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54	TITLE OF INVENTION
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Method and device for purifying and treating waste water in order to obtain drinking water

57	ABSTRACT (NOT MORE THAN 150 WORDS)
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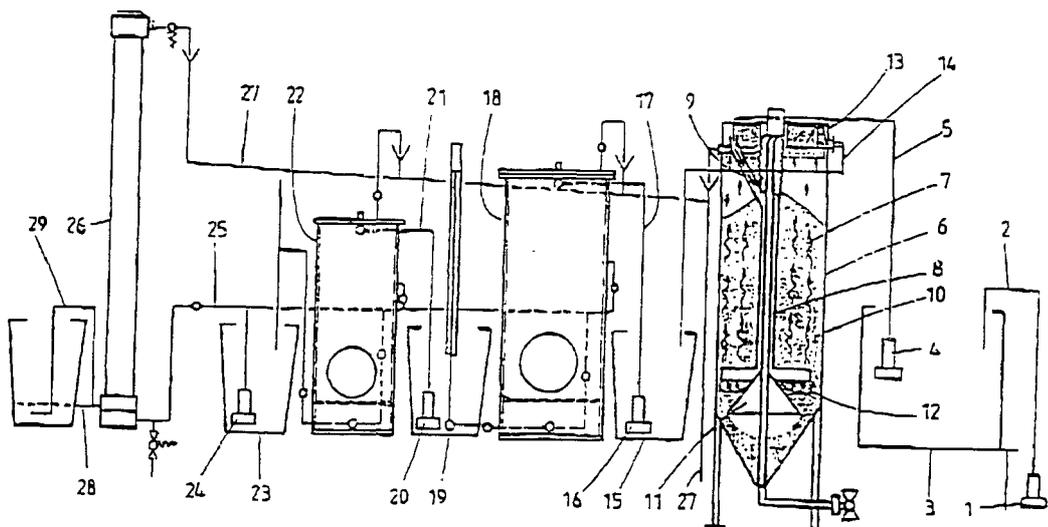
NUMBER OF SHEETS	19
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The sheet(s) containing the abstract is/are attached.

If no classification is furnished, Form P.9 should accompany this form.
The figure of the drawing to which the abstract refers is attached.



WO 02/06168 A1



Abstract: The invention relates to a method for purifying and treating waste water in order to obtain drinking water, and a device for carrying out the method. Waste water is treated in a first step in a microbiological aerobic manner. Non-biodegradable foreign bodies or particles are then separated from the waste water. This is followed by biological post-purification, and biologically and chemically non-degradable substances are then removed from the treated waste water by means of post-filtration. The following step involves guiding the waste water through a static sand filter, and can involve a dynamic sand filter, an activated carbon filter, and ultrafiltration as further options. The inventive device comprises a microbiologically aerobic waste purification system, a system for separating off non-biodegradable foreign bodies and for removing residual degradable substances, and a post-filtration system.

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The invention relates to a process for cleaning wastewater and the purification thereof to drinking water. The invention furthermore relates to an apparatus for implementing this process.

Wastewater within the framework of the invention is used water (sewage water) from households, residences, hotels, residential complexes of up to 1000 persons and small towns. It also refers to water with a comparable or lesser dirt composition.

To clean wastewater, it is known to treat it biologically, chemically or physically on large purification plants in such a way that it can be discharged into inland waters. However, with these known purification processes the cleaned water is not purified up to drinking water quality.

When treating water by reverse osmosis no attention is paid to important minerals such as salts remaining behind in the water.

For this reason the known processes for cleaning wastewater are not suitable for supplying drinking water for consumption and re-purifying this in a direct circulatory system, without discharging the water as intermediate stage into inland waters or treating it by passing it through the ground. The known cleaning processes are especially not suitable for the purification of water which is used in a relatively small consumption unit that is not connected to a public water supply system. Thus the known processes cannot be used for the water supply of, for example, hotels, residential complexes⁷ or small towns, which are put up and operated in arid areas or areas that do not have suitable inland waters for the drinking water supply.

It is the object of the invention to make potable water available in an easy to monitor consumption unit such as a hotel, independently of public water supplies, and to re-purify it for re-use.

According to the invention this object is achieved by a process, which has the characteristics of claim 1. Advantageous embodiments and further

developments of this process form the subject of the sub-claims that refer back to claim 1.

