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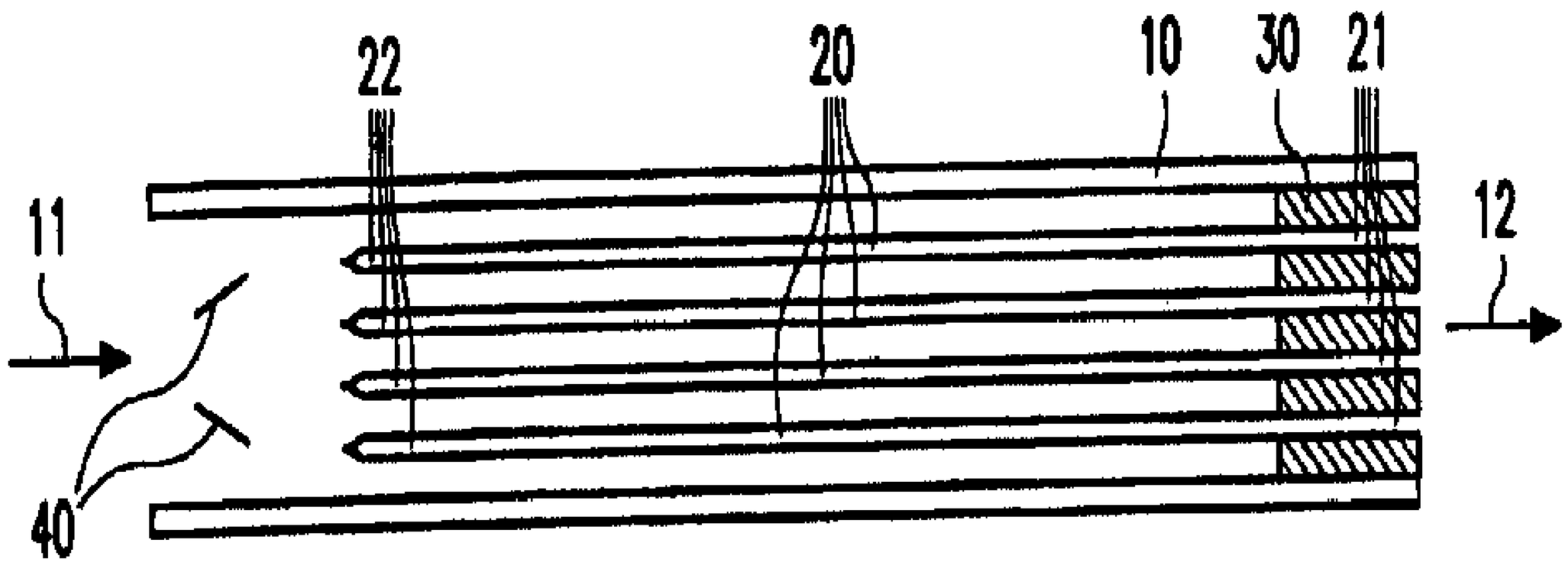

(57) Abrégé/Abstract:
The invention relates to a water filtration device for the local sterilization of domestic and/or drinking water, comprising a filter housing (10) provided with an inlet (11) and outlet (12) connection and provided in said filter housing (10) with a bundle of capillary membranes (20), a first end (21) of said capillary membranes being open and another end (22) being closed, and said capillary membranes (20) being at the first end (21) cased in a membrane holder closing off the space between the capillary membranes (20) and the filter housing. The membranes are micro or ultrafiltration membranes having an asymmetric pore structure, the pore structure being asymmetric in that the pore diameter gradually decreases in the flow direction of the liquid flow through the membrane wall. The membranes are manufactured from a polyether sulphone polyvinyl pyrrolidone polymer (PES/PVP polymer) and the pore diameter at the side of the asymmetric pore structure having the smallest diameter being between 0.01 and 0.3 µm, depending on the application.

