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The invention relates to a siphonic flushing device having a reservoir which is provided, at its bottom, with a riser which changes over, via a pipe bend, into a vertical down-pipe to which there is connected a substantially U-shaped pipe which is in communication with a horizontal outlet.

The device can be flowed through not only by small continuous amounts of liquid but also by larger amounts which flow in intermittently, the latter leaving the device in the form of liquid plugs with high kinetic energy. Such liquid plugs may be deliberately aimed at in order to avoid blockages, for example in waste-pipes from dwellings and the like, where, with a free outflow, the pipe would otherwise not be self-cleaning. Another field in which the conveying of liquid in plug form is desired is artificial irrigation, if seepage pipes are connected to a raising mechanism.

With reference to drainage systems of dwellings, it should be borne in mind that the amount of liquid conveyed in such a system amounts to somewhat more than 200 litres per person and 24 hours. Of this amount, 40 litres consist of flushing water from water closets, through which the largest amounts of depositable waste are introduced into the waste-pipe. A large proportion of the water enters the waste pipe with a small volume of flow while the sewage from the water closets occurs intermittently when they are flushed.

Now there are several types of water closet which can be satisfactorily flushed out with 3 litres of water at normal pressure. In the case of reduced-pressure systems, it is a question of even smaller amounts of flushing water. Such low-consumption water closets are not allowed to be connected to communal sewer networks which is because

the opinion is held that the waste introduced into the waste-pipe with the flushing water would settle and so cause this not to be self-cleaning any more.

The self-cleaning capacity of a waste-pipe depends to a certain extent on its dimensions. Hitherto, however, no results of experiments carried out with the dimensioning of drainage systems in houses in which water closets with a reduced amount of flushing water are used, have yet been published. Neither is there any documentation regarding the dimensioning of drains laid in streets, to which low-consumption water closets are connected.

In general, it applies to waste-pipes that these should be dimensioned so that the maximum amount of water which occurs can be introduced and that the pipe should be self-cleaning. Hitherto, the self-cleaning capacity has generally been made dependant on the necessary velocity of water. For sanitary sewers, a water velocity of 0.6 m/s was indicated as necessary for self-cleaning. The period of time to which the flow through at this velocity is related, differs from one country to another. It is common to many countries, however, that the velocity of the water is regarded as being independent of the pipe dimensioning and what is meant by the velocity of the water is the maximum velocity during a minimum day: expressed more precisely, the velocity of the flow through during the maximum hour of the minimum day. In this case, the

day of the year on which the waste-pipe has the lowest flow loading is designated as the minimum day. The maximum hour is the hour when the inflow from other outflow units than the water closet is greatest. In somewhat simplified form, it may be said that the determining flow through is that which occurs if the maximum number of water closets connected to the waste-pipe in question is flushed during the maximum hour. This method of calculation formed the basis for the permission given by Swedish authorities for water closets to be flushed with 6 litres of water.

In recent times, the self-cleaning has been related to the shearing stress along the bottom of the pipe which occurs during the flowing of the water. This method of calculation of the self-cleaning capacity is used in the Swedish government building regulations. The requirement with regard to the necessary protection against sludge deposits is met if the shearing force, calculated in accordance with the following formula, has a value of $0.25 \text{ kp/m}^2 (2.45 \text{ Pa})$.

$$S = J \times \gamma \times R$$

$$S = \text{shearing force (kp/m}^2\text{)}$$

$$J = \text{gradient of the energy line (m/m)}$$

$$R = \text{hydraulic radius (m}^2\text{/m)}$$

$$\gamma = \text{weight by volume (t/m}^3\text{)}$$

$$\text{Hydraulic radius} = \frac{\text{cross-section of pipe}}{\text{wetted circumference}}$$

Hitherto, research has not been in agreement as to which of the two methods used to calculate the self-cleaning capacity accords best with the practical conditions. At present, however, extensive research projects are in progress at various research institutes all over the world and because of the ever more acute water shortage, high priority is allocated to these.

In the case of outside waste pipes, including branch pipes to houses, the same considerations with regard to the self-cleaning capacity apply on the whole as in the case of pipelines in the interior of buildings. There is an important difference, however, in so far as the dimensions of the outside pipes are considerably larger which leads to the fact that the requirement with regard to the volume of flow through increases greatly. A special and important case is the sanitary sewers in residential areas with only a small number of branch pipes connected up to houses, that is to say with an intermittent flow of water which is very small on the average. It is doubtful whether considerations similar to the above with regard to the self-cleaning can be used at all here. The organic waste consists to a large extent of large lumps (faeces etc.) which have not yet been able to decompose or be dispersed by other mechanical means. The conveying is effected partially as a result of the fact that lumps flow with the water, possibly coming into contact with the bottom of the pipe and the walls of the pipe. If the flow of water is interrupted, the lumps

sink to the bottom or they are deposited on the sides of the pipe. During the next flushing with water, they are lifted and participate in the flow for a short distance or, if the amount of water is too small, they remain in the same place in which case fresh organic lumps may be deposited thereon. Such an increasing depositing can gradually lead to a total blockage.

