(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
27 December 2018 (27.12.2018)

WIPO | PCT

(10) **International Publication Number**
WO 2018/234816 A2

(51) International Patent Classification:
A61L 2/10 (2006.01) *C02F 1/32* (2006.01)

(21) International Application Number:
PCT/GB2018/051738

(22) International Filing Date:
21 June 2018 (21.06.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1709953.2 22 June 2017 (22.06.2017) GB

(72) Inventors; and
(71) Applicants: DORRER, Samuel Charles [GB/GB]; Flat 2, 10 Milton Road, Swindon Wiltshire SN1 5JR (GB). **DORRER, James Iain** [GB/GB]; 6 Greenfinch Lodge, Kingfisher Drive, Bristol Bristol BS16 1UA (GB).

(74) Agent: MARLES, Alan David et al.; Stevens Hewlett & Perkins, 1 St Augustine's Place, Bristol Bristol BS1 4UD (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: DISPENSING DEVICE FOR DELIVERING A LIQUID

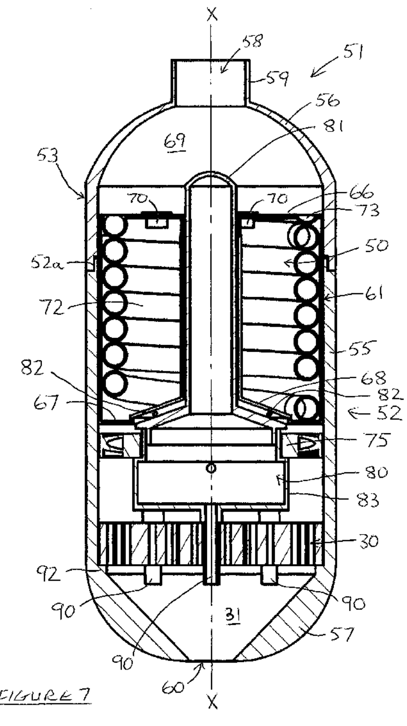


FIGURE 7

(57) Abstract: There is provided a dispensing device for delivering a liquid, the device comprising a UV ray apparatus (50) having an elongate tube (72) which is non-linear, preferably spiral, and which has a liquid inlet end (72a) and an outlet end (72b). A UV-C ray emitter (74) is associated with the tube (72) and is arranged to direct a UV-C beam along the inside of the tube via the outlet end (72b) and/or via the inlet end (72a). The arrangement is configured such that the UV-C beam is reflected off an internal surface of the tube (72) multiple times between the two ends of the tube (72). The UV-C rays have a beneficial antibacterial/antimicrobial effect on the liquid, particularly water.

WO 2018/234816 A2

Dispensing Device for Delivering a Liquid

The present invention relates to dispensing/supply devices for delivering a liquid, particularly but not exclusively water. In some arrangements the dispensing devices may be connectable to an existing tap or may be incorporated in a tap construction.

It is known to provide to tap adaptors which incorporate one or more coloured lights in an attempt to provide a coloured flow of water. Whilst these can have a limited effect, there is a need for a more efficient system.

According to one aspect of the present invention there is provided a dispensing device for a tap for delivering a liquid, the device comprising: an inlet, an outlet aperture downstream of the inlet, a laminar flow device provided between the inlet and the outlet aperture, a reservoir provided between the laminar flow device and the outlet aperture such that in use a laminar flow of liquid exits the outlet aperture, and a light source provided in the reservoir and arranged to direct a light beam through the outlet aperture, wherein the angle of incidence of the light beam to the laminar flow of liquid exiting the outlet aperture is greater than or equal to the critical angle of the liquid.

In preferred arrangements the outlet area of the laminar flow device is greater than the area of the outlet aperture and entirely overlies the outlet aperture when viewed axially from upstream to downstream. For best results, the outlet aperture has substantially clean, sharp edges which are substantially free of imperfections and in many cases the outlet aperture is circular.

Conveniently, the light source comprises a lens provided adjacent the laminar flow device, offset from the outlet aperture, and further comprises an LED or other light emitting device behind the lens. Usually the dispensing device incorporates a power source such as a battery but in other arrangements the power source comprises a generator incorporating an impeller disposed downstream of the inlet and upstream of the laminar flow device. In said other arrangements it is possible that the inlet provides liquid diverting walls to direct the inlet flow of liquid to the impeller at a predetermined angle.

Normally, control means are provided for controlling the power source and the light source and often the control means are provided in a side compartment which is laterally offset from the laminar flow device. Sometimes the side compartment is sealed against ingress of liquid.

In preferred arrangements the light source is capable of providing light beams of different colours. In further preferred arrangements there is provided a temperature sensor in the liquid flow upstream of the laminar flow device, the colour of the light beam being determined by the temperature sensed.

Incoming main water pressure can be quite high so in some arrangements deceleration means are provided upstream of the laminar flow device to slow the flow of liquid. It is envisaged that in some embodiments the deceleration means comprises one or more of the following: mesh, sponge, foamed plastic, baffle means.

It is a preferred feature that the laminar flow device comprises a multiplicity of close-packed straight tubular passages, the axes of the tubular passages being parallel to each other and to a longitudinal, upstream to downstream axis of the device. In some devices the tubular passages are formed in a single block, the walls between the tubular passages being thin and in other devices the tubular passages are defined by a multiplicity of individual thin-walled tubes held together in a close-packed formation. Usually the tubular passages are circular or hexagonal in lateral cross-section.

For a water tap the device may be arranged such that the angle of incidence is greater than 48.62°.

For anti-bacterial reasons the device may be adapted such that a UV light powered by the power source is provided between the inlet and the laminar flow device.

Also, where required, coupling means are provided adjacent the inlet for coupling the dispensing device to a tap. In some arrangements said coupling means incorporates a ball and socket coupling to enable the orientation of the dispensing device to be varied.

The present invention also provides a tap incorporating a dispensing device as described above.

The use of UV light, and particularly UV-C rays in the wavelength range 250-280 nm, have been found to be effective in the treatment of water because the UV-C rays have anti-microbial/anti-bacterial properties.

According to a second aspect of the present invention there is provided a UV ray apparatus for use in a liquid supply device, the apparatus comprising: an elongate tube having a first end and a second end, one of said ends constituting a liquid inlet and the other constituting a liquid outlet, a UV-C ray emitter provided adjacent the first end of the tube and configured to direct a UV-C beam along the inside of the tube, wherein the tube is non-linear between its first and second ends and is configured such that the UV-C beam is reflected off an internal surface of the tube a multiple number of times between the first end and the second ends.

Preferably the tube defines a serpentine path between the inlet and the outlet and is preferably of circular cross-section. Ideally, the tube is spiral in form and defines a circular spiral path between the inlet and the outlet, the first end preferably being the liquid outlet. It has been found beneficial if the internal surface of the tube is e-PTFE and the tube is preferably made from aluminium.

In preferred arrangements the angle of incidence of the UV-C beam relative to the internal surface of the tube is in the range 10° to 60° and preferably in the range 40° to 50°. Preferably the UV-C ray emitter is a UV LED and the apparatus includes a power source for the UV-ray ray emitter.

In another aspect there is provided a liquid supply device comprising a UV ray apparatus of the type discussed wherein the device further comprises an external housing defining an internal volume in which the UV ray apparatus is received, and having a housing inlet and a housing outlet. In preferred arrangements the volume includes an upstream chamber between the housing inlet and the liquid inlet of the UV ray apparatus, the UV ray apparatus being provided in an enclosed volume within the external housing such that the tube provides the only path for the liquid from the upstream chamber towards the housing outlet.

With some embodiments the liquid supply device includes at least one ultrasonic inducer configured to induce cavitation in the liquid in the upstream chamber prior to entering the tube inlet. Often, the liquid supply device further comprises an electronics module sealed from the liquid and disposed within the external housing to power the UV-C ray emitter. The electronics module may be powered by means of a rotatable turbine arranged adjacent the liquid outlet of the tube and configured to provide power to the electronics module via a generating means.

In some embodiments, downstream of the tube outlet is a laminar flow device and there is further provided a reservoir between the laminar flow device and the housing outlet aperture such that, in use, a laminar flow of liquid exits the housing outlet, and there is further provided a light source in the reservoir arranged to direct a light beam through the housing outlet, the angle of incidence of the light beam to the laminar flow of liquid exiting the outlet aperture being greater than or equal to the critical angle of the liquid.

In such embodiments the electronics module may have at least one leg extending through the laminar flow device into the reservoir, the leg incorporating the light source. Ideally, an outlet area of the laminar flow device is greater than the area of the housing outlet aperture and entirely overlies the housing outlet aperture when viewed axially from upstream to downstream, the housing outlet aperture having clean, sharp edges free of imperfections. Conveniently, the housing outlet aperture is circular.

Often, the light source incorporates an LED and a lens adjacent the laminar flow device and radially offset from the outlet aperture. Preferably the light source is configured to provide light beams of different colours. There may be provided a sensor, the colour of the light beam being determined by the property sensed by the sensor, preferably temperature.