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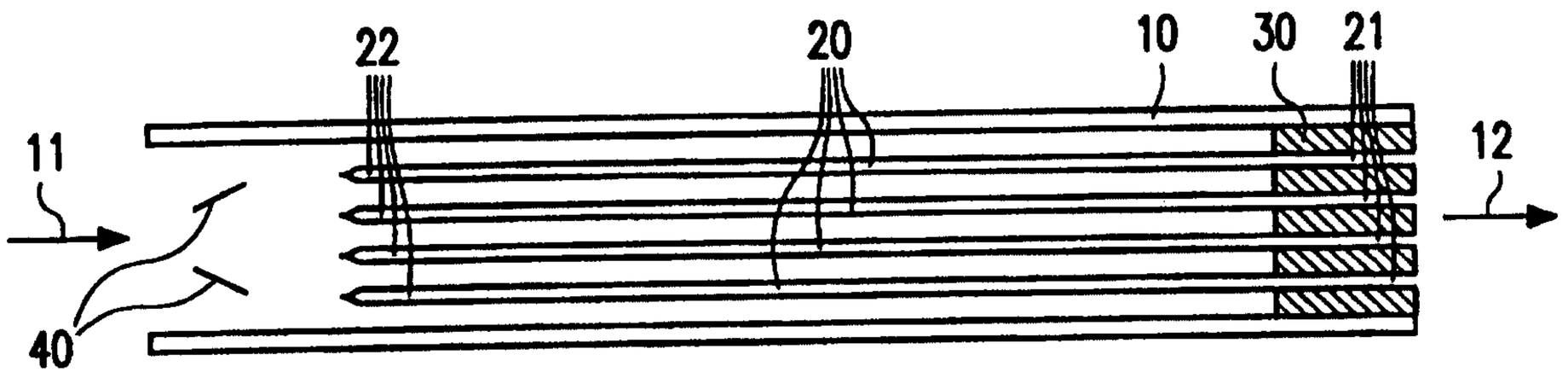


(57) Abstract

The invention relates to a water filtration device for the local sterilization of domestic and/or drinking water, comprising a filter housing (10) provided with an inlet (11) and outlet (12) connection and provided in said filter housing (10) with a bundle of capillary membranes (20), a first end (21) of said capillary membranes being open and another end (22) being closed, and said capillary membranes (20) being at the first end (21) cased in a membrane holder closing off the space between the capillary membranes (20) and the filter housing. The membranes are micro or ultrafiltration membranes having an asymmetric pore structure, the pore structure being asymmetric in that the pore diameter gradually decreases in the flow direction of the liquid flow through the membrane wall. The membranes are manufactured from a polyether sulphone polyvinyl pyrrolidone polymer (PES/PVP polymer) and the pore diameter at the side of the asymmetric pore structure having the smallest diameter being between 0.01 and 0.3 μm, depending on the application.

Water filtration device and method of its manufacture

The present invention relates to a water filtration device for the local sterilization of domestic and/or drinking water, comprising a filter housing provided with an inlet and outlet connection and provided in said filter housing a bundle of capillary membranes, a first end of said capillary membranes being open and another end being closed, and said capillary membranes being at the first end cased in a membrane holder closing off the space between the capillary membranes and the filter housing.

Devices for the purification of liquids, and more specifically for the purification of drinking water and for the removal of live microorganisms from said drinking water, are known in the art. Generally the installations in use for the purification of drinking water are large to serve an extensive area. Often outdated techniques or antiquated installations are employed so that it is not easy to realize an adequate purification of the drinking water. It is also possible that later on pathogens or other kinds of contamination appear in the initially purified water. In many cases chlorine is added to the drinking water to prevent the occurrence of health-threatening pathogens. This has the major disadvantage that the taste and smell of the water deteriorate very considerably. Moreover, a number of microorganisms, like *Cryptosporidium* and *Giardia*, are resistant to chlorine and survive in chlorinated drinking water. It is also problematic that in many areas, especially in developing countries, no reliable drinking water supply exists at all.

Local (point of use) sterilization of water by means of capillary membranes fitted in a housing is known. A disadvantage of these devices is, that on the one hand the capacity expressed in litres filtered liquid per unit area of membrane surface and per time unit is low, and that on the other hand a high pressure drop over the filtration device is required in order to obtain filtering action.