One possibility of mastering the said problem consists in taking the self-cleaning into consideration in the dimensioning of sanitary sewers so that the flow through at any moment each day is once so great that the deposited impurities are flushed away. As already explained, it has therefore been proposed that the flow through during the maximum hour on a minimum day should be regarded as the determining flow through in this connection.

From the method described here for determining the determinative flow through for sanitary sewers, it is possible to draw the conclusion that if the pipe can be loaded intermittently with a large flow of water by means of a special device, any deposits will be flushed away.

Certain problems arise in the case of artificial irrigation by means of perforated seepage galleries buried in the earth. Since soils normally have an absorption capacity, the water flowing through the pipeline emerges rapidly over a comparatively short distance. For this reason, such a seepage gallery must have inlets disposed comparatively close to one another which means that a

complete supply pipe with a plurality of branches to the seepage gallery must be laid parallel to the pipeline in question. On the other hand, if the water can be conveyed through the seepage pipe in the form of a plug, the number of inlets to the said pipeline can be considerably reduced and in this manner no excessive flow of water occurs at certain sections of the artificially irrigated area. (Such an excess of water mostly evaporates and so is of no use to the seed.)

A double siphonic flushing device is known from the DE-C-247 851, wherein, disposed in a reservoir, is a riser which changes over, via a pipe bend, into a vertical down pipe. A vent pipe which projects above the level of the liquid in the reservoir and which forms a water seal is connected to the highest point of the pipe bend. In the event of a rise in the water level in the reservoir, the air in the vent pipe is compressed and the water is driven out of the water seal, as a result of which the path for the water of the reservoir through the double siphon is cleared. This known device is very expensive to construct because of the double-U-shaped vent pipe.

A siphon is known from the DE-C-170 855 wherein, with an appropriate height of the liquid level, liquid overflows out of the riser via a pipe bend into the down pipe. Below the free end of the down pipe there is a small chamber which is filled by the water emerging from the down pipe and so closes the opening of the down pipe. The air

present in the down pipe and in the pipe bend is drawn off by a suction device working constantly until the siphon action begins. This device is also very expensive because a suction device working constantly is necessary to draw off the air.

The present invention serves the purpose of providing a device from which liquid can emerge in the form of plugs with high kinetic energy. Two fields of application were indicated above, namely on the one hand to improve the self-cleaning capacity in waste pipes, in which case these can be made with smaller dimensions than others because of the kinetic energy of the water plug, and on the other hand to achieve longer conveying sections through seepage pipes as a result of the fact that the coherent water plug covers a comparatively long distance, as a result of its kinetic energy, while the plug gradually decreases in volume as a result of the fact that it surrenders some of its liquid through the perforations at the wall of the pipe.

According to the invention, this is achieved in that the reservoir is connected to the riser via a pipe bend projecting downwards from its bottom and that the U-shaped pipe changes over into the horizontal outlet in such a manner that a liquid seal which does not close completely is formed with a normal inflow of water but that with a greater inflow of water, the liquid seal in the pipe closes and causes a starting of the siphonic flushing device.

The invention is described in more detail with reference to the accompanying drawings in which

Figure 1 shows the device when this is half filled for the first time;

Figure 2 illustrates the conditions when the device is filled and begins its plug-forming mode of operation;

Figure 3 shows the device when this is completely filled and a coherent water plug is on the way out of the waste pipe;

Figure 4 illustrates the liquid remaining after the water plug has flowed out;

Figure 5 illustrates a modification of the invention which comprises a vent connection between outlet pipe and inlet pipe.

Liquid enters a flushing device or reservoir 2 through an inlet pipe 1 into which the waste pipes of all the sanitary installations occurring in a building lead or which comes from a conveying system driven by hand, foot, oxen or other draft animals. A pipe 5 extending with a selected gradient to a highest point 4, extends from the bottom 3 of the reservoir. At the end of the riser 5 there is a pipe bend 6 from which a down pipe 7 extending vertically is taken. A variation in dimensions may take place between pipe bend 6 and down pipe 7. This variation is normally constructed in the form of a narrowing 8, as a result of which the velocity of the liquid can be altered. It has been possible to prove by experiments that the

velocity of the water increases exponentially in the down pipe 7 with the decreasing dimensions thereof, with a certain dimension of the riser 5.