In preferred arrangements, the laminar flow device comprises a multiplicity of close-packed straight tubular passages, the axes of the tubular passage being parallel to each other and to a longitudinal, upstream to downstream axis of the device. The tubular passages may have one or more of the following features:

i) they are formed in a single block, the walls between the tubular passages being thin,
ii) they are defined by a multiplicity of individual thin-walled tubes held together in a close-packed formation,
iii) they are circular or hexagonal in lateral cross-section.

Preferably the angle of incidence of the light beam is greater than 48.62°. Conveniently, the external housing comprises two portions which are sealingly yet releasably secured to each other.

The following technical aspects are of primary importance in relation to the present invention:

1. Maximising UV dosage to create sterile liquid from an end point device:

Ultraviolet germicidal irradiation (UVGI) is a disinfection method that uses short-wavelength ultraviolet (UV-C) light to kill or inactivate micro-organisms by destroying nucleic acids and disrupting their DNA, leaving them unable to perform vital cellular functions. UV disinfection relies on radiation emitted in the wavelength of of 250nm-280nm; commonly known as UV-C, in order to make pathogens inactive. The amount of UV-C radiation applied to a given volume over a specific time period is commonly referred to as UV 'dosage'. Therefore, UV dosage is comprised of two factors, the irradiance of the UV light and the length of exposure to the radiation, as defined by the following equation:

UV Dose (mJ/cm^2) = Intensity (millijoules/(sec) (cm^2)) x Time

It is known in published journals that reaching certain UV-C dosage eliminates particular pathogens. The present apparatus is capable of eliminating pathogens that are highly resistant such as MRSA, Legionella, Rotavirus, Norovirus as well as many more lesser known pathogens, and the present apparatus can be designed accordingly to meet various regulatory standards. For example, Optimal Sterilisation/Class A* (High UV Dosage) as set out by the USA's National Science Foundation (NSF) can be achieved with this design through a multitude of factors. Therein lies the distinction between this device and other 'tank' type set-ups that are currently on the market. The novel aspects of the present invention allow it to successfully sterilise liquid at standard flow rates of modern faucets (between 6-10 litres/minute), although it will be readily appreciated by the skilled person that scaled up versions could achieve greater flow rate results. In terms of scale, the current device achieving these results fits comfortably as an adaptor or as an integrated design for a faucet.

2. Minimising Area through the use of Reflective Material:

The design maximises UV-C dosage by effectively minimising the area through which the liquid passes into a serpentine or spiral tube system. This small tube area/diameter can be determined on a case by case basis depending on the necessary flow rate required for the device. By optimising the materials on the inside of the tubing with highly reflective properties, the efficiency of the UV Dosage equation can be shifted in the invention's favour. Using a preferential material like e-PTFE (expanded-PolyTetraFluoroEthylene) with a reflection efficiency of 95% coated on the inside of the tubing allows the UV-C radiation to effectively remain in contact with the liquid for as long as possible. Standard commercial disinfection systems use stainless steel as the primary material. While this surface is highly resistant to microbial growth it only has a 20-28% reflectance of UV light in comparison. Microbial growth resistance is important in more static systems but due to the rate of flow through the present device, e-PTFE is used to ensure optimal sterilisation through reflection. The following list gives an indication of relative reflection efficiencies for various materials, which list shows why e-PTFE would be a preferred, though not essential, material for the tube lining: E-PTFE - 95%, Aluminium (sputtered on glass) - 80%, Aluminium Foil - 73%, Stainless Steel (formula dependent) - 20-28%.

3. Curvature of the design to increase dosage time whilst maintaining flow rate: Using a curved, spiralling or serpentine tube allows the device to effectively increase UV dosage by increasing the length of time that the water has to travel through the device before reaching the outlet, thereby shifting the UV dosage further in favour of sterilisation. The curved nature of the device enables minimal axial usage of space. The angle of reflection of the UV-C radiation is set up in such a way to as to reflect all the way down the length of tube (in a similar way to the TIR discussed in reference to the coloured LED into a laminar flow). Of note is that due to the flowing nature of the water through the device and the reflection of the UV-C radiation due to the choice of material, the same small area of water (less than 1cm^2) is 'hit' multiple times with the high intensity UV radiation (because light travels faster than liquid). This creates a cumulative effect where a very small area of water (due to pipe diameter) is radiated to a specified UV dosage (in the case of the design illustrated below the UV-C LED bulb is 11.5 mW for example) not just once but multiple times due to both the reflection of the radiation through the tube and the subsequent speed of the UV-C rays/photons vs the liquid. This cumulative flowing effect should not be underestimated with regards to maximising UV Dosage.

More generally, UV-C treatment compares favourably with other water disinfection systems in terms of cost, labour, and the need for technically trained personnel for operation. Water chlorination treats larger organisms and offers residual disinfection, but these systems are expensive because they need special operator training and a steady supply of a potentially hazardous material. Finally, boiling of water is the most 'reliable' treatment method but it demands labour, and imposes a high economic cost. UV-C treatment is rapid and, in terms of primary energy use is perhaps 20,000 times more efficient than boiling.

UV-C is most effective for treating high-clarity, purified, reverse osmosis distilled water. Suspended particles (dirty water for example) can be a problem because micro-organisms or pathogens may be buried within particles and are shielded from the UV light and can pass through the unit unaffected. The preferred inclusion of ultrasound cavitation devices as shown below are the best solution to this apparent disadvantage.

A preferred embodiment of the present invention utilises a method of cleaning called 'hydrodynamic caviation' combined with a mild form of cyclonic separation due to the curvature of the tubing. The device achieves this by using an ultrasound transducer made from piezo ceramic plates vibrating at approximately 358 KHz for example. The ultrasonic transducers use the housing of the apparatus as the resonant chamber allowing the cavitation to happen whilst inside the tubing as opposed to in a separate tank.

The cavitation works by the water entering the tubing at such an angle as to cause the water to vortex. This causes any particles to be separated & pushed to the outside of the vortex (tubing). The ceramic plates vibrate at a speed that cause micro bubbles less than 50 micro meters across to form around any foreign particles within the fluid, be that solid matter, a virus, bacteria, phenols, solvents and cyanobacterial blooms. (Also pharmaceuticals such as Naproxen, diclofenac, ibuprofen, aspirin & some of the oestrogens & hormones being increasingly found in 'filtered' water supplies). As the micro bubble is formed it explodes (cavitates) with such force that it vaporizes the foreign particle. For a nano-second the pressure inside the bubble can reach 10K atms and a temp of 5000K. This hydrodynamic cavitation works in tandem with the UV-C by breaking up the larger particles that the UV-C may otherwise be unable to penetrate.

The device will now be discussed in reference to the attached figures 6 to 20. Embodiments of the invention will now be described in more detail. The description makes reference to the accompanying diagrammatic drawings in which:

Figure 1 is a lengthwise perspective sectional view through a dispensing device according to the present invention,

Figure 2 is a lengthwise sectional view of a downstream part of the dispensing device shown in figure 1 in use,

Figure 3 is a section taken on line A-A of figure 2,

Figure 4 is a section taken on line B-B of figure 2, and

Figure 5 is a section taken on line C-C of figure 2,

Figure 6 is a side view of a liquid supply device incorporating a UV ray apparatus according to the present invention,

Figure 7 is a central lengthways cross-section through the liquid supply device shown in figure 6,

Figure 8 is a side view of the UV ray apparatus incorporated in the device shown in figure 7,

Figure 9 is a central lengthways cross-section through the UV ray apparatus shown in figure 8,

Figure 10 is a perspective view of a tube part of the UV ray apparatus of figure 9,

Figure 11 is a perspective view from below of a top end plate of the UV ray apparatus of figure 8,

Figure 12 is a perspective view from above of the top end plate show in figure 11,

Figure 13 is a side view of the top end plate of figure 11,

Figure 14 is a sectional view on line 14-14 of figure 9 showing a UV LED of the UV ray apparatus,

Figure 14a is a sectional view on line A-A of figure 14,

Figure 15 is a plan view of a turbine rotor incorporated in the device of figure 7,

Figure 16 is a cross-section on line 16-16 of figure 15,

Figure 17 is a side view of part of an electronics module incorporated in the device of figure 7,

Figure 18 is a side view of another part of the electronics module incorporated in the device of figure 7,

Figure 19 is a view from below the part shown in figure 18, and

Figure 20 is a plan view of a laminar flow device incorporated in the device of figure 7.

In figures 1 to 5 there is shown one embodiment of a dispensing device or adaptor 10 for use with a tap or faucet (not shown) for dispensing a liquid such as water. Water is the preferred liquid, but it will be appreciated that the adaptor could be used in a modified form with other liquids. As mentioned in the introductory paragraphs above, it is generally known to introduce a coloured light into a flow of liquid in an attempt to illuminate the water. It is also known for the lights to change colour, perhaps by virtue of a multi-coloured LED, and this may be done in association with a temperature sensor such that if the water is above a predetermined temperature then the LED is red, if it is below a predetermined temperature then the LED is blue and if the temperature is within a preferred range then the LED is green.