Furthermore, according to the invention this object is achieved with an apparatus that has the characteristics of claim 5. Advantageous embodiments and further developments of this apparatus form the subject of the sub-claims that refer back to claim 5.

For the purification and direct re-use of wastewater, the invention combines biological, chemical and physical cleaning processes.

During the purely biological purification, with the aid of air-oxygen, bacteria and other micro-organisms can oxidise about 98 to 99% of the organic constituents of the dirty water or wastewater to carbon dioxide and water.

However, 1 to 2% of the organic constituents contained in the wastewater cannot be decomposed biologically or not sufficiently quickly. A biological after-treatment on filters is, therefore, required. In addition it is possible to remove the organic constituents so-to-speak physically from the to be cleaned wastewater, at least partly by adsorption on activated carbon. The particulate constituents that then still remain behind in the to be cleaned wastewater can, for example, also be removed from the wastewater by ultra-filtration. Undesirable constituents of an organic or inorganic nature and particles, as well as bacteria and viruses, are finally removed in a third step by nanofiltration or reverse osmosis.

Due to the unique pore distribution in nanofilters, it is ensured during the nanofiltration that the concentration of the minerals, which are important for water and especially for drinking water, is not removed by complete demineralisation of the water, but is adjusted to the optimal concentration for living things.

Bacteria and corresponding particles are separated in the second treatment step provided according to the invention, preferably in several filter stages. By the ultrafiltration all bacteria, viruses or other particles are held back

completely on the filter, i.e. a so-called sterile filtration takes place. The nanofiltration that follows the ultrafiltration is a double-security system. It is also able to completely hold back any particles and bacteria that may still be present. Only very small quantities of chemicals are required here for the treatment and purification of the wastewater.

However, the ultrafiltration is not absolutely essential. In many cases it is also possible to obtain biologically stabilised drinking water also without ultrafiltration.

The nanofiltration as last treatment step is more economical than reverse osmosis. When the ultrafiltration is dispensed with, a significant amount of energy costs is saved.

For the chemical treatment anti-scaling agents and also chlorine can be used.

a. Anti-scaling agents

A few millilitres of the anti-scaling agent per m^3 of water are added during the nanofiltration, so as to prevent, for example, lime deposits on the membranes provided for the nanofiltration.

b. Chlorine

As dirt in downline pipes or basins can carry germs into the system, it is provided that after the final filtration (nanofiltration) approx. 0,1 to 0,3 mg/l chlorine are added to the germ-free purified water in order to prevent a renewed uptake of germs in the downline tanks and piping systems of the apparatus according to the invention.

In the following the invention will be explained in detail with reference to practical exemplified embodiments of an apparatus for cleaning wastewater and for the direct purification thereof to drinking water.

Aeration plant

In an aeration basin with a capacity of, for example, 60 m^3 wastewater,

activated sludge in floc form is mixed with the wastewater that must be cleaned. The organic impurities contained in the wastewater are absorbed by the activated sludge floc and within a few hours for the greater part biologically decomposed. The oxygen required for this is fed into the to be cleaned wastewater by fans arranged at the bottom of the aeration basin.

The described aeration basin is followed by a sedimentation basin, which is hydraulically connected to the former. In this non-aerated sedimentation basin the sludge settles. The clarified, supernatant wastewater is pumped into a second aeration basin. The sludge slides down and from there moves back again to the aeration basin. Inclined plates can be arranged far down below the maximum water level as baffle plate thickeners or lamellar thickeners, in order to achieve an improved separation of the activated sludge. Because the plates are arranged far down in the sedimentation basin, this basin can also be used as a storage basin with variable water level.

In a further basin the to be cleaned wastewater undergoes a forced biological decomposition. The basin provided for this contains growth bodies with very large growth surfaces. The water-cleaning organisms grow on the surface of the solid bed (solid body) provided in the basin and eliminate particularly difficult decomposable constituents that were not yet eliminated in the first basin. This water can also be aerated. Also here oxygen is used, but considerably less. Alternatively, also another aeration basin can be used as a further basin.

