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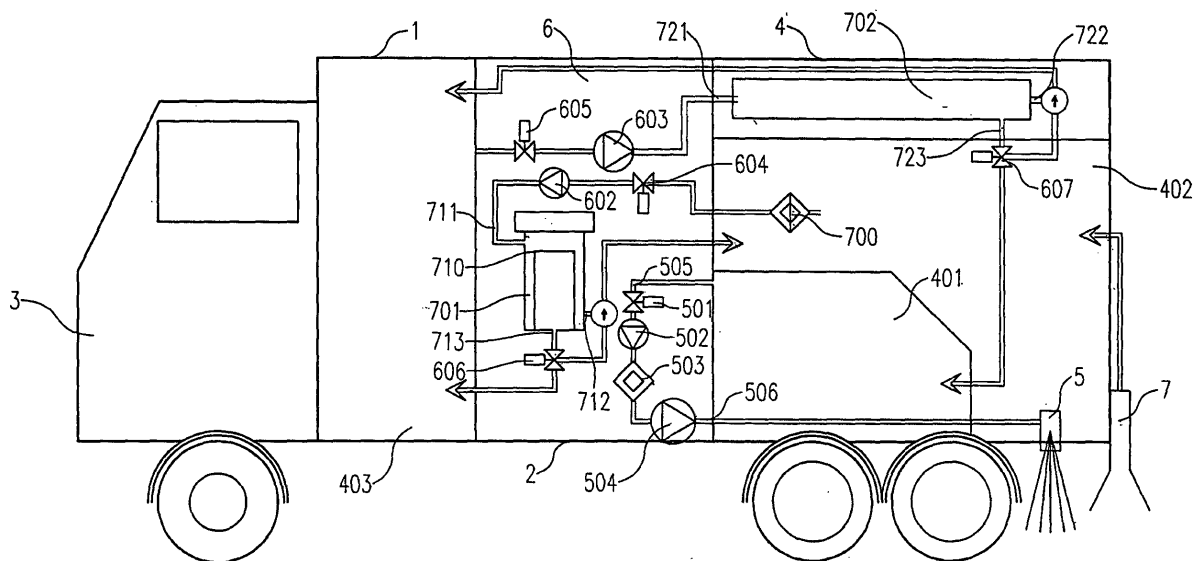
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(54) Mobile device for the treatment of a surface

(57) A mobile device for treating a surface makes use of a liquid which is sprayed on the surface under high pressure using one or more spray heads (5). The device comprises an optionally self-propelling chassis (2) with a first reservoir (401) for the liquid and first pumping means (504) for guiding the liquid under increased pressure to the spray head. Recovery means (7) are herein provided for taking up contaminated liquid from the sur-

face and storing it in a second reservoir (402). A purifying installation is able to make recovered liquid suitable for re-use. The purifying installation comprises first filter means (700,701) for filtering particles having at least a first size and second filter means (702) for filtering particles having at least a second, smaller size. A buffer reservoir (403) is arranged between a filtrate outlet (713) of the first filter means and an inlet (721) of the second filter means.



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Description

[0001] The present invention relates to a mobile device for treating a surface making use of a liquid which is sprayed thereon under high pressure using at least one spray head, comprising at least one optionally self-propelling chassis with a first reservoir for the liquid, first pumping means for guiding the liquid under increased pressure from the first reservoir to the at least one spray head, recovery means for taking up used liquid and a second reservoir for at least temporarily storing recovered liquid.

[0002] Such devices are utilized in many ways and for diverse applications, varying from cleaning surfaces, for instance of walls, outside walls, floors, pavements, runways and roads, to the pre-treatment and roughening of surfaces. This may for instance involve local removal of chewing gum and graffiti, but also total surface reconditioning such as in streets and roads, wherein particularly rubber from tyres must be removed. Particularly asphalt, and in particular the very open asphalt concrete (ZOAB) which is being applied increasingly on provincial and national roads, requires a regular surface treatment to re-open clogged pores therein and/or to roughen the surface. A mobile cleaning device, optionally on a self-propelling vehicle, can herein be employed wholly autonomously, i.e. without necessary fixed connections, to perform the desired surface treatment on site. For this purpose the vehicle has available a first reservoir, the so-called clean water tank, from which water can be drawn which is sprayed on the surface under high pressure to remove deposits and other dirt or to modify the surface as such. Recovery means are usually also provided to take up water from the surface once it has been used and to store it temporarily in a second reservoir, the so-called contaminated water tank, for discharge upon return of the vehicle.

