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VACUUM SEWER SYSTEM

The invention relates to an arrangement in a vacuum sewer system according to the preamble of claim 1.

In vacuum sewer systems it is known to use ejector devices for generating vacuum. Systems like these are disclosed for example in patent publications FI 63985 and EP 653524 / US 5,535,770. In these vacuum sewer systems the ejector device is at the same time arranged to provide a collecting container for the sewage coming from the sewer network. The sewage flow that is circulated by a pump from the collecting container is used as the working medium of the ejector of the ejector device. The suction side of the ejector is connected to the sewer network so that it generates partial vacuum in the sewer network, whereby the sewage coming from the sewer network flows through the ejector into the collecting container. In practice this means that the ejector discharges its working medium, that is the sewage flow circulated by the pump, together with air sucked from the sewer network and the sewage flow coming from the sewer network to the collecting container under high pressure.

The function of the ejector causes foaming in the collecting container due to the strong jet effect, which first of all is transferred to the surroundings through the overflow pipe of the collecting container, through the ventilation duct and through possible leaks and secondly is transferred into the circulation process of the ejector lessening the degree of efficiency of vacuum generation. The foaming causes problems with the sewage volume in the collecting container and with the monitoring of the state of the same, which can damage the pump and lead to disturbances in the control functions of the vacuum sewer system. The behaviour of the foaming sewage is subject to random changes and it may cause cavitation in the pump. The aforementioned circumstances also reduce the working life of the components of the device. Fur-

thermore, the opening of the device, for example in connection with maintenance or repair, causes a discharge of dangerous gases.

The object of the present invention is to avoid the above mentioned disadvantages and to achieve an arrangement that has a simple structure and a reliable function. This object is attained by an arrangement according to the invention, the main features of which are given in claim 1.

The invention is based on the idea that a liquid driven ejector is used in the vacuum sewer system, the circulation process of which is kept compact and without disturbances, and that the sewage collecting process is kept substantially separate from the circulation process of the ejector device so that the sewage and its treatment do not directly have an effect on the vacuum generation in the sewer system, i.e. on the ejector device.

The vacuum generation provided by the ejector device forms a primary circuit and the sewage collecting process a secondary circuit.

The main components of the ejector device advantageously comprise to their substantial parts a container, in which substantially normal atmospheric pressure prevails, an ejector, circulation means for the liquid functioning as a working medium of the ejector and a suction connection connected to suction side of the ejector, which suction connection is connected to the sewer network.

In the vacuum sewer system, on the side of the sewage collecting process, a collecting container, to which the suction connection of the ejector device is connected, connected to the sewer network is advantageously used.

The circulation means of the liquid functioning as a working medium of the ejector advantageously comprise a circulation pump, particularly a centrifugal pump. The liquid functioning as the working medium may advantageously be water, which has been blended for neutralising the harmful effects of the sewage, particularly of the gases formed therefrom.

The ejector container is advantageously provided with sensor means connected to a control center for monitoring the surface level of the liquid

functioning as the working medium of the ejector. In this way a stable and efficient functioning of the circulation means and the ejector may be ensured.

In order to ensure the functioning of the sewage collecting process, i.e. the secondary circuit, the sewage collecting container is advantageously provided with emptying means and sensor means for monitoring the surface level of the sewage.

The emptying means for the collecting container advantageously comprise a circulation pump, particularly a centrifugal pump.

By using separate, advantageously similar means, both as the circulation means for the ejector device and as the emptying means for the collecting container, these may be advantageously be cross-coupled so that they are alternatively usable when one is e.g. damaged, in maintenance or replaced.

Alternatively the same means may be used as the circulation means for the ejector device and as the emptying means for the collecting container, which for example in smaller vacuum sewer systems may be advantageous in view of costs.

The sewage collecting container advantageously forms an intermediate container, whereby the vacuum sewer system further comprises for example a sewage container for storing the sewage for a desired time.

The sewage collecting process covers the transfer of sewage from the source of sewage to the sewer network and the transport of sewage to a possible circulation, treatment, storage or other discharge space, for example via an intermediate collecting container.