The present adaptor 10 has an inlet 11 and an outlet aperture 12 which is axially downstream of the inlet 11. In the illustrated embodiment, the inlet incorporates a coupling arrangement in the form of a ball and socket pairing 13 having a through bore 14. The upstream end 15 of the coupling may be screw-threaded for attachment to a tap, although other coupling methods are of course possible. The ball and socket coupling 13 enables the orientation of the adaptor 10 to be varied so as to alter the direction of the flow from the adaptor 10, as is well known. The ball and socket coupling 13 is however optional and the adaptor could be coupled to a tap in a fixed orientation.

The adaptor 10 comprises an external housing 16 having generally cylindrical side walls 17 closed by a lower end wall 18 in which the outlet aperture 12 is formed. For reasons that will be explained, the aperture 12 has clean, sharp edges that are substantially free of imperfections. An ovoid, preferably circular, aperture is ideally suited to producing such clean, sharp edges.

The inside of the housing 16 is divided into two compartments 19, 20 by an internal wall 21. The larger main compartment 19 extends from the inlet to the outlet aperture and accommodates the flow of liquid through the adaptor. The smaller side compartment 20 incorporates an electronic control device 22, and an LED 23 which is provided behind a lens 24. A power source such as a battery (not shown) is housed in a chamber 25 which extends into the main compartment 19 but which communicates with the side compartment so that the LED 23 and the control device 22 can be powered. Depending on size and space, the battery could be located elsewhere in the side compartment thereby avoiding the need for the chamber 25. The housing 16 also has an openable/closeable access door 26 enabling access to the side compartment 20 and/or chamber 25 for maintenance or repair or battery changing. The access door 26 is however optional and a sealed unit could be provided, the whole adaptor being replaced when the battery expires.

The main compartment 19 houses a laminar flow device 30 which is provided at a location which is spaced from the end wall 18 and the outlet aperture 12 by a reservoir 31. The lower face of the laminar flow device 30, when looking along the longitudinal axis X of the adaptor from the upstream inlet end towards the downstream outlet end, completely overlies the outlet aperture 12 as illustrated in figure 4 in which the outlet aperture 12 is visible through the laminar flow device 30. The lens 24 of the light source is laterally offset from the laminar flow device and is effectively located in the reservoir 31, sealing the side compartment 20 from the liquid/water in this particular embodiment. It is however envisaged that the components in the side compartment 20 could be individually sealed such that the side compartment 20 could also contain liquid.

The laminar flow device 30 is designed to laminate the liquid such that at the downstream end of the laminar flow device 30, the liquid flow into the reservoir is laminar and non-turbulent. Laminar flow devices are known and in this particular arrangement the construction of the laminar flow device 30 comprises a multiplicity of closely packed straight tubular passages 32 with the axes of the tubular passages being parallel to each other and parallel to the longitudinal, upstream to downstream axis X of the adaptor 10. In the illustrated arrangement, the tubular passages 32 are formed in a single block element 33 with the walls between the individual passages being as thin as possible. The lateral cross-section of each passage may be circular but other shapes such as hexagonal are possible to maximise the combined area of the passages and minimise the combined area of the thin walls. In alternative arrangements, the unitary block 33 containing the tubular passages 32 could be replaced by a multiplicity of individual thin-walled tubes held together in a close-packed formation.

Just upstream of the laminar flow device 30 is an optional liquid deceleration means 35. The deceleration means 35 can take one of a number of forms such as a mesh or a sponge or a foamed plastic or baffle walls or a combination of these. The deceleration means 35 essentially slows the liquid down so as to enable the laminar flow device 30 to work more effectively. The deceleration means 35 would not of course be required where the inlet liquid pressure is low enough for deceleration not to be required.

Figures 1 and 2 also show an optional UV light 36 disposed behind a further lens 37 located in the internal wall 21 upstream of the laminar flow device 30 and the optional deceleration means 35. The UV light 36 is connected to the power source and the control device 22. UV light has been found to have anti-microbial/anti-bacterial properties such that the illustrated embodiment will dispense purer water than the standard tap.

When liquid such as water flows through the tap and into the adaptor 10 the flow of liquid is slowed if necessary by the optional deceleration means 35. The liquid is then 'straightened' in the laminar flow device 30 by virtue of the multiplicity of tubular passages 32. The liquid then passes into the reservoir 31 and exits the adaptor 10 through the outlet aperture 12. The clean, sharp edges of the outlet aperture ensure that the liquid flow remains laminar or straight such that the flow of liquid exiting the adaptor is in the form of a smooth-sided laminar column 40. Ideally the exterior surface of the column of liquid is perfectly smooth, although this is somewhat dependent on the 'cleanness' or 'sharpness' of the outlet aperture 12 because any imperfections will adversely affect the smoothness of the laminar column 40 exiting the outlet aperture 12.

The lens 24 and associated LED (or other light) is angled and specified such that it directs a light beam 41 through the water in the reservoir and through the outlet aperture 12 to the interface between the laminar flow 40 of liquid and the surrounding air at a point outside the device 10. The angle of incidence θ of the light beam 41 where it meets the interface between the laminar flow 40 of water and the surrounding air is greater than or equal to the critical angle θ_c such that the light beam is internally reflected inside the laminar flow of water 40. If the angle of incidence was less than the critical angle θ_c then the light beam would be refracted at the interface between the water and the air and would pass out of the laminar flow of water with no internal reflection as indicated by beam 42 in figure 2.

Every material that light can be shone through has an "Index of Refraction" which is a number that indicates the number of times slower that a light wave would be in that material than it is in a vacuum. A vacuum has an index of 1. Water has an index of 1.333 and air has an index of 1.0003. Total internal reflection (TIR) can only occur when the light is travelling from a more optically dense material to a less optically dense material, e.g. water to air, hence the positioning of the lens 24 of the light source in contact with the water in the reservoir.

The optimum angle at which TIR is achieved is referred to as the critical angle and this is calculated by taking the inverse sine of the ratios of each medium's index of refraction for water to air:

$$\text{Critical angle} = \text{Sin}^{-1}\left(\frac{1.0003}{1.333}\right) = 48.626\,°$$

where 1.0003 = Index of Refraction of air

1.333 = Index of Refraction of water

Hence the critical angle for water/air combination is 48.626 so, in the present arrangement for a water tap, the lens is set to deliver the light beam 41 with an angle of incidence of 48.626° or greater. The preferred range of angle of incidence θ is in the range of 49° to 70°, the actual angle having an effect on the intensity of the illumination.

When TIR is achieved, the resulting laminar flow of liquid has the appearance of a coloured shaft or column of light, similar to an illuminated shaft of coloured glass with no or minimal lateral splashing of liquid. This effect is not only pleasing to the eye but has particular benefit to indicate that a tap is running. In embodiments where the colour of the light beam changes depending on the temperature of the water, the illuminated coloured flow is particularly beneficial for giving an indication that the liquid is too hot or too cold in comparison to known devices.

Whilst the arrangement discussed above incorporates a battery (either replaceable or non-replaceable) as a power source it is also envisaged that the battery could be replaced or supplemented by a power generating device within the housing 16 upstream of the laminar flow device and deceleration means if provided. Such a power generating device may in one version comprise a rotating impeller driven by the inlet flow of liquid, the shaft of the impeller driving an electrical generator either directly or via a gearbox arrangement. In such embodiments it is possible to include fins or other walls in the inlet area to optimise the direction of the inlet flow through the impeller.

It will be appreciated by the skilled person that instead of the optional temperature sensor which may be used in order to vary the colour of the light emitted by the LED, other sensors could be used to measure other properties of the liquid flow or even other properties including external conditions to vary the light accordingly.

The adaptor 10 described above is shown as an after-market device which can be coupled to an existing tap or faucet. However it is also envisaged that the device could be incorporated unobtrusively within a tap or faucet.

Figures 6 to 20 show an embodiment of a UV ray apparatus 50 for use in a liquid supply device 51. The apparatus 50 is primarily for use in supplying water but could be adapted for use in supplying other liquids. In particular, the apparatus could be incorporated in a tap or faucet (not shown) or could be an after-marked product which can be coupled to an existing tap/faucet. Alternatively, the apparatus could be incorporated in larger liquid or water treatment plants.

The liquid supply device 51 shown in the figures is adapted to be attached to an existing tap/faucet. The device 51 comprises an external housing 52 comprising an upstream portion 53 and a downstream portion 54 which are removable coupled together by means of a suitable connection such as a screw thread 52a.