[0003] The advantage of the described autonomy of the device does however also have a drawback. Owing to the absence of fixed connections the vehicle is totally reliant on its own supply of liquid, which is thereby inevitably limited or at least finite. As soon as the clean water tank is empty or the contaminated water tank is full, the device must be taken out of operation to be (re)filled or emptied. This takes time and thereby slows down the work.

[0004] The present invention has for its object, among others, to provide a device of the type stated in the preamble which obviates this drawback without relinquishing the described advantages of a mobile device.

[0005] In order to achieve the intended object, a device of the type stated in the preamble has the feature according to the invention that the recovery means comprise a purifying installation for making recovered liquid suitable for re-use, that the purifying installation comprises at least first filter means for filtering particles having at least a first size and second filter means for filtering particles having at least a second, smaller size, that an inlet of the

first filter means is coupled to the second reservoir, that a filtrate outlet of the second filter means is coupled to the first reservoir, and that a buffer reservoir is arranged between a filtrate outlet of the first filter means and an inlet of the second filter means. The placing of such a purifying installation in the device enables the device to use at least a significant part of the liquid a number of times, so that the maximal operating cycle of the device is extended significantly. The distribution of the purification over at least a first, relatively coarse filter and a second, relatively fine filter allows a sufficiently high filtration throughput, wherein mutually differing throughput times of both filters are compensated by interposing the buffer reservoir. Both filters can thus each be operated at their optimal throughput.

[0006] For the cleaning of asphalt and concrete in particular, exceptionally high pressures are found in practice to be most effective. This involves for instance a water pressure at the extremity of the spray head in the order of typically about 1000-2500 bar. Spray heads and pumps which can produce such a high pressure are highly sensitive to solid particles in the liquid, which may not therefore be larger than the order of 1 μm when they occur. In order to also provide for re-use of liquid in such extremely high pressure applications, a particular embodiment of the device according to the invention has the feature that the first filter means comprise at least one relatively coarse screen filter and the second filter means a microfiltration filter. More particularly a further embodiment of the device herein has the feature that the first size is in the order of 100-1000 micrometres and the second size is in the order of a maximum of 1-10 micrometres. The screen filter herein removes the coarse contaminants from the taken-up liquid, while the microfiltration filter can remove particles in the order of tenths of microns from the recovered liquid, and can be adjusted to the requirements of the spray head. The resulting filtrate is then sufficiently pure to enable safe feedback to the spray head.

[0007] In a further particular preferred embodiment, the device according to the invention has the feature that the second size lies below 0.1 micrometre, and in particular is in a range of 10-20 nanometres. Because the filtration using the second filter means is herein performed to a region of the size of bacteria and viruses, the fed back liquid is thus substantially free of germs which, particularly in sewer cleaning and other less hygienic applications, is an important factor in avoiding or at least reducing contamination of persons involved therein.

[0008] A preferred embodiment of the device according to the invention has the feature that at least one of said filters comprises a longitudinal filter with a main inlet and a main outlet for a main liquid flow on a first side of a filter surface and a filtrate outlet for an obtained filtrate on a second side of the filter surface. The main flow of such a longitudinal filter not only provides a continuous supply of liquid for filtering, but moreover ensures a cleaning action on the filter surface so that premature clogging

thereof can be avoided. The filtrate is drawn off on an opposite side of the filter surface. Owing to this self-cleaning action such filters are highly suitable for the present mobile application, wherein fully continuous operation is desired.