The sewage may comprise grey water, i.e. for example waste water and/or solid waste from a wash room, and black water, i.e. for example waste water and/or solid waste from a toilet unit. The vacuum sewer system may also be used for example in connection with supermarkets or corresponding sites, in which in addition to the above mentioned other sewage of different types are found. The sewage may be grey water comprising for example waste from meat or fish treatment utilities which usually firstly has to be transferred to a treatment plant before its further transport. Furthermore, con-

densate from refrigerators or freezers may come in question, which, if so desired, may recirculated for use as flush water for example for a toilet unit.

The invention also relates to an ejector device, which is intended for generating vacuum in a vacuum sewer system. The characterising features of the ejector device according to the invention are given in claim 12 and its advantageous embodiments in claims 13 to 16.

In the following the invention is described more in detail, by way of example only, and with reference the accompanying schematic drawings, in which:

Fig. 1 shows a process diagram of a vacuum sewer system;

Fig. 2 shows a first embodiment of the ejector device and the collecting container;

Fig. 3 shows a second embodiment of the ejector device and the collecting container; and

Fig. 4 shows a third embodiment of the ejector device and the collecting container.

In the vacuum sewer system shown in Fig. 1 the ejector device is generally indicated by reference numeral 1, the sewer network by reference numeral 2 and the circulation, treatment, discharge or storage space for the sewage coming from the sewer network by reference numeral 3.

The ejector device 1 comprises an ejector 4 with a suction connection connected to the sewer network 2, an ejector container 5 under substantially normal atmospheric pressure provided with a ventilation pipe 6 and circulation means, which comprise a circulation pump 7, which advantageously is a centrifugal pump. In the ejector container 5 a certain supply of liquid is maintained, which is monitored by sensor means 9 and 10 connected to a control center 11 for monitoring the surface level of the liquid. Liquid is sucked through the liquid transport pipe 8 from the ejector container 5 by the circulation pump 7 and supplied to the ejector 4, which discharges the liquid with high pressure back to the ejector container 5. Air is sucked in a manner known per se from the sewer network 2 through the suction pipe 22 by the ejector 4,

i.e. through its suction connection connected to the sewer network 2. This procedure provides a vacuum in the sewer network, which preferably is in the range of about -0.3 to -0.7 bar, mostly in the range of about -0.4 to -0.6 bar.

The liquid functioning as the working medium of the ejector 4 advantageously is water, which when necessary can be treated with chemicals in order to prevent harmful effects from the sewage in the sewer network 2. Water is an economical and environmentally friendly substance, and furthermore, it may easily be treated so that the harmful effects of contamination, i.e. the corrosive effects on the ejector device 1 and any undesirable odors, from the sewage or from the gases developing from it easily may be neutralised.

The circulation process of the ejector, i.e. of the vacuum generation, is consequently substantially closed, except for the suction connection connected to the sewer network, and forms a primary circuit, which is separated from the secondary circuit of the vacuum sewer system, i.e. the sewage collection process. This makes it possible to keep the liquid supply as small as possible. When for example substantially clean water is used as a liquid, its circulation and discharge does not cause foaming or any other factors that disturb the function of the ejector device. As an example may be mentioned that when using one ejector the supply of liquid can be in the range of about 100 liters, whereby there is no actual upper limit.

The number of ejectors can be chosen according to the need for vacuum generation in the sewer network in each case.

The liquid may be something else than water, whereby the liquid advantageously is chosen so that the above mentioned objectives are attained.

The secondary circuit of the vacuum sewer system, i.e. the sewage collecting process, mainly comprises the sewer network 2 and the sewage circulation, treatment, storage or other discharge space 3, and advantageously an intermediate collecting container 32 arranged before said space.