The water filtration device according to the

invention intends to eliminate said disadvantages. To this end the water filtration device according to the invention is characterized in that the membranes are micro or ultrafiltration membranes having an asymmetric pore structure, the pore structure being asymmetric in that the pore diameter gradually decreases in the flow direction of the liquid flow through the membrane wall.

As a consequence of the asymmetric pore structure with a gradually decreasing pore diameter, the flow resistance through the membrane is considerably reduced, thus increasing the capacity. Further, the asymmetric structure delays contamination of the membranes and allows easy cleaning of the device in order to be reused. Cleaning takes place by inverting the flow direction whereby contamination is easily removed from the asymmetric pores. Particles and molecules larger than the pore diameter of the water filtration membranes, are effectively filtered out of the liquid to be purified.

The effectiveness and applicability of the water filtration device is further improved if the membranes are manufactured from a polyether sulphone/polyvinyl pyrrolidone polymer (PES/PVP polymer). Hereby permanently hydrophilic membranes are obtained which, in combination with the asymmetric structure, results in a low differential pressure which is required over the membrane while resulting in a high filtration/permeate yield, that is a high capacity is realized at a low operational pressure. The water filtration device according to the invention may now be applied at operational pressures ranging from 0.5 to 4 bars while in a simple manner realizing a capacity larger than 1000 litres/m^2/h/bar. This makes the water filtration device particularly suitable for utilization in or at a water outlet such as the effluent pipe of a mixing tap, or at any other location in the domestic water supply system.

Further, by using PES/PVP polymer in the manufacture, a very consistent pore structure is obtained, meaning there is little variation in the selected pore diameter. When manufacturing the membranes, the pore diameter can be adjusted so that capillary membranes with a predetermined

pore diameter can be produced. Due to the very consistent pore structure the distribution of the pore diameters will differ little from the selected diameter, making the capillary membrane extremely effective for the intended application. For instance, if a very small pore diameter is selected for the purpose of forming an absolute barrier against bacteria and viruses, there will be no large pore diameters present which would cancel the effect of this barrier. A typical log removal value for the microorganisms is above 8.

Another advantage of manufacturing the membrane from a PES/PVP polymer is that said polymer possesses a very high mechanical, chemical and thermal resistance. The membrane may be disinfected by means of hot water or steam, for instance, in an autoclave. This is a manner to eliminate pathogens that are possibly left behind in the membrane after cleaning by inversion of the liquid flow through the membrane.

Depending on the intended application, the pore diameter at the side of the asymmetric pore structure having the smallest diameter is preferably between 0.01 and 0.3 μm. By choosing the pore diameter in this range an effective filtration is obtained, while the variation around the selected pore diameter will be much smaller than said range. Selecting a pore diameter at the lower limit of this range (0.01 μm), especially when used for medical purposes, results in an absolute barrier against bacteria and viruses. In addition, bacterial degradation products such as pyrogens and endotoxins are filtered out exceptionally effectively when the value of the pore diameter is very close to 0.01 μm. With the increase in diameter the capacity will increase, however, this will allow the particles having a diameter smaller than the selected pore diameter to pass through the membranes. The choice of pore diameter will depend on the intended application. Above 0.3 μm the effectiveness of the filter diminishes. At this value of 0.3 μm the smallest bacterium, namely *Pseudomonas diminuta*, taken as a standard by the Food and Drug Administration (FDA) in the United States, is still filtered out.

In a preferred embodiment in the filter housing of the water filtration device according to the invention is made from a plastic that is resistant to temperatures above 100°C. The water filtration device can now be used at a temperature above 100°C, allowing the device to be heated for, among other purposes, sterilization.

The plastic for the manufacture of the filter housing is preferably polysulphone. Said plastic is resistant to a temperature of about 150°C and the filter housing may be manufactured from said plastic in a simple manner.

In an advantageous embodiment of the water filtration device, at least two baffles are provided at the inlet connection of the filter housing, said baffles being mounted obliquely with respect to the flow direction of the liquid to be filtered. This induces a constant turbulence of the incoming water, preventing the formation of large air bubbles which would obstruct the membranes. Hereby the filtration properties of the device are further improved.