The housing 52 has a generally circular cylindrical side wall 55 with domed ends 56, 57. The upstream domed end 56 has a main liquid inlet 58 provided by a neck portion 59 which is adapted to be secured to a liquid supply means (such as a tap) for example with a screw threaded connection or push-fit connection or other suitable connection. The downstream domed end 57 has a main liquid outlet 60 in the form of a circular aperture in this instance, although other shapes are possible. The main inlet 58 and outlet 60 are disposed on a central longitudinal, upstream to downstream, axis X-X of the device, but this is an example, not a limiting feature. Normally the external housing 52 would be made from metal such as stainless streel or aluminium or a suitable plastic material.

Housed within the external housing 52 is the UV ray apparatus 50. In this embodiment the UV ray apparatus is disposed within an internal housing 61. The internal housing 61 is generally circular cylindrical and dimensioned to be received within the interior volume of the external housing 52. The housing 61 has a generally axial through bore 62 defined by a central cylindrical wall 63. The housing 61 defines an annular internal volume 64 between the central wall 63 and the external cylindrical wall 65. The volume 64 is closed-off by top and bottom plates 66, 67, the bottom plate 67 in this particular embodiment being connected to a frusto-conical lower portion 68 of the cylindrical wall 63.

Above the top plate 66 and partially defined by the domed end 56 is an upstream chamber 69 which receives liquid from the liquid supply via the main inlet 58. Associated with the top plate 66 (and/or the domed end 56) are one or more ultrasonic transducers/emitters 70 which, when powered, induce cavitation in the liquid in the upstream chamber 69.

The top plate 66 is formed with an inlet opening 71 which connects to a spiral tube 72 which is coiled within the volume 64 of the housing 61. The inlet opening 71 may also incorporate a lead-in groove 73 in the upper face of the top plate 66 to encourage flow of liquid in the upstream chamber into the opening 71 and subsequently into an inlet 72a of the spiral tube 72. In the illustrated embodiment a single, downwardly extending spiral tube 72 is provided, but it is envisaged that alternative tube configurations/shapes/dimensions are possible and indeed an additional tube or tubes could be provided depending on spatial availability within the volume 64. Although a spiral shape for the tube is illustrated, it will become apparent that other non-linear and serpentine configurations will be possible. In this embodiment the spiral tube 72 is disposed adjacent the external wall 65 so as to maximise the length of tube.

The present tube 72 is a thin-walled aluminium tube, preferably with an internal e-PTFE coating. The close-formed spiral of the tube 72 enables a long tube to be provided in a small axial space, the longer the tube meaning that the liquid is disposed within the tube 72 for a longer period of time.

At the downstream end of the tube 72, the outlet 72b of the tube 72 discharges through an opening 76 in the bottom plate 67 of the internal housing 61. The outlet of the tube 72/opening 76 direct the flow of liquid at a turbine 75 comprising a rotor which incorporates multiple turbine blades 75a intended to maximise the use of the flow in the creation of power as is known. For simplicity, the componentry of the generating means associated with the turbine 75 are not shown but numerous alternatives would be apparent to the skilled person.

Incorporated at or adjacent the exit from the internal housing 61 there is provided a UV-C ray emitter 74 such as a UV-C LED although larger, more powerful emitters may be utilised in larger arrangements. The UV-C ray emitter is housed in a small pocket 77 aligned with the outlet 72b of the tube 72 and there may be a UV-transparent sealing compound to protect the emitter 74 from the liquid flowing past. The emitter 74 is arranged to focus the direction of its UV-C rays up the spiral tube 72. The UV-C rays will be reflected off the internal walls of the tube a number of times (depending, for example, on the tube length, angle of beam, radius of curvature of the spiral) before the rays emerge at the inlet 72a of the tube 72. The interior of the tube 72 is effectively ‘soaked’ in UV-C rays along its entire length such that liquid/water passing along the tube 72 is exposed to UV-C for its entire passage along the tube.

Purely for illustration purposed, in some particular arrangements the power output of the UV-C emitter 74 will be in the region of 11.5 mW, the overall diameter of the external housing will be in the region of 6 cm, and its length in the region of 14 cm. This is however just one example of numerous alternatives dependent on the various design parameters discussed in the introduction.

The turbine 75 is associated with a sealed electronics module 80 in which an electricity generator is provided, together with rechargeable batteries and control electronics, the turbine rotor rotating about a portion 85 of the electronics module 80 which provides suitable bearing surfaces. Power from the electronics module 80 can then be supplied to the ultrasonic tranducers/emitters 70 and to the UV-C emitter 74. The shape/form of the electronics module 80 is a matter of design choice given the spatial constraints of the device. The electronics module 80 is in this embodiment conveniently made in two-parts 80a, 80b which can be secured together and disconnected perhaps with a screw-threaded connection to enable access to the interior volume of the electronics module 80. In this embodiment the electronics module 80 has a shaft portion 81 which is received in the through bore 62 of the internal housing 61 with a seal element 82 such as an O-ring being provided between the shaft portion 81 and the through portion 62 so that liquid in the upstream chamber 69 cannot flow through the bore 62 but must move downstream only via the spiral tube 72.

The shaft portion 81 has at its lower, downstream end a radially wider section 83 having a frusto-conical upper surface 84 which mates within the frusto-conical lower portion 68 of the cylindrical wall 63. Another seal element 82 may seal these mating frusto-conical surfaces and in such circumstances that frusto-conical seal could replace the seal along the shaft portion 81 of the electronics module 80. It will be appreciated that the shape and location of the electronics module 80 is a matter of design choice. The particular example illustrated is one of numerous alternatives and has been selected to fit best with the other components of the illustrated UV ray apparatus.

Extending from the base of the electronics module 80 are three legs 90, although a different number of legs 90 could be provided. The legs 90 extend through associated through holes 95 provided in a laminar flow device 30 which may be of the sort described above in connection with figures 1 to 5. The legs 90 have upper shoulders 91 against which the laminar flow device 30 bears, spaced from the base of the electronics module. The lower surface of the laminar flow device 30 is retained at its edges on a suitable annular shoulder 92 (or circumferentially spaced projections) provided on the inside surface of the housing 52.

Upstream of the laminar flow device 30 and below the turbine 75 is a downstream chamber which receives the liquid from the spiral tube 72 after it has passed through the turbine 75 to extract power. The liquid then passes through the laminar flow device to a reservoir 31 which corresponds to the reservoir described above in connection with figures 1 to 5.

One or more of the legs 90 incorporates at a lower end a light/lens combination (23/24) of the sort described above in connection with figures 1 to 5, the LED/lens combination(s) directing their light beam at a suitable angle (as described above) through the main outlet 60 (which corresponds to the outlet aperture 12 described above in relation to figures 1 to 5) such that TIR occurs in the existing laminar flow of water. Similar technical considerations apply in the embodiment of figures 6 to 20 as they did in the embodiments of figures 1 to 5.

The laminar flow device 30 is also shown with an optional central through hole 93 for receiving an optional central light beam from a further light source (not shown) in the electronics module 80 shining through optical central lens 95 in the lower face of the electronics module 80.

Although the embodiment of figures 6 to 20 includes other features in addition to the UV ray apparatus, namely the ultrasonic transducers/cavitation, the turbine/electricity generation, electronics module, laminar flow device and lighting of the laminar flow at the main outlet, it will be appreciated that the invention in this present aspect is the provision of the non-linear tube and the UV-C emitter directing the UV-C beam down the tube such that the beam is reflected off the internal surface of the tube a number of times between the two ends of the tube. However, the particular combination of the UV-C ray apparatus with the coloured laminar flow aspect does provide distinct advantages in certain situations, such as healthcare environments. This is because treated water is clearly beneficial and the benefits of a temperature controlled colour to the outlet flow are discussed earlier in the specification.

It will be readily appreciated by the skilled person that although the embodiments of figures 6 to 20 incorporate an in-built generator, all embodiments could be powered either by such a generator, batteries (replaceable or rechargeable) or could be powered by an external power source by means of suitable electrical connections/wiring. It will be noted that the wiring/connections for the UV-C LED, coloured LEDs and ultrasonic transducers has not been shown but this detail would be within the skill set of the person skilled in the art.

Whilst the UV-C ray emitter 74 is shown directing UV-C rays up the tube 72 from the outlet end of the tube 72 it could alternatively, or additionally, be provided at the inlet end of the tube 72. Directing the UV-C rays up the tube 72 can minimise the possibility of any UV-C rays exiting the device via the outlet 60.

It will be further appreciated by the skilled person that the materials of construction are a matter of design choice, although metal or plastic or a combination thereof is envisaged. Similarly the particular shape and size of the adaptor can be varied according to the particular applications of the devices, flow requirements and/or aesthetics.

CLAIMS

1. A UV ray apparatus for use in a liquid supply device, the apparatus comprising: an elongate tube having a first end and a second end, one of said ends constituting a liquid inlet and the other constituting a liquid outlet, a UV-C ray emitter provided adjacent the first end of the tube and configured to direct a UV-C beam along the inside of the tube, wherein the tube is non-linear between its first and second ends and is configured such that the UV-C beam is reflected off an internal surface of the tube a multiple number of times between the first end and the second ends.