The down pipe 7 is connected to a partially U-shaped pipe 9 with a horizontal outlet 10. The outflow 10 is connected to a communal sewer network or, in the case of artificial irrigation, to an outgoing seepage gallery.

The following mode of operation applies to the device: Liquid enters the reservoir 2 via the inlet pipe 1. As a result of the fact that the reservoir 2 is in communication with the riser 5, the same liquid level becomes established in both. The highest point 4 of the riser 5 is selected so that it comes to lie at the same height as the cover of the reservoir 2. When the liquid in the reservoir 2 has reached this height, an amount of liquid which normally corresponds to the inflow occurring at the reservoir 2 flows over the highest point 4 of the riser 5. If this inflow is small, only a comparatively small amount of liquid flows through the down pipe 7 per unit of time and down to the U-shaped pipe 9 serving as a water seal which does not close completely. Since the whole process takes place at atmospheric pressure, the outflow coming from the pipe 9 is equal in magnitude to the inflow in the inlet pipe 1. If this inflow is increased, the amount of liquid flowing out through the down pipe 7 is also increased to the extent that the liquid seal in the pipe 9 closes. If the increased flow through is extended over a few seconds in time, a coherent water plug is formed in the pipe 9 and flows out

via the outlet pipe 10. In the course of this, a reduced pressure is formed in the down pipe 7 as a result of which, liquid is sucked out of the riser 5 and the reservoir 2. As a result of this suction, the flow in the down pipe 7 is increased to the extent that a fresh liquid plug is formed directly in the pipe 9. The process then takes place so quickly that it is no longer possible to speak of a plurality of separate liquid plugs but a coherent column of liquid is formed from the reservoir 2, via the riser 5 and the down pipe 7 and through the pipe 9, as illustrated in Figure 3. This coherent column of liquid is forced through the device by the atmospheric pressure prevailing at the inlet pipe 1 and there is a siphonic action in existence until all the liquid has been emptied out of the reservoir and air is drawn into the riser 5. After that, the siphonic action of the siphon ends and the device returns to the position of rest as illustrated in Figure 4.

The modification of the invention illustrated in Figure 5 cannot be used with reduced-pressure systems and is provided primarily for those drainage systems which work with atmospheric pressure. In the same manner as in the original variant, it has an inlet pipe 11 which is connected to the top of a reservoir 12 from the bottom 13 of which there extends a riser 15 laid upwards at a selected angle. At the end of the riser there is a pipe bend 16, the inside radius of which represents the highest point 14 of the

riser. Extending from the pipe bend 16, via a narrowing 18, is a vertical down pipe 17 which is connected to a partially U-shaped pipe 19, the outlet side of which is connected horizontally to an outlet pipe 20. Branched off from the outlet pipe 20 is a vent pipe 21 which is connected to the inlet pipe 11 of the device. As a result of this vent pipe 21, the effect is achieved that a water plug originating from the pipe 19 does not have to work against a counter-pressure prevailing in the outlet pipe 20. Should there be a blockage in the further course of the outlet pipe 20 preventing a free flow through of the air in the pipe, this air can be supplied, via the pipe 21, to the inlet pipe 11 and by this route via the vent pipes normally occurring in the building, into the atmosphere.

The device has been described here mainly as a device for discharging sewage out of a conventional drainage system. By appropriate formation and dimensioning of the riser 5, however, it can easily be adapted to drainage systems which work with reduced pressure. It can also be adapted as a proportioning device in manufacturing processes where an intermittent supply of material to be mixed is desired in the liquid phase and where fluctuations in volume of an order of magnitude of $\pm 10\%$ are acceptable.



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Comments on the English translation of the Claims

Claim 1: Line 1: "Device for flushing sewers by siphonic action". Since there is no reference to sewers in the German claim and the specification indicates other application I should prefer "Siphonic flushing device".

Line 2: "collection basin (2, 12)". I should prefer the more usual rendering "reservoir" or "storage tank" for the German "Sammelbehälter".

Column 8, lines 2/3: "vertical pipe (7, 17)". The German text specifies a "vertical down pipe (7, 17)".

Claim 3, line 20: "culmination point (4)". I should prefer "highest point" in this context.

Line 21: "top". The German "Deckel" usually means "cover".

Claim 4, line 24: "vertical pipe (7)". The German text says "vertical down pipe (7)".

Claim 6, line 33: "exhaust line (21)". "Entlüftungsleitung" means "vent pipe".

There are also two misprints in the Claims. In Claim 1, line 60, "siphinic" should read "siphonic" and in Claim 3, line 19 "Devise" should read "Device".