In a broad aspect, then, the present invention relates to a water filtration device for the local sterilisation of domestic and/or drinking water, comprising a filter housing (10) provided with an inlet (11) and outlet (12) connection and provided in said filter housing (10) a bundle of capillary membranes (20), a first end (21) of said capillary membranes being open and another end (22) being closed, and said capillary membranes being at the first end (21) cased in a membrane holder (30) closing off the space between the capillary membranes (20) and the filter housing (10), the membranes (20) are micro or ultrafiltration membranes and have an asymmetric pore structure in that the pore diameter decreases from the outside to the inside across the membrane wall, that is the larger pores are located on the outside surface of the capillary membranes, characterized in that said capillary membranes (20) are

permanently hydrophilic and have a pore diameter of about 1μm on the outside surface and a pore diameter of 0.01 - 0.3 μm on the inside surface.

A preferred method for the manufacture of a water filtration device according to the invention, wherein said device is provided with capillary membranes having a first end and a second end, is characterized, in that at the second end the capillary membranes are closed by means of heat sealing. By this method the capillary membranes can be closed in a simple, quick and reliable manner. This method of closing has also the advantage that no other materials need to be introduced into the capillary membranes, which other materials might impair the characteristics of the water filtration device.

In the following the invention will be further explained with reference to the drawing, in which the only figure shows a preferred embodiment of the water filtration device according to the invention.

In the figure the filter housing is indicated by reference number 10. The filter housing 10 is provided with an inlet connection 11 and an outlet connection 12. In the filter housing 10 a bundle of capillary filtration membranes 20 is provided, being at the first end 21 cased in a membrane holder 30. At this first end 21 the capillary

membranes are open and at the other end 22 the capillary membranes are closed. The filter housing 10 may be made from a rigid material, such as polysulphone, P.V.C., or a metal, but it may also be made from a flexible material. In the latter case the water filtration device may be applied in a bent condition. In the embodiment shown, the filter housing 10 comprises a tubular element.

In the preferred embodiment shown, the membranes 20 are at the first end 21 embedded in a resin, such as epoxy or polyurethane, serving as membrane holder 30. At the other end 22 the capillary membranes 20 are closed by heat sealing, that is pinching and simultaneous heating. This constitutes an effective and reliable manner of closing the membranes. It is also possible to close each capillary membrane 20 individually by means of a resin plug. Analogous with the first end 21, the capillary membranes 20 may at the second end also be embedded in a resin; at this second end 22 the capillary membranes 20 will, however, be closed by means of the resin.

At the inlet connection 11, two obliquely placed baffles 40 are provided in the filter housing 10. This will induce a constant turbulence in the liquid flow to be filtered, preventing any clustering of air in the liquid flow. The membranes cannot now become obstructed by air bubbles, so that the filter works more effectively.

The pores of the capillary membranes 20 have an asymmetric structure, in that the pore diameter gradually decreases in the flow direction of the liquid flow, that is the larger pores are located at the outside of the capillary membranes of the embodiment shown. It should be noted that it is also possible to pass the liquid through the capillary membranes from the inside outward, in which case the larger pores have to be located at the inside. With the approach flow at the outside of the capillary membranes, the resistance is lower, realizing a higher flow rate at an equal number of capillary membranes.

It has been shown that due to the asymmetric structure the filtration properties are considerably better than when a membrane having a symmetric pore structure is

used. For instance, the flow resistance is considerably lower. Thanks in part to this asymmetric structure and the permanently hydrophilic properties of the membrane material - preferably a polyether sulphone/polyvinyl pyrrolidone polymer (PES/PVP polymer) - the membranes are not easily clogged with contamination so that a high capacity can be realized at a lower operational pressure, especially, more than 1000 litres/m²/h/bar. After the capillary membranes have been in use for a period of time, they can be cleaned extremely well thanks to the asymmetric structure of the pores, by inverting the flow direction, after which they may be reused.

In the embodiment shown, the pores have a diameter of about 1 μm at the outside of the capillary membranes 20 and at the inside a diameter between 0.01 and 0.3 μm, depending on the application. Particles sized above this selected diameter range, the variation around the selected value being much smaller than said range, will thereby very effectively be filtered out of the drinking water to be purified. In addition, the membranes may be employed very well at temperatures of 0-120°C.