2. A UV ray apparatus as claimed in claim 1 wherein the tube defines a serpentine path between the inlet and the outlet and is preferably of circular cross-section.

3. A UV ray apparatus as claimed in claim 2 wherein the tube is spiral in form and defines a circular spiral path between the inlet and the outlet, the first end preferably being the liquid outlet.

4. A UV ray apparatus as claimed in any one of claims 1 to 3 wherein the internal surface of the tube is e-PTFE and the tube is preferably made from aluminium.

5. A UV ray apparatus as claimed in any one of claims 1 to 4 wherein the angle of incidence of the UV-C beam relative to the internal surface of the tube is in the range 10° to 60° and preferably in the range 40° to 50°.

6. A UV ray apparatus as claimed in any one of claims 1 to 5 wherein the UV-C ray emitter is a UV LED.

7. A UV ray apparatus as claimed in any one of claims 1 to 6 wherein the apparatus includes a power source for the UV-ray ray emitter.

8. A liquid supply device comprising a UV ray apparatus as claimed in any one of claims 1 to 7 wherein the device further comprises an external housing defining

an internal volume in which the UV ray apparatus is received, and having a housing inlet and a housing outlet.

9. A liquid supply as claimed in claim 8 wherein the volume includes an upstream chamber between the housing inlet and the liquid inlet of the UV ray apparatus, the UV ray apparatus being provided in an enclosed volume within the external housing such that the tube provides the only path for the liquid from the upstream chamber towards the housing outlet.

10. A liquid supply as claimed in claim 9 wherein the liquid supply device includes at least one ultrasonic inducer configured to induce cavitation in the liquid in the upstream chamber prior to entering the tube inlet.

11. A liquid supply device as claimed in claim 9 or claim 10 further comprising an electronics module sealed from the liquid and disposed within the external housing to power the UV-C ray emitter.

12. A liquid supply device as claimed in claim 11 wherein the electronics module is powered by means of a rotatable turbine arranged adjacent the liquid outlet of the tube and configured to provide power to the electronics module via a generating means.

13. A liquid supply device as claimed in claim 11 or 12 wherein downstream of the tube outlet is a laminar flow device and there is further provided a reservoir between the laminar flow device and the housing outlet aperture such that, in use, a laminar flow of liquid exits the housing outlet, and there is further provided a light source in the reservoir arranged to direct a light beam through the housing outlet, the angle of incidence of the light beam to the laminar flow of liquid exiting the outlet aperture being greater than or equal to the critical angle of the liquid.

14. A liquid supply device as claimed in claim 13 wherein the electronics module has at least one leg extending through the laminar flow device into the reservoir, the leg incorporating the light source.

15. A liquid supply device as claimed in claim 13 or claim 14 wherein an outlet area of the laminar flow device is greater than the area of the housing outlet aperture and entirely overlies the housing outlet aperture when viewed axially from upstream to downstream, the housing outlet aperture having clean, sharp edges free of imperfections.

16. A liquid supply device as claimed in any one of claims 8 to 15 wherein the housing outlet aperture is circular.

17. A liquid supply device as claimed in any one of claims 13 to 16 wherein the light source incorporates an LED and a lens adjacent the laminar flow device and radially offset from the outlet aperture.

18. A liquid supply device as claimed in any one of claims 13 to 17 wherein the light source is configured to provide light beams of different colours.

19. A liquid supply device as claimed in claim 18 wherein there is provided a sensor, the colour of the light beam being determined by the property sensed by the sensor, preferably temperature.

20. A liquid supply device as claimed in any one of claims 13 to 19 wherein the laminar flow device comprises a multiplicity of close-packed straight tubular passages, the axes of the tubular passage being parallel to each other and to a longitudinal, upstream to downstream axis of the device.

21. A liquid supply device as claimed in claim 20 wherein the tubular passages have one or more of the following features:

    i) they are formed in a single block, the walls between the tubular passages being thin,
    ii) they are defined by a multiplicity of individual thin-walled tubes held together in a close-packed formation,
    iii) they are circular or hexagonal in lateral cross-section.

22. A liquid supply device as claimed in any one of claims 13 to 21 wherein the angle of incidence of the light beam is greater than 48.62°.

23. A liquid supply device as claimed in any one of claims 8 to 22 wherein the external housing comprises two portions which are sealingly yet releasably secured to each other.

24. A dispensing device for delivering a liquid, the device comprising:

an inlet,

an outlet aperture downstream of the inlet,

a laminar flow device provided between the inlet and the outlet aperture,

a reservoir provided between the laminar flow device and the outlet aperture such that in use a laminar flow of liquid exits the outlet aperture, and

a light source provided in the reservoir and arranged to direct a light beam through the outlet aperture,

wherein the angle of incidence of the light beam to the laminar flow of liquid exiting the outlet aperture is greater than or equal to the critical angle of the liquid.

25. A dispensing device as claimed in claim 24 wherein the outlet area of the laminar flow device is greater than the area of the outlet aperture and entirely overlies the outlet aperture when viewed axially from upstream to downstream.

26. A dispensing device as claimed in claim 24 or claim 25 wherein the outlet aperture has substantially clean, sharp edges which are substantially free of imperfections.

27. A dispensing device as claimed in claim 26 wherein the outlet aperture is circular.

28. A dispensing device as claimed in any one of claims 24 to 27 wherein the light source comprises a lens provided adjacent the laminar flow device, offset from the outlet aperture, and further comprises an LED behind the lens.

29. A dispensing device as claimed in any one of claims 24 to 28 further comprising a power source wherein the power source comprises a battery.

30. A dispensing device as claimed in any one of claims 24 to 28 further comprising a power source wherein the power source comprises a generator incorporating an impeller disposed downstream of the inlet and upstream of the laminar flow device.

31. A dispensing device as claimed in claim 30 wherein the inlet provides liquid diverting walls to direct the inlet flow of liquid to the impeller at a predetermined angle.

32. A dispensing device as claimed in any one of claims 24 to 31 wherein control means are provided for controlling the power source and the light source.

33. A dispensing device as claimed in claim 32 wherein the control means are provided in a side compartment which is laterally offset from the laminar flow device.

34. A dispensing device as claimed in claim 33 wherein the side compartment is sealed against ingress of liquid.

35. A dispensing device as claimed in any one of claims 24 to 34 wherein the light source is capable of providing light beams of different colours.

36. A dispensing device as claimed in claim 35 wherein there is provided a sensor, the colour of the light beam being determined by the property sensed by the sensor.

37. A dispensing device as claimed in claim 36 wherein the sensor is a temperature sensor which is provided upstream of the laminar flow device and which in use of the device measures the temperature of the liquid.

38. A dispensing device as claimed in any one of claims 24 to 37 wherein deceleration means are provided upstream of the laminar flow device to slow the flow of liquid.

39. A dispensing device as claimed in claim 38 wherein the deceleration means comprises one or more of the following: mesh, sponge, foamed plastic, baffle means.

40. A dispensing device as claimed in any one of claims 24 to 39 wherein the laminar flow device comprises a multiplicity of close-packed straight tubular passages, the axes of the tubular passages being parallel to each other and to a longitudinal, upstream to downstream axis of the device.

41. A dispensing device as claimed in claim 40 wherein the tubular passages are formed in a single block, the walls between the tubular passages being thin.

42. A dispensing device as claimed in claim 40 wherein the tubular passages are defined by a multiplicity of individual thin-walled tubes held together in a close-packed formation.

43. A dispensing device as claimed in any one of claims 40 to 42 wherein the tubular passages are circular or hexagonal in lateral cross-section.

44. A dispensing device as claimed in any one of claims 24 to 43 wherein the angle of incidence is greater than 48.62°.

45. A dispensing device as claimed in any one of claims 24 to 44 wherein a UV light powered by the power source is provided between the inlet and the laminar flow device.

46. A dispensing device as claimed in any one of claims 24 to 45 wherein coupling means are provided adjacent the inlet for coupling the dispensing device to a tap.

47. A dispensing device as claimed 46 wherein said coupling means incorporates a ball and socket coupling to enable the orientation of the dispensing device to be varied.

48. A tap incorporating a UV ray apparatus as claimed in any one of claims 1 to 8 or a liquid supply device as claimed in any one of claims 9 to 23 or a dispensing device as claimed in any one of claims 24 to 47.