As small quantities of activated sludge floc can be carried out of the activation basin, in a second treatment stage provided according to the invention, a filter is, for example, provided which cleans itself. Thus, water flowing out of the second basin is pumped, e.g. by means of a pump, into the bottom third of a dynamic sand filter and flows upwards or from the bottom to the top through the sand contained in this filter. The sand contained in the dynamic sand filter is pumped upwards by air and water through a pipe located inside the filter housing. As a result of the turbulence the sand is continually washed.

The sand coming out of the inside pipe in the upper part of the dynamic sand filter trickles through a baffle plate onto the surface of the filling of the sand filter. A small portion of the already filtered or purified water flows in the direction opposite to the sand contained in the sand filter and in this way prevents dirt from penetrating into the outlet of the filtrate.

The water flowing in the opposite direction in the dynamic sand filter together with the washing water of the sand is fed back into the first aeration basin.

As a result of this washing operation, loaded sand continually slides to the bottom zone of the dynamic sand filter, so that fresh sand is continually available for the filtration.

The sand circulation is preferably controlled by the air supply.

A solenoid valve shuts off the air supply during a stoppage of the plant.

By adjusting the air supply, the sand circulation is regulated in such a way that the sand starts moving again automatically also after a stoppage of the plant. Higher circulation speeds are not required.

According to the invention this second treatment stage furthermore comprises a static sand filter, in which a further biological decomposition of the foreign matter contained in the to be purified wastewater takes place. This biological decomposition can after some time lead to a compacting of the top layer of the sand filling. This causes an increase in pressure in the plant, which is indicated by a pressure gauge. Thus, for example, when the pressure gauge indicates an increase in pressure of more than 0,3 bar, the filter must be backwashed in order to maintain the operating ability of the plant.

In this second treatment stage the cleaning of the wastewater preferably also takes place with the aid of an activated carbon filter. This activated carbon filter serves to remove part of the biologically difficult decomposable substances contained in the wastewater. Depending on the composition of

the wastewater, an undesirable compacting of the surface can also take place in the activated carbon filter, which necessitates a backwashing in one to six months.

Thus, some surfactants can be biologically decomposed only to a limited extent. The content of biologically difficult decomposable surfactants can reduce the absorption capacity of the activated carbon of the activated carbon filter up to exhaustion.

By using several series-connected filters in the second treatment stage, the content of bacteria and organic constituents of the to be treated wastewater can be very greatly reduced. To obtain a complete sterilisation of the treated wastewater and to avoid deposits in the subsequent nanofiltration (third treatment stage), the wastewater can also still be treated by ultrafiltration in the second treatment stage.

So that deposits formed on the surface of the membrane provided for the ultrafiltration can be removed by rinsing, preferably compressed air and backwashing water is pressed into the ultrafiltration unit for half a minute every thirty minutes. After opening a solenoid valve, the backwashing water flows into the return pipe leading to the first aeration basin. This operation takes place automatically.

By means of the nanofiltration furthermore provided according to the invention as the third treatment stage, the last amounts of organic constituents of the to be purified water such as salts, phosphates, sulphates, hardening constituents (e.g. calcium, magnesium), but also a considerable portion of sodium chloride, i.e. cooking salt, are removed. The concentrate with enriched salt and other constituents can be thrown away, partly fed back into the reservoir or aeration basin, or can also be used for other purposes, e.g. for flushing toilets.

To prevent deposits on the surface of the membrane used for the nanofiltration, preferably an anti-scaling agent is added to the water that flow into the nanofiltration. The dosing preferably takes place automatically.

In the drawing two exemplified embodiments of an apparatus according to the invention for implementing the second step of the process according to the invention for cleaning wastewater and purifying this to drinking water are illustrated diagrammatically, wherein:

Fig. 1 is a diagrammatic representation of the one embodiment of the apparatus and

Fig. 2 is a diagrammatic representation of the second embodiment of this apparatus according to the invention.

With the embodiment according to Fig. 1 microbiologically precleaned water is fed by means of a pump 1 through a pipe 2 into a basin 3, which acts as further aeration basin.

From this basin 3 by means of another pump 4 the already treated wastewater that, however, still requires further treatment, is fed through a pipe 5 from above into a dynamic sand filter 6.