[0009] In a further particular preferred embodiment, the device according to the invention has the feature that a multi-stage valve is coupled to a filtrate outlet of at least the longitudinal filter and has at least two exits, one of which leads to a main flow through the filter. A shunt safety is hereby provided at the filtrate outlet and the flow through the filter does not have to be interrupted or tempered when there is insufficient filtrate demand, so that the filter can always be operated in an optimum state.

[0010] The used liquid, after being used, can be removed per se from the surface in different ways, for instance by scooping or mopping and the like. Particularly good results have however been achieved with a further particular embodiment of the device according to the invention, characterized in that the recovery means comprise at least one suction mouthpiece for suctioning used liquid from the surface. The suction mouthpiece can herein be held at a small distance from the surface and do its work in contact-free manner. This reduces the chance of wear and damage.

[0011] A preferred embodiment of the device according to the invention has the feature that the first filter means are coupled to an outlet of second liquid pumping means, that the second filter means are coupled to an outlet of third liquid pumping means, and that during operation the second and third pumping means exert a mutually differing liquid flow rate on a filtrate flow out of the first filter means and a main flow through the second filter means. By thus providing each of the filter means with their own liquid pumping means, the flow through the filters can be individually controlled and thus adjusted optimally to the relevant filter. Owing to the presence of the buffer reservoir the filters can nevertheless be applied successively if desired.

[0012] The invention will now be further elucidated on the basis of an exemplary embodiment and an associated drawing. In the drawing:

figure 1 shows a schematic representation of an exemplary embodiment of the device according to the invention.

[0013] The figure is purely schematic and not drawn to scale. Some dimensions in particular may be exaggerated to a greater or lesser extent for the sake of clarity. Corresponding parts are generally designated with the same reference numeral.

[0014] Figure 1 shows a cross-section of a mobile device for treating a surface 1, in this example a washing vehicle, with which the surface of asphalt, concrete and in particular very open asphalt concrete (ZOAB) of roads can be thoroughly cleaned and roughened. The washing vehicle comprises a more or less standard truck chassis

2 with a driver's cab 3 on which is placed a washing device 4. Use is made in this embodiment of a double-axle chassis, but chassis with more or fewer axles also lie within the scope of the invention. Instead of a self-propelling chassis as in this embodiment, it is also possible to opt for a truck-semi-trailer or truck-trailer combination in accordance with the desired transport capacity, and the device can also be divided over a number of chassis.

[0015] Washing device 4 comprises a first reservoir 401 in the order of five thousand litres, in which a supply of liquid can be stored. Use is made in this embodiment of cleaning with water under high pressure, wherein the liquid consists simply of clean water, optionally supplemented with a herbicide, soap or other additive. First reservoir 401 will therefore be designated hereinbelow as clean water tank to distinguish this tank from a second reservoir 402 to which used and therefore contaminated water is returned. This latter reservoir will be designated hereinbelow as contaminated water tank.

[0016] The surface cleaning takes place by spraying water from clean water tank 401 onto the surface under extremely high pressure using one or more spray heads 500, in this embodiment three. This is here a rotating spray head 403 which delivers a pressure at its outer end in the order of about 1000-1500 bar at a flow rate in the order of about 135 litres per minute. In order to provide this water pressure, first pumping means in the form of a pump-filter combination 501-504 adapted to this pressure are accommodated in a pump space 6 of the device. This pump/filter combination is actuated via a hydraulic valve 501 and, in addition to a pre-pump 502 and an end pump 504 which provides the final pressure, comprises a filter 503 which is able to effectively stop solid particles from a size of 1 μm in the unlikely event these are present in the liquid. End pump 504 and spray head 500 are generally extremely susceptible to wear as a result of such solid particles in the liquid of a size from typically 1-10 μm , depending on the type of pump, and thus retain their normal lifespan as a result of filter 503. For filter 503 is applied a commercially available cross-filter which meets these specifications. An inlet 505 of pumping means 501-504 is coupled to clean water tank 401, while an outlet 506 leads to spray heads 500.