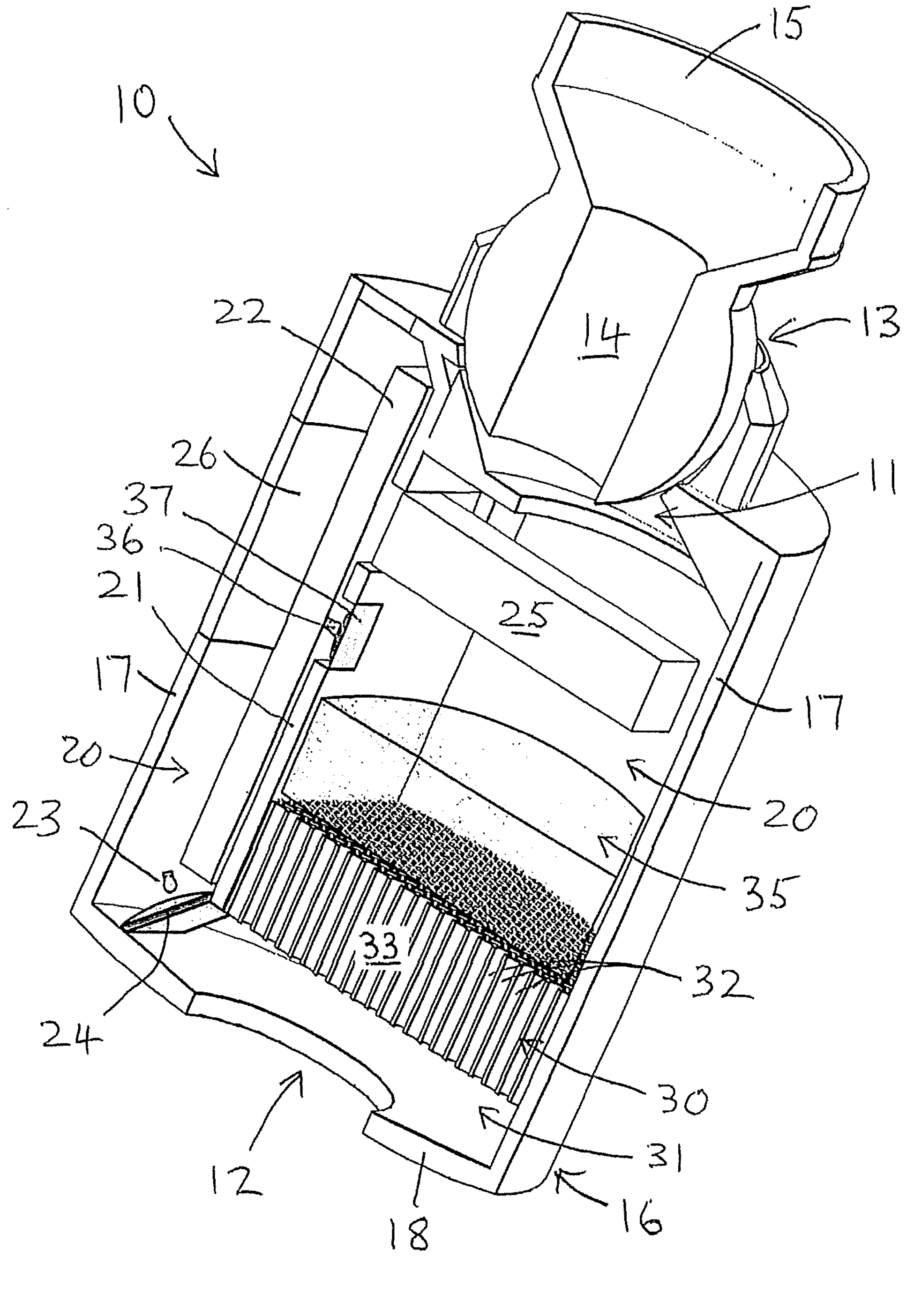

10
15
14
13
22
26
11
37
36
25
21
17
17
20
20
23
35
33
32
24
30
12
31
18
16

FIGURE 1

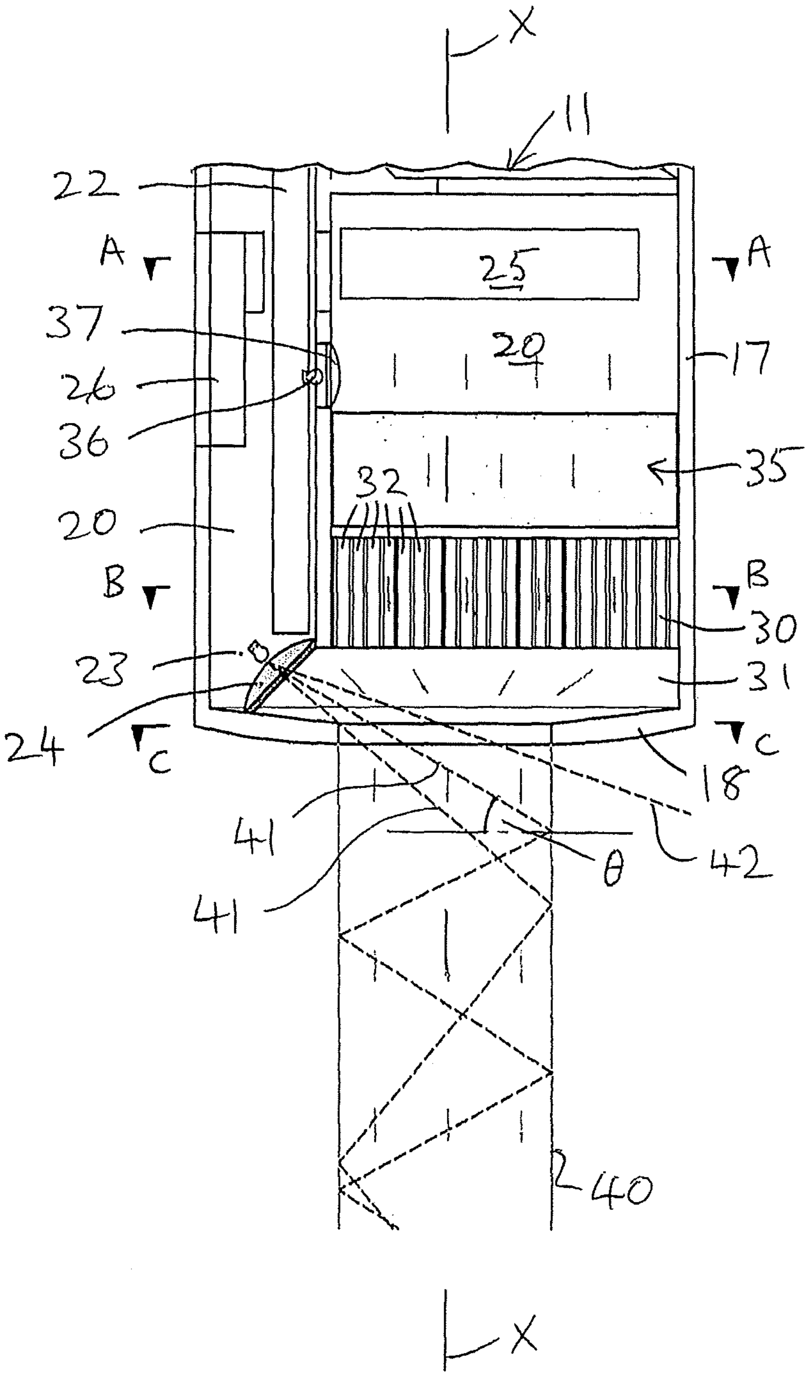


FIGURE 2

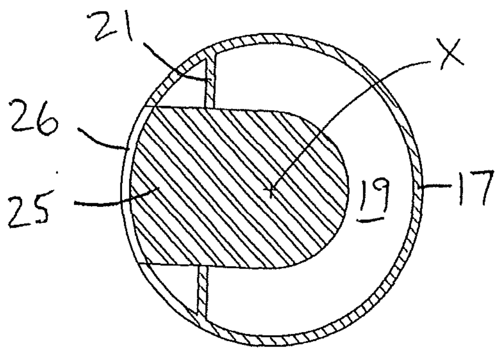


FIGURE 3

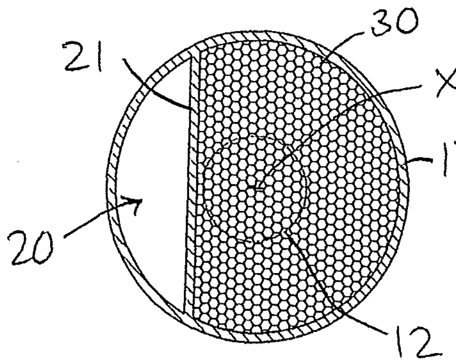


FIGURE 4

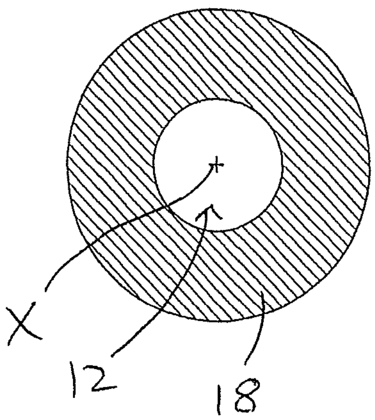


FIGURE 5

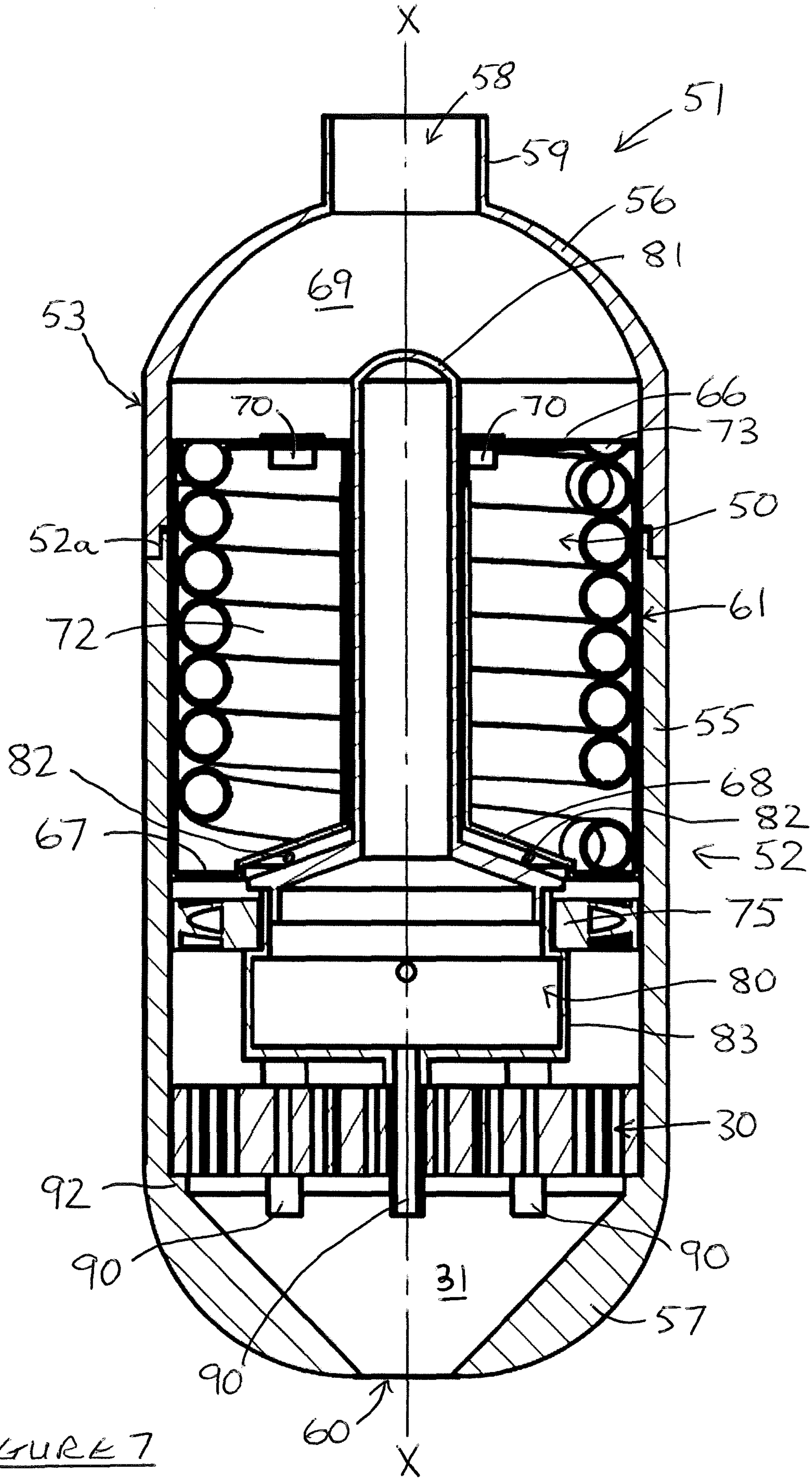

X
58
51
59
56
81
69
53
70
70
66
73
50
52a
61
72
55
82
68
82
67
52
75
80
83
30
92
90
90
31
57
90
60
X

