids according to claim 4, said wiper means comprising a wiper having a portion which slidably engages said jacket, said portion being chemically inert and unaffected by ultraviolet rays and a ring-shaped folding member for holding said portion, said portion being ring-shaped and held by said holding member along a diameter greater than the interval of said portion.

6. A system for purifying continuously flowing liquids, said system comprising a plurality of units connected in series, each of said units comprising a closed container, one of said containers having an outlet, ultraviolet ray-emission means in said container, an ultraviolet light transmitting jacket surrounding said ray-emission means, wiper means for said jacket, hydraulic means connected to said wiper means for reciprocating said wiper means at predetermined periodic time intervals, a shutoff valve located adjacent said outlet, power supply means mounted on each said containers adapted to supply electric energy for said ray-emission means, and said valve, and fail-safe monitoring means having sensor means for said units, said monitoring means for measuring the output of said ray-emission means and for activating devices for rendering said system fail-safe, and a timer in said power supply means for actuating at said predetermined periodic time intervals said power supply for reciprocatingly operating said wiper means.

7. A system for purifying continuously flowing liquids according to claim 6, said system having a plurality of said series of said units connected in parallel.

8. A system for purifying continuously flowing liquids according to claim 7, wherein said parallely connected series are connected to a common inlet means and a common outlet means.