The sewer network 2 according to the given example may comprise one or more sources of sewage, although in the diagram of Fig. 1 only a vacuum toilet 24 and a thereto connected source of flush water 26 are shown. Sewage from a vacuum toilet unit is usually categorised as black water. Furthermore, the sewer network may comprise for example wash basins, showers, etc., which are not shown in Fig. 1 and from which the above mentioned grey water originates. The vacuum toilet unit 24 is connected to sewer piping, i.e. to the vacuum piping 28, through a valve means. From the vacuum toilet unit 24 the vacuum piping 28 leads to the sewage collecting container 32.

As has been described above, a vacuum of a certain magnitude is generated in the sewer network 2 by the ejector device 1, i.e. in this case through the suction connection connected to the suction side of the ejector 4 and through the pipe 22 directly to the collecting container 32 in order to provide for transportation of the sewage coming from the vacuum toilet unit 24 through the vacuum piping 28 to the collecting container 32. The vacuum piping 28 is provided with a pressure transducer 30 and/or pressure gauge 34 connected to the control center 11 for monitoring the pressure level in the vacuum piping 28 and collecting container 32. The collecting container 32 is advantageously provided for example with sensor means 36 and 38 connected to the control center 11 for monitoring the sewage surface level in the collecting container and and/or with an observation window 40. The sewage collecting container 32 in the described vacuum sewer system functions as an intermediate container and it is provided with emptying means, which comprise a discharge valve 42 and emptying means 44, for example a circulation pump, which advantageously may be a centrifugal pump.

In so far as the circulation means for the liquid functioning as the working medium of the ejector 4 and the emptying means for the collecting container both comprise a centrifugal pump, these can easily be cross-coupled so that one can be used instead of the other according to need, for example in case of damage or maintenance.

In connection with the emptying of the collecting container 32 used as an intermediate container, the collecting container is set under substantially normal atmospheric pressure, for example through a ventilation pipe 46, whereby the valve 48 in the vacuum piping 28 is closed. The collecting container 32 is emptied through the discharge valve 42 by the circulation pump 44 to a discharge space under substantially normal atmospheric pressure, i.e. in this case into a sewage container 50 provided with a ventilation pipe 52. The sewage container 50 is also provided with emptying means, in the described case with a discharge valve 54 and an overflow guard 56. The amount of sewage collected in the sewage container 50 is monitored by a sensor means 58 connected to the control center 11 for monitoring the surface level of the sewage.

The collecting container 32 may also be arranged to be emptied into a free discharge space, to a sewage treatment plant or into another selected space depending on the type of sewage in question and in which connection the vacuum sewer system is applied.

In Fig. 2 is shown a first embodiment of the ejector device and the sewage collecting container, which may be applied to the above disclosed vacuum sewer system.

The ejector device 101 comprises a centrifugal pump 107 to the suction side of which is connected a transport pipe 108 for working medium which is connected to the lower part of the ejector container 105, which is under substantially normal atmospheric pressure. The centrifugal pump 107 circulates the liquid sucked from the ejector container 105 and functioning as the working medium of the ejector 104 and feeds it with high pressure through the ejector 104 back into the ejector container 105. In this way the ejector 104 in a manner known per se draws air through a suction pipe 122 in communication with a suction connection 113 connected to the suction side of the ejector 104 from the sewage collecting container 132 and forms a partial vacuum in the collecting container 132 and the vacuum piping 128 of the

sewer network. The ejector container 105 is provided with a ventilation pipe 106.

In this embodiment the ejector container 105 of the ejector device and the sewage collecting container 132 are formed of two adjacent, vertically arranged containers.

The ejector 104 is arranged in the upper part of the ejector container 105 so that it discharges the liquid from its discharge opening 104a downwards, from the upper part of the ejector container 105 towards its lower part. A certain liquid supply is maintained in the ejector container 105 monitored by sensor means 109 and 110 for monitoring the liquid surface level. The maximum height H1 of the liquid surface level is advantageously kept below the discharge opening 104a of the ejector 104 and the minimum height H2 above the inlet opening 108a of the liquid transfer pipe 108, which forms the liquid inlet of the centrifugal pump 107, whereby the liquid without disturbances can transfer to the circulation pump 107 so that the function of the ejector 104 is as efficient as possible.