[0017] The device further comprises recovery means which comprise, among other parts, a suction mouthpiece 7 with which liquid, which has been sprayed on the surface with spray heads 500, can be taken up from this same surface using pumping means (not further shown). The surface is thus more or less dried after being cleaned. The collected, contaminated water is discharged to contaminated water tank 402 which in this embodiment has a volume of about 12000 litres.

[0018] In order to increase the range of the vehicle, the device according to the invention is equipped with a purifying installation which is added to the recovery means to make the contaminated water taken up from the surface therewith once again suitable for re-use. The purifying installation comprises in the first instance first

filter means 700,701 which are coupled to the contaminated water tank and are formed in this embodiment by a relatively coarse drum screen 700 in combination with a finer hydrocyclone filter 701. Drum screen 700 prevents solid particles any larger than typically about 300-1000 μm in the contaminated water from leaving the contaminated water tank 402. The contaminated water is carried to hydrocyclone filter 701 via drum screen 700 using second pumping means 602 provided for this purpose. This process is controlled by means of a hydraulic valve 604 which is arranged in the supply line and which is in an opened position during operation.

[0019] The hydrocyclone filter is of the so-called longitudinal type, which has an inlet 711 and outlet 712 for a main liquid flow on a first side of the actual screen filter surface 710 and a filtrate outlet 713 for filtrate on a second side thereof. The contaminated water is thus pumped around continuously over cyclone filter 701 and fed back to the contaminated water tank, wherein a filtrate is drawn off at filtrate outlet 713. Owing to the continuous circulation of a main flow of contaminated water the filter surface is cleaned continuously, and such a longitudinal filter can hereby be employed fully continuously for a relatively long time before the surface becomes clogged. This type of filter is therefore highly suitable for the present application, where continuous operation is desired with relatively heavily contaminated water.

[0020] Cyclone filter 701 is able to effectively filter solid particles having a size of typically in the order of a hundred to several hundred microns, so that the filtrate is at least practically free thereof. Although the worst contamination is hereby removed from the contaminated water by means of first filter means 700,701, the filtrate is not yet suitable for feeding to the spray nozzle. The lance 5 and first pumping means 504 applied here do not tolerate particles of a size greater than about 1-10 μm , and would break down in a short time under the influence of the filtrate from first filter means 701. The filtrate therefore undergoes a second filtration with second filter means 702, which here comprise a (sub)micromembrane filter and are able to perform a microfiltration wherein, depending on the filter membrane applied, particles larger than about 0.01-10 μm can be removed effectively. In this embodiment an ultrafiltration membrane which filters out solid particles from 10-20 nanometres has been chosen in respect of membrane filter 702.

[0021] Membrane filter 702 is also of the longitudinal type, which means that a main flow of relatively contaminated water is guided continuously thereover along a first membrane side, while a clean filtrate is drawn off at a filtrate outlet 723 on a second, opposite membrane side. The main flow herein runs over a main inlet 721 of the membrane filter and is fed back via a main outlet 722 and herein kept moving by means of third pumping means 603 in combination with a hydraulic valve 605 which is open during operation.

[0022] In the present embodiment the membrane filter comprises a long bundle of hollow tubes, the wall of which

is formed from membrane material. Due to this specific form, such filters are also designated as straw filters. The main flow herein runs through the interior of the tubes, while the filtrate is drawn off on an outer side of the straws.

5 The main flow pumped around continuously over the filter herein keeps the membrane relatively clean, so that relatively long operation is also possible for this filter.

[0023] The longitudinal filters used here require a relatively strong main flow to prevent rapid clogging of the surface. The main flow of the second filter means is however fed by the drained filtrate from the first filter means, which has a markedly lower rate of flow in order to maintain the desired filtration quality. According to the invention a buffer reservoir 403, which in the present embodiment has a volume of about 9000 litres, is therefore arranged between filtrate outlet 713 of first filter means 700,701 and main inlet 721 of second filter means 702. Filtrate from first filter means 701 is collected in this reservoir before being guided over second filter means 702. Upon departure of the vehicle, the clean water tank 401, contaminated water tank 402 and buffer reservoir 403 are filled at least partly with clean water so that the vehicle has available from the outset a relatively large supply of liquid, wherein this supply is continually replenished with recovered filtrate from the first filter means. An exceptionally long fully-continuous operation of the mobile device is thus possible.