The water filtration device is preferably employed in or at a water outlet such as a mixing tap. Generally, such a tap supplies 10 litres water per minute, requiring a membrane surface of about 0.1 m². This membrane surface is realized by using a bundle of about 150 capillary membranes having an outside diameter of about 1.2 mm, an inside diameter of about 0.8 mm and a pore size of 0.1 μm at the side of the asymmetric structure having the smallest diameter, which will be used mostly when there is a slight chance of viruses in the water to be purified. In practice the number of membranes may vary from 100 to 200 and, depending on the number of membranes used, the length of said membranes should be between 30 and 15 cm. It has been shown that the capacity of the total device, depending on the dimensions of the filter housing, exhibits a maximum value for a specific number of membranes.

The water purified by means of the shown water filtration device, is purged from contaminations and patho-

gens such as bacteria and viruses. The result is reliable drinking water from which, in combination with carbon adsorption, possible unpleasant smell and taste caused by the addition to the drinking water of chlorine and other solutes may be further removed. The water filtration device has a long service life and can be cleaned and reused. The water filtration device according to the invention can, when used in a water tap, be incorporated in a component of the tap but it is also quite feasible to connect the water filtration device to the water tap by means of, for instance, a threaded or bayonet connection whereby the water filtration device serves also as effluent pipe. It is also possible to incorporate the water filtration device in a water supply mains for a building, such as a house. Obviously, the dimensions of the water filtration device must then be adapted.

The invention must not be regarded as being limiting to the above-described embodiments. Within the framework of the invention and the appended claims, the water filtration device may be realized in a variety of embodiments, all lying within the invention's scope of protection.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A water filtration device for the local sterilisation of domestic and/or drinking water, comprising a filter housing (10) provided with an inlet (11) and outlet (12) connection and provided in said filter housing (10) a bundle of capillary membranes (20), a first end (21) of said capillary membranes being open and another end (22) being closed, and said capillary membranes being at the first end (21) cased in a membrane holder (30) closing off the space between the capillary membranes (20) and the filter housing (10), the membranes (20) are micro or ultrafiltration membranes and have an asymmetric pore structure in that the pore diameter decreases from the outside to the inside across the membrane wall, that is the larger pores are located on the outside surface of the capillary membranes, characterized in that said capillary membranes (20) are permanently hydrophilic and have a pore diameter of about 1μm on the outside surface and a pore diameter of 0.01 - 0.3 μm on the inside surface.

2. A water filtration device according to claim 1, characterised in that the membranes (20) are manufactured from a polyether sulphone/polyvinyl pyrrolidone polymer.

3. A water filtration device according to any one of claims 1 or 2, characterized in that the filter housing (10) is made from a plastic that is resistant to temperatures above 100°C.

4. A water filtration device according to claim 3, characterized in that the plastic for the manufacture of the filter housing (10) is polysulphone.

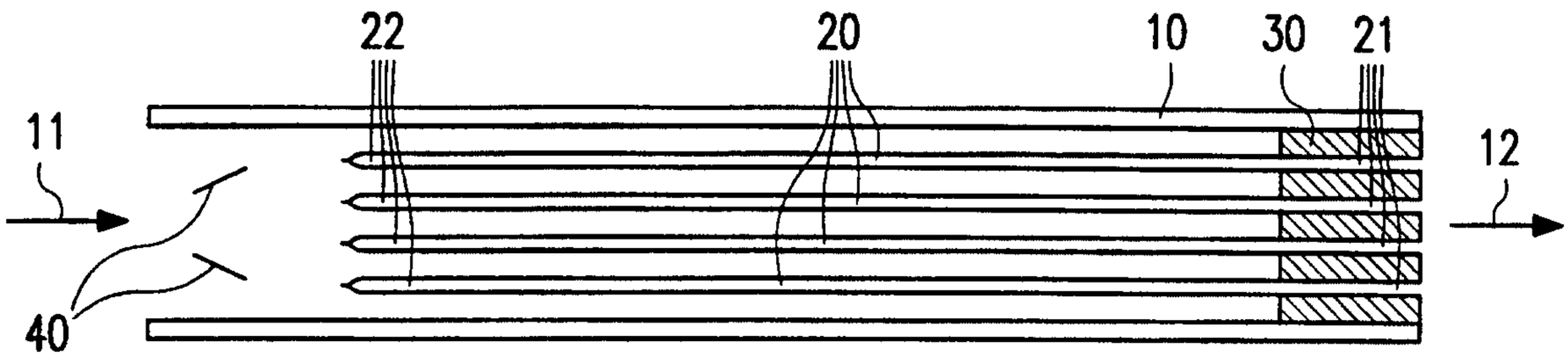
5. A water filtration device according to any one of claims 1 - 4, characterized in that at least two baffles (40) are provided at the inlet connection (11) of the filter housing (10), said baffles (40) being mounted obliquely with respect to the flow direction of the liquid to be filtered.