The ejector device can also be arranged so that the ejector is arranged at the lower part of the ejector container, whereby the ejector discharges the liquid upwards towards the upper part of the ejector container. Also in an arrangement of this type the above given surface level limits are valid.

The primary circuit formed by the ejector device 101 is substantially closed, with exception of the suction connection. The liquid functioning as the working medium is advantageously water, which has been blended with appropriate chemicals which neutralise the gases developed by the sewage collected in the collecting container 132, whereby they do not cause harm to the ejector device.

The sewage collecting container 132 is provided with a ventilation pipe 146, an emptying valve 142 and sensor means 136 and 138 for monitoring the surface level of the sewage.

In Fig. 3 is shown a second embodiment of the ejector device and the collecting container, which may be applied to the above disclosed vacuum sewer system.

The ejector device 201 comprises a centrifugal pump 207 to the suction side of which is connected a working medium transfer pipe 208 connected to the lower part of the ejector container 205. The centrifugal pump 207 circulates liquid under substantially normal atmospheric pressure sucked from the ejector container 205 and functioning as the working medium of the ejector 204 and feeds it with high pressure through the ejector 204 back into the ejector container 205. The ejector container 205 is provided with a ventilation pipe 206. In this way the ejector 204 through the suction connection 213 connected to its suction side sucks air in a manner known per se from the sewage collecting container 232 and creates a partial vacuum in the collecting container 232 and the vacuum piping 228 of the sewer network.

In this embodiment the ejector device 201 and the collecting container 232 are arranged separate from each other.

The primary circuit formed by the ejector device 201 is substantially closed, with the exception of the suction pipe connection. The liquid functioning as the working medium is advantageously water, which is blended with appropriate chemicals which neutralise gases formed by the sewage collected in the collecting container 232, whereby they do not cause damages to the ejector device.

The sewage collecting container 232, which is shown vertically arranged, is provided with sensor means 236 and 238 for monitoring the surface level of the sewage collected in the collecting container, as well as with a discharge valve 242 and a ventilation pipe 246.

The ejector container 205 has a substantially longitudinal configuration with a cylindrical cross-section and it is horizontally arranged, whereby the ejector 204 discharges the liquid from its discharge opening 204a in the longitudinal direction of the ejector container 205. The liquid transfer pipe 208 connected to the suction side of the centrifugal pump 207 is connected to an

opposite end of the ejector container 205 with regard to the ejector 204 and it runs inside the ejector container 205 near its lower edge, substantially to the ejector end of the ejector container 205. The liquid is arranged to be sucked into the transfer pipe 208 from a suction slot 214 on its underside, which forms the inlet of the centrifugal pump 207 and which extends to a distance L from the ejector end of the transfer pipe 208 towards the opposite end. The suction slot 214 is advantageously at its broadest at the ejector end of the transfer pipe 208 and narrows in the other direction, i.e. in the suction direction. This has shown to be an advantageous arrangement for securing that the liquid is sucked to the centrifugal pump and from there further on to the ejector, thus avoiding that air is sucked into the liquid during the process. Any additional air could disturb the functioning of the arrangement.

The minimum height H2 of the liquid surface level in the ejector container 205 is kept above the transfer pipe 208 which forms the inlet of the working medium of the centrifugal pump 207, at least above the suction slot 204 of the transfer pipe 208, and the maximum level H1 below the discharge opening 204a of the ejector 204. The ejector container 205 is provided with sensor means 209 and 210 for monitoring the liquid surface level.

The liquid jetting with high pressure from the ejector 204, however, causes strong splashing in the ejector container 205 creating air bubbles in the liquid. In addition to the arrangement of the above described liquid transfer pipe 208 comprising its suction slot 214, it has shown to be advantageous that a structure 215, 216 dampening the movement of the working medium, i.e. a structure dampening the splashing of the liquid, is formed above the transfer pipe 208. Such a structure may for example be formed by overlapping wings 215, opening away from the ejector 204, which receive the liquid flow striking back from the end of the ejector container 205 opposite the ejector 204. The wings 215 advantageously extend over the whole width of the ejector container 205 and they may also be provided with downwards extending front edges 216, which in turn stop the liquid flow returning from the wings.