[0024] For safety reasons both the first filter means 700,701 and the second filter means 702 are provided at a filtrate outlet 713, 723 respectively with an optionally self-thinking, hydraulic multi-stage valve 606, 607 respectively. As soon as there is no (more) demand for filtrate, this valve opens towards the main flow of the relevant filter 701,702 so that the filtrate is entrained in the main flow. This occurs for instance when buffer reservoir 403 or clean water tank 401 is completely full, so that the filter cannot dispose of the filtrate. Such a situation can be determined in reliable manner by means of a flow-rate meter in the filtrate line. The filter does not therefore need to be taken out of operation when such a situation occurs, which enhances operation thereof.

[0025] Although the invention is further elucidated above with reference to only a single embodiment, it will be apparent that the invention is by no means limited thereto. On the contrary, many other variations and embodiments are still possible within the scope of the invention for a person with ordinary skill in the art. In the shown embodiment use is for instance made of first filter means divided over two stages, i.e. the screen filter and the hydrocyclone filter, while the second filter means comprise a single stage in the form of the membrane filter. Instead the first filter means can in some circumstances also be embodied in a single stage or, conversely, more stages can be used in respect of both filter means.

55 **[0026]** The embodiment is based on a cleaning vehicle for cleaning a street surface. The device according to the invention is also suitable instead for cleaning other surfaces and, owing to the high operating pressure which

can be obtained therewith, also for more drastic surface treatments wherein the surface is roughened or otherwise modified. In addition, the device can advantageously be applied for cleaning or otherwise treating walls of sewers, storage tanks and other installations which may or may not be underground.

Claims

1. Mobile device for treating a surface making use of a liquid which is sprayed thereon under high pressure using at least one spray head, comprising at least one optionally self-propelling chassis with a first reservoir for the liquid, first pumping means for guiding the liquid under increased pressure from the first reservoir to the at least one spray head, recovery means for taking up used liquid and a second reservoir for at least temporarily storing recovered liquid, **characterized in that** the recovery means comprise a purifying installation for making recovered liquid suitable for re-use, that the purifying installation comprises at least first filter means for filtering particles having at least a first size and second filter means for filtering particles having at least a second, smaller size, that an inlet of the first filter means is coupled to the second reservoir, that a filtrate outlet of the second filter means is coupled to the first reservoir, and that a buffer reservoir is arranged between a filtrate outlet of the first filter means and an inlet of the second filter means. 5 10 15 20 25 30
2. Device as claimed in claim 1, **characterized in that** the first filter means comprise at least one relatively coarse screen filter and the second filter means a microfiltration filter. 35
3. Device as claimed in claim 2, **characterized in that** the first size is in the order of 100-1000 micrometres and the second size is in the order of a maximum of 1-10 micrometres. 40
4. Device as claimed in claim 3, **characterized in that** the second size lies below 0.1 micrometre, and in particular is in a range of 10-20 nanometres. 45
5. Device as claimed in one or more of the foregoing claims, **characterized in that** at least one of said filters comprises a longitudinal filter with a main inlet and a main outlet for a main liquid flow on a first side of a filter surface and a filtrate outlet for an obtained filtrate on a second side of the filter surface. 50
6. Device as claimed in claim 5, **characterized in that** a multi-stage valve is coupled to a filtrate outlet of at least the longitudinal filter and has at least two exits, one of which leads to a main flow through the filter. 55

7. Device as claimed in one or more of the foregoing claims, **characterized in that** the recovery means comprise at least one suction mouthpiece for suctioning used liquid from the surface.
8. Device as claimed in one or more of the foregoing claims, **characterized in that** the first filter means are coupled to an outlet of second liquid pumping means, that the second filter means are coupled to an outlet of third liquid pumping means, and that during operation the second and third pumping means exert a mutually differing liquid flow rate on a filtrate flow out of the first filter means and a main flow through the second filter means.