The dynamic sand filter 6 contains a filling 7 of sand. Centrally through this filling 7 there extends a pipe 8, into which the water that requires further treatment runs in through an inlet 9. Near the bottom end of the housing 10 of the dynamic sand filter 6 a cone-shaped or funnel-shaped widened part 11 is arranged, onto which the to be treated wastewater that flows downwards through the pipe 8 impinges and there reverses its direction of flow as indicated by the arrows 12 in Fig. 1, so that the wastewater that first flowed downwards now flows upwards through the sand filling 7.

At the upper end of the housing 10 of the dynamic sand filter 6 an overflow 13 is provided, through which the wastewater that has undergone further cleaning in the dynamic sand filter 6 flows into a discharge pipe 14, which opens out into an intermediate basin 15.

From the intermediate basin 15 the wastewater that requires further cleaning is fed by means of a pump 16 through a pipe 17 into the top end of a static

sand filter 18.

From the static sand filter 18 the wastewater that requires further treatment flows into another intermediate basin 19, in which a pump 20 is immersed in order to feed the wastewater from this intermediate basin 19 through a pipe 21 into the top end of an activated carbon filter 22.

From the activated carbon filter 22 the wastewater, which has undergone further treatment there, flows into an additional intermediate basin 23, from where it is pumped by means of a pump 24 through a pipe 25 into the bottom end of a column-like ultrafiltration 26.

A common collecting pipe 27 serves to feed back the sludge separated from the individual filter elements illustrated in Fig. 1 to the first aeration basin of the plant - not illustrated in the drawing - for further treatment.

The collecting basins of the apparatus, i.e. the basins 15, 19 and 23, can be additionally aerated in a manner that has not been illustrated.

With the apparatus illustrated in Fig. 1, which carries out the further treatment of the wastewater, the waste water that has undergone further purification in the ultrafiltration 26, flows through a pipe 28 into a nanofiltration 29, where the already treated wastewater undergoes an after-treatment so as to securely eliminate foreign matter that has not yet been separated or undesirable constituents that have not yet been removed, so that the treated wastewater is of drinking water quality and need not be discharged into inland waters, but is available for direct reuse as drinking water.

With the embodiment of the apparatus according to the invention illustrated in Fig. 2, the wastewater that has been extensively precleaned in the aeration basins and is to undergo a final after-treatment in the nanofiltration, can according to the invention undergo an intermediate treatment in one single apparatus, and this accordingly represents an alternative embodiment to the embodiment illustrated in Fig. 1.

The apparatus illustrated in Fig. 2 contains in a housing 30, into which the biologically or microbiologically pretreated wastewater flows from above through a pipe 31, a meander-shaped filter 32 of open-pored foam material, underneath this a grate 33 and underneath this a sand filter 34 consisting of a sand filling, the wastewater that requires further treatment flowing through these parts from the top downwards.

Connected to the sand filter 34 by way of an outlet pipe 35 is a discharge valve 36, which optionally can also be switched as inlet valve to permit the backwashing of the sand contained in the sand filter 34 for cleaning purposes. Inside the housing 30 the outlet pipe 35 is constructed as a filter pipe.

Furthermore, on the discharge valve 36 in the top end of the housing 30 a float 37 is arranged by way of a reversing mechanism, with the aid of which the water level in the housing 30 can be adjusted and regulated.

Preferably two layers of foam material are wound in such a way that the inlet principle illustrated in the drawing is maintained.

The meander-shaped filter 32 consisting of open-pored foam material, because of its numerous pores ensures the filtering of the wastewater that passes through and also acts as a bacteria carrier, so that a further biological cleaning of the wastewater can take place here.

This embodiment provides a very large flow-on surface, which leads to the ascertained high filtering efficiency, which displays an associated reduced tendency to get blocked. A further advantage is the low rate of flow.

Rinsing water that occurs during the backwashing of the sand filter 34 can be fed back through at least one filter pipe 39 with connection piece 40, arranged underneath the grate 33, into the first aeration basin for the treatment.

The combination of the meander-shaped foam material filter 32 and the sand filter 34 in one housing 30 is not only particularly efficient but also extremely

economical. The two can also be provided as separate units. The combination filter illustrated in Fig. 2 can only be used for the second treatment stage of the wastewater.