In this manner a steady and disturbance-free function of the centrifugal pump 207 and the ejector 204 respectively may be ensured.

The ejector container 205 may further be provided with separation means 217 shown by broken lines in order to separate air from the water. The separation means 217 in this example are perforated plates 217 arranged at the end of the ejector container 205 opposite the ejector 204. The perforated plates 217 are advantageously arranged in an inclined position, for example at an angle in the range of 45° with respect to the longitudinal direction of the ejector container 205.

In Fig. 4 is shown a third embodiment of the ejector device and the sewage collecting container, which may be applied to the above disclosed vacuum sewer system.

The ejector device 301 comprises a centrifugal pump 307 to the suction side of which is connected a working medium transfer pipe 308 connected to the lower part of the ejector container 305, which is under substantially normal atmospheric pressure. The centrifugal pump 307 circulates the liquid sucked from the ejector container 305 and functioning as the working medium of the ejector 304 and feeds it with high pressure through the ejector 304 back into the ejector container 305. In this way the ejector 304 through the suction pipe 213 connected to its suction side in a manner known per se sucks air from the sewage collecting container 332 and creates a vacuum in the collecting container 332 and the vacuum piping 328 of the sewer network. The ejector container 305 is provided with a ventilation pipe 306.

In this embodiment the ejector container 305 of the ejector device and the sewage collecting container 332 are formed into two containers arranged one on top of the other and in a horizontal direction.

The primary circuit formed by the ejector device 301 is substantially closed, with exception of the suction pipe. The liquid functioning as the working medium is advantageously water, which is blended with appropriate chemicals which neutralise the gases formed by the sewage collected in the

collecting container 332, whereby they do not cause damages to the ejector device.

The sewage collecting container 332 is provided with a ventilation pipe 346, a discharge valve 342 and sensor means 336 and 338 for monitoring the surface level of the sewage.

In the horizontal ejector container 305 the ejector 304 is arranged to discharge liquid from its discharge opening 304a in the longitudinal direction of the ejector container 305. The minimum height H2 of the surface level of the liquid in the ejector container 305 is kept above the inlet opening 308a of the transfer pipe 308, which forms the working medium inlet of the centrifugal pump 307, and the maximum height H1 below the discharge opening 304a of the ejector 304. The ejector container 305 is provided with sensor means 309 and 310 for monitoring the surface level of the liquid.

This embodiment provides an example of having the same centrifugal pump used both as the circulation means 307 for the working medium of the ejector 304 as well as as the discharge means 344 of the sewage collecting container 332.

The above described dampening structure and the perforated plates used for avoiding splashing and formation of air bubbles are examples of how to avoid air being transferred into the circulation means for the working medium of the ejector 204, comprising a centrifugal pump 207. Such means increase the degree of efficiency of vacuum generation and ensure an appropriate function of the centrifugal pump. These arrangements can be used together or separately. Corresponding structures can, if so desired, also be applied in connection with the embodiments shown in Figs. 2 and 4.

The above described three embodiments are only examples of possible applications of the invention. The objective is that the liquid circuit of the ejector device is closed, i.e. separate from the sewage collecting process, that the amount of liquid is kept as small as possible, that the state of the liquid is stabilised after discharge from the ejector, so that it is transferred to the cir-

culation means in a stabile state without air bubbles etc., and that the size of the ejector device is kept as small as possible.

In connection with these three embodiments separate pumps may be used as the circulation means for the ejector device and as the discharge means for the sewage collecting container, as described in connection with Fig. 1, or the same pump, as described in connection with Fig. 4. Instead of the centrifugal pump mentioned any other suitable pump or device suitable for the purpose may be used as a circulation means for the ejector device and as the discharge means for the sewage collecting container.

The drawings and the description related thereto are only intended for clarification of the idea of the invention. The invention may vary in detail within the scope of the ensuing claims.