FIGURE 7

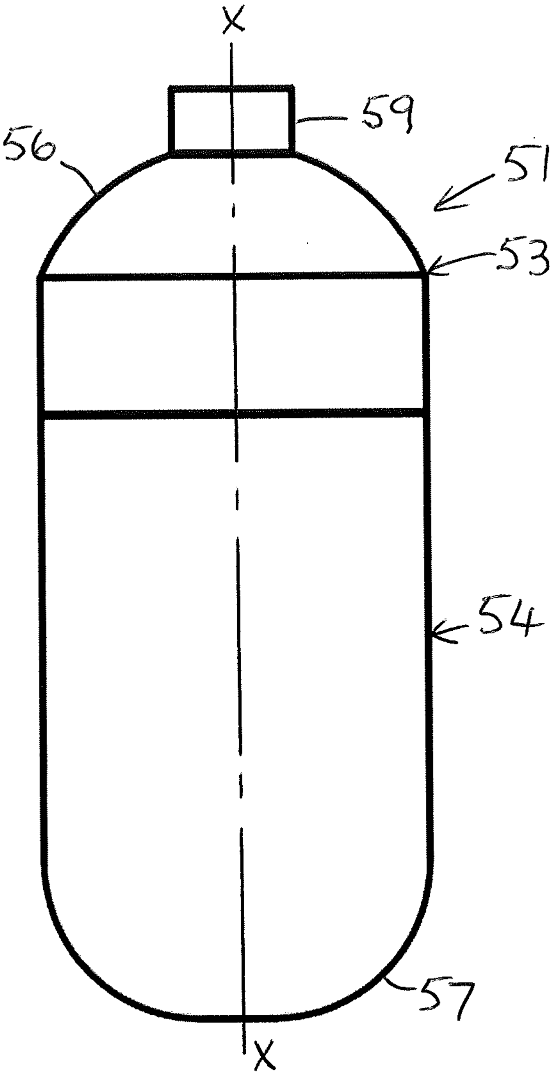


FIGURE 6

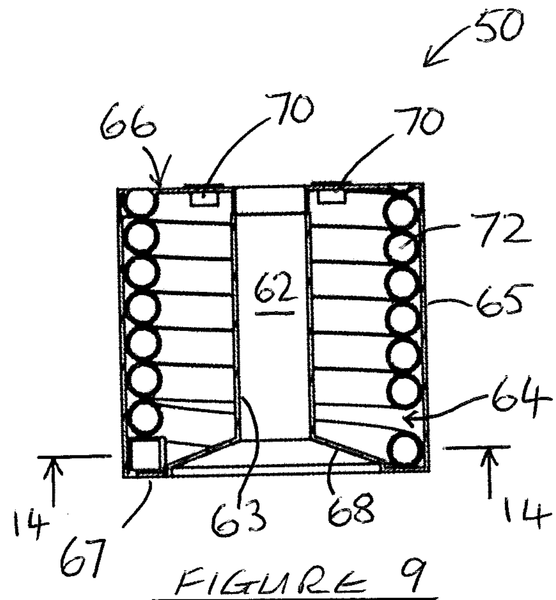


FIGURE 9

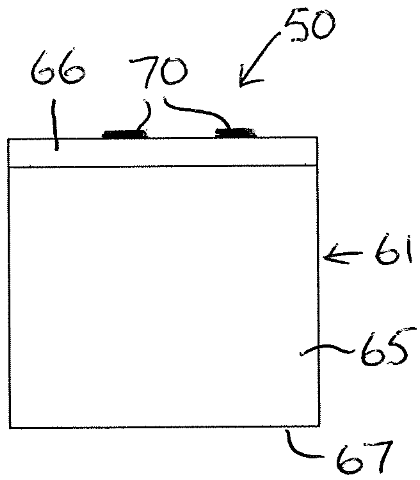


FIGURE 8

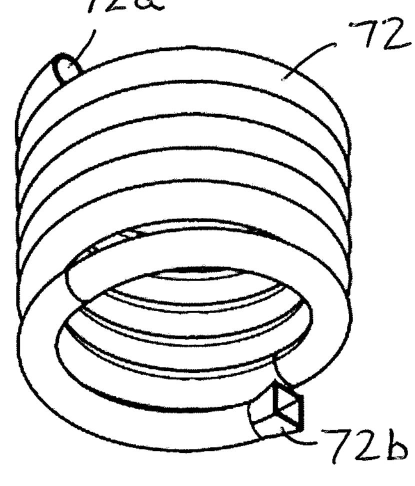


FIGURE 10

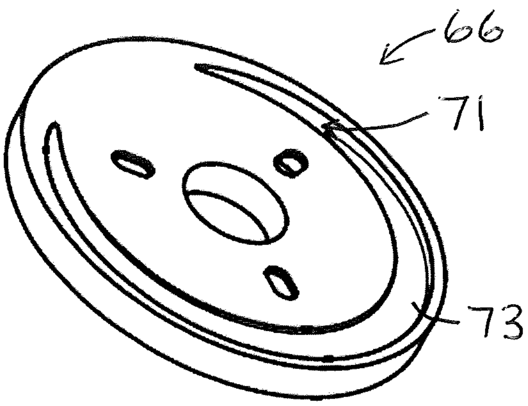


FIGURE 12

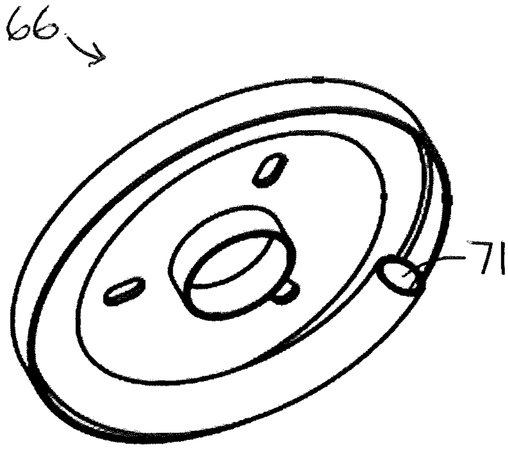


FIGURE 11

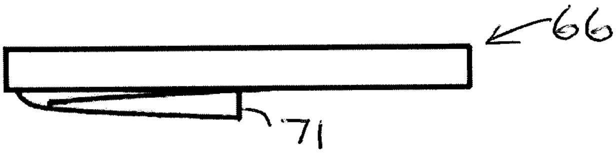