6. A water filtration device according to any one of claims 1 - 5, incorporated in the supply pipe to, or in the effluent pipe of a water outlet such as a mixing tap.

7. A capillary filtration membrane (20) as described as a part of the water filtration device according to any one of claims 1 - 6.

8. A capillary filtration membrane according to claim 7 to be used as a drinking straw.

9. A method of manufacturing a water filtration device according to any one of claims 1 - 6, wherein said device is provided with capillary membranes having first end and a second end, characterized in that at the second end (22) the capillary membranes (20) are closed by means of heat sealing.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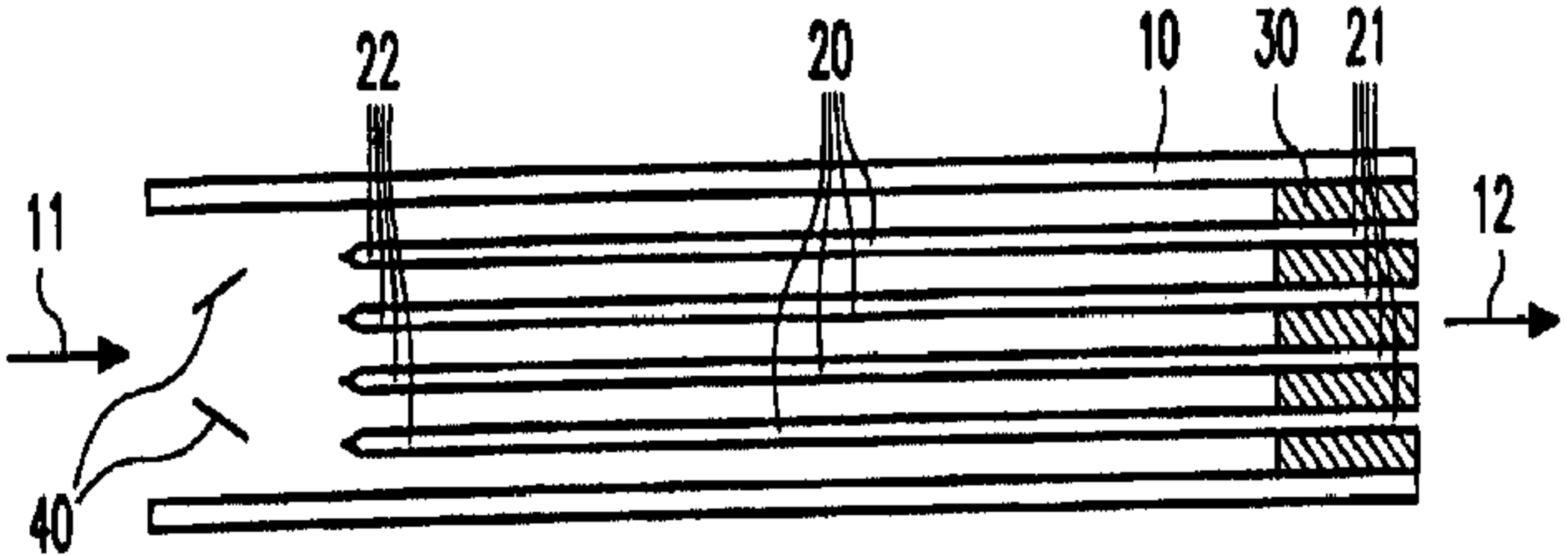
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