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CLAIMS

1. Arrangement in a vacuum sewer system, which comprises a sewer network (2), which comprises a source of sewage (24) and sewer piping (28;128;228;328), which is intended for receiving sewage coming from the source of sewage, and a liquid driven ejector device (1;101;201;301), which functions as a source of vacuum for the vacuum sewer system, **characterised** in that the ejector device (1;101;201;301) forms a primary circuit, that the sewage collecting process forms a secondary circuit, and that said primary circuit and said secondary circuit are separated from each other.
2. Arrangement according to claim 1, **characterised** in that the ejector device (1;101;201;301) comprises an ejector container (5;105;205;305), in which atmospheric pressure prevails, an ejector (4;104;204;304), circulation means (7;107;207;307) for the liquid functioning as a working medium of the ejector, and a suction connection (113;213;313) connected to the suction side of the ejector and to the sewer network (2).
3. Arrangement according to claim 2, **characterised** in that the sewer network (2) comprises a sewage collecting container (32;132;232;332) and that the suction connection (113;213;313;413) of the ejector device is connected to the sewage collecting container (32;132;232;332).
4. Arrangement according to claim 2, **characterised** in that circulation means for the working medium of the ejector (4;104;204;304) comprise a circulation pump (7;107;207;307), preferably a centrifugal pump.
5. Arrangement according to claim 4, **characterised** in that the working medium of the ejector (4;104;204;304) is water, which has been blended in order to neutralize disadvantageous effects of the sewage.
6. Arrangement according to claim 2, **characterised** in that the ejector container (5;105;205;305) is provided with sensor means (9,10;109;110;209;210) connected to a control center (11) for monitoring the surface level of the working medium of the ejector (4;104;204;304).

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7. Arrangement according to claim 3, **characterised** in that the sewage collecting container (32;132;232;332) is provided with emptying means (42,44;142,144;242,244;342,344) and with sensor (36,38;136,138;236,238;336,338) connected to a control center (11) for monitoring the surface height of the sewage.

8. Arrangement according to claim 7, **characterised** in that the emptying means for the sewage collecting container (32;132;232;332) comprise a circulation pump (44;344), preferably a centrifugal pump.

9. Arrangement according claim 4 and 8, **characterised** in that the circulation means for the ejector and the emptying means for the collecting container comprise separate means and that they are cross-coupled so that they are alternatively usable.

10. Arrangement according to claim 4 and 8, **characterised** in that the circulation means for the ejector and the emptying means for the collecting container comprise the same means.

11. Arrangement according to claim 8, **characterised** in that the sewage collecting container (32) provides an intermediate container and that the vacuum sewer system comprises a sewage container (50) for storing the sewage.

12. Ejector device, which is intended for generating vacuum in a vacuum sewer system, which comprises a sewer network (2), which comprises a source of sewage (24) and sewer piping (28;128;228;328), which is intended for receiving sewage coming from the source of sewage, which ejector device (1;101;201;301) comprises an ejector container (5;105;205;305), an ejector (4;104;204;304), circulation means (7;107;207;307) for the liquid functioning as a working medium of the ejector and a suction connection (113;213;313) connected to the suction side of the ejector and to the sewer network (2), **characterised** in that the circulation process of the working medium for the ejector device (1;101;201;301) is separated from the sewage collecting process.

13. Ejector device according to claim 12, **characterised** in that the ejector container (105) is arranged substantially vertically.

14. Ejector device according to claim 12, **characterised** in that the ejector container (105) is arranged substantially horizontally.

15. Ejector device according to claim 13 or 14, **characterised** in that the ejector container (5;105;205;305) is provided with sensor means (9,10;109;110;209;210;309,310) for monitoring the surface level of the working medium for the ejector (4;104;204;304) and that the surface level (H1,H2) of the working medium in the ejector container is arranged to be maintained below the outlet opening (104a;204a;304a) of the ejector and above the inlet opening (108a;214;308a) of the circulation means (107;207;307).

16. Ejector device according to claim 13 or 14, **characterised** in that the ejector container (5;105;205;305) is provided with a structure (215;216) for dampening the movement of the working medium and/or with separation means (217).

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