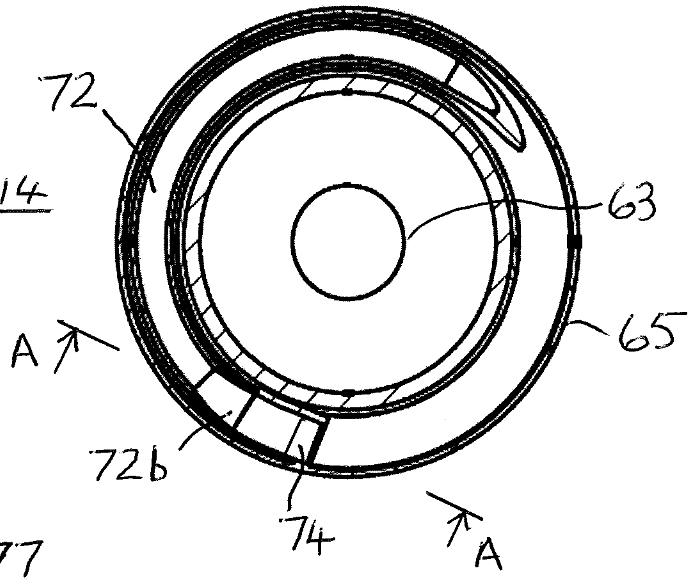


FIGURE 13

FIGURE 14



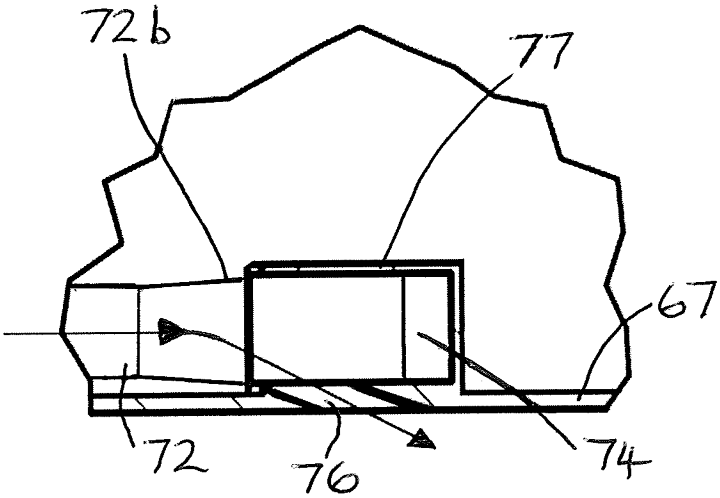


FIGURE 14a

FIGURE 16

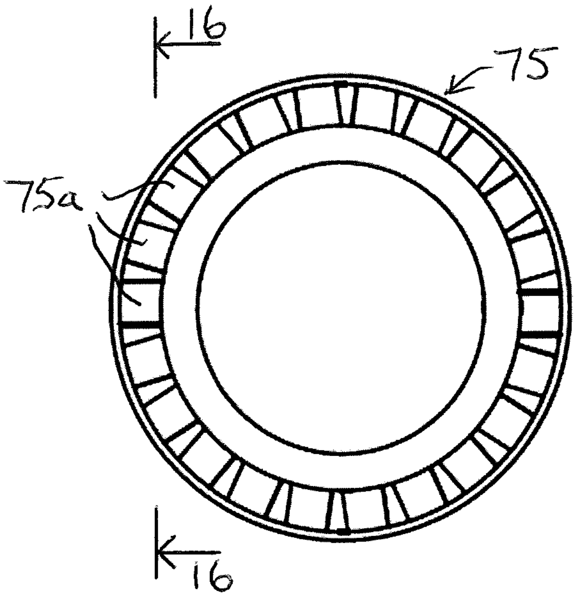


FIGURE 15

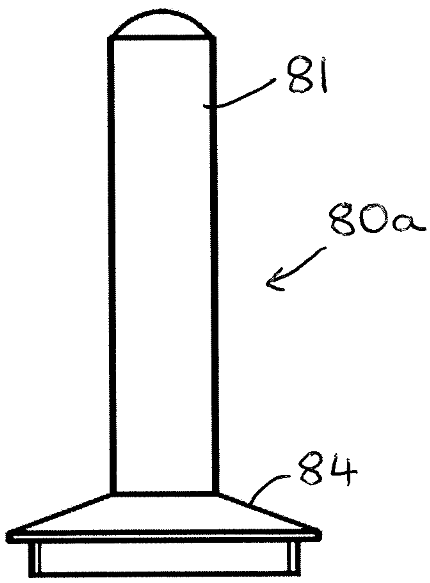


FIGURE 17

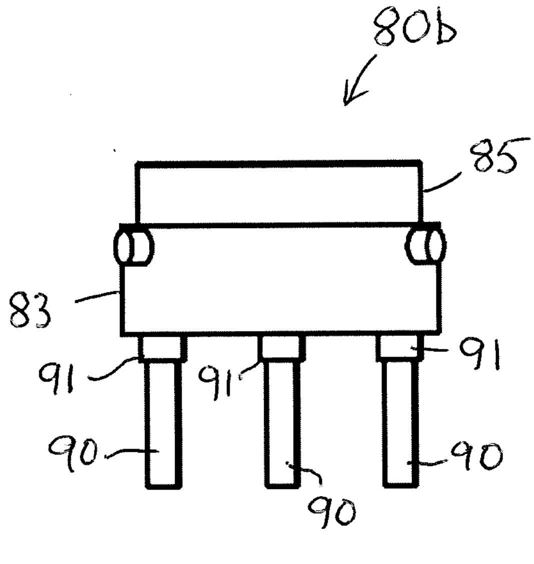


FIGURE 18

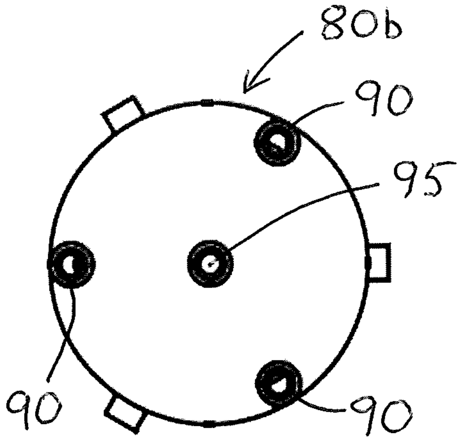


FIGURE 19

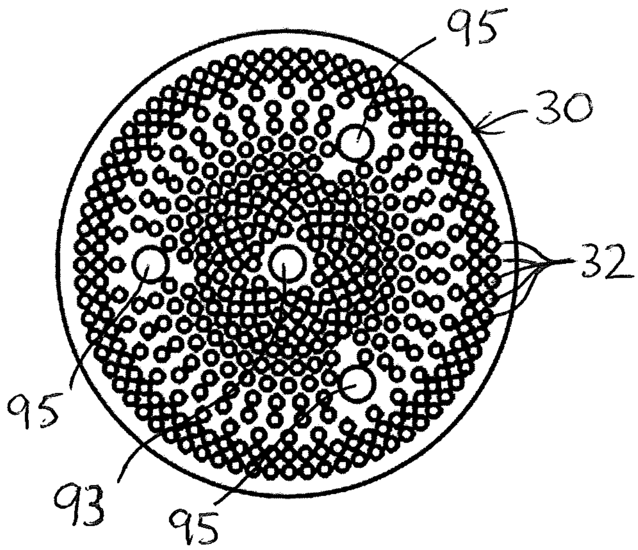


FIGURE 20