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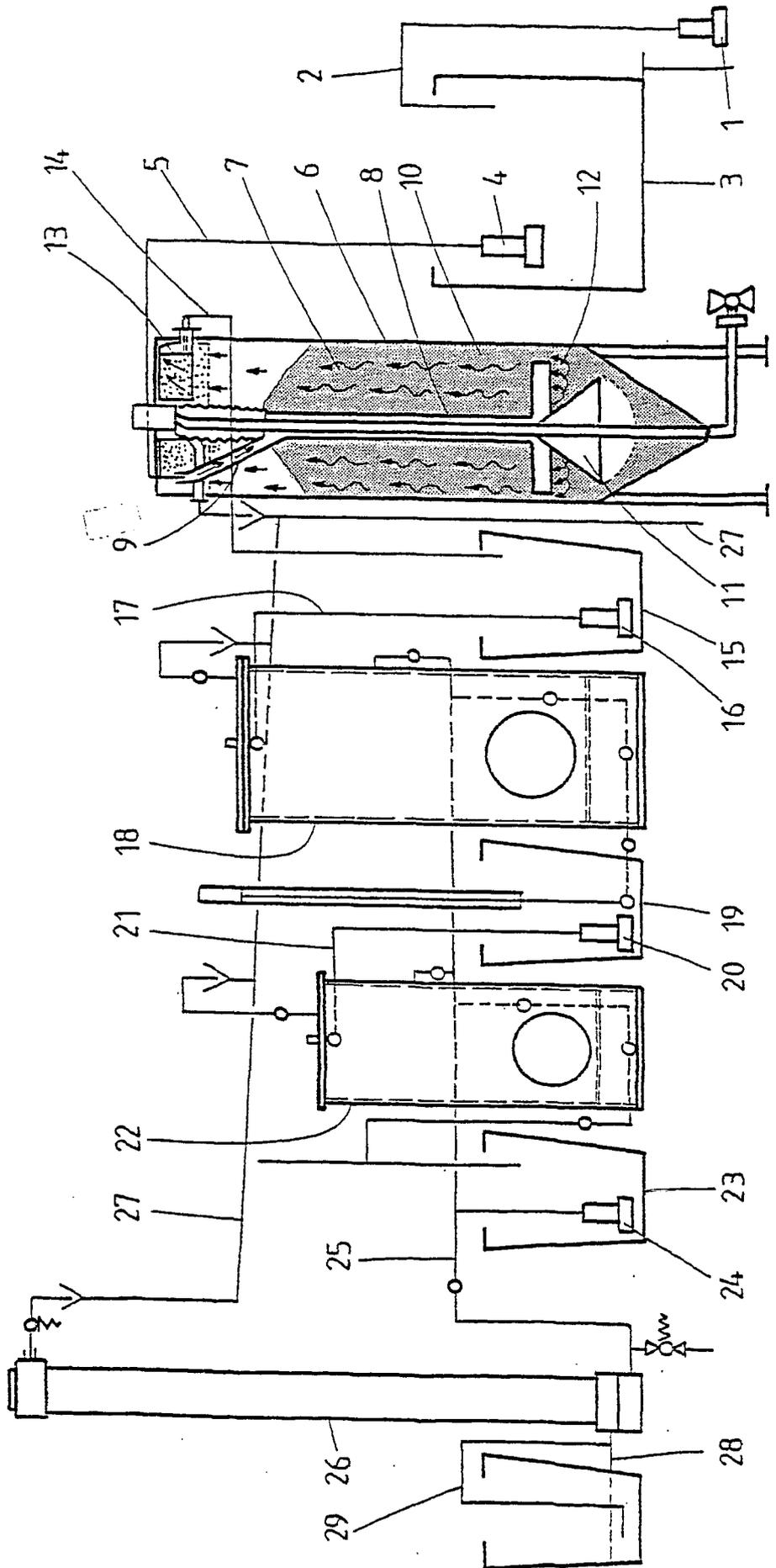
Claims:

1. Process for cleaning wastewater and the purification thereof to drinking water, wherein
 - in a first step the waste water is microbiologically aerobically cleaned,
 - subsequently in a further step biologically not decomposable foreign matter or particles are separated from the wastewater and a biological after-cleaning takes place and
 - finally biologically and chemically not decomposable constituents are removed from the treated wastewater by after-filtration.
2. Process according to claim 1, characterised in that in the further step the wastewater is physically and/or mechanically filtered.
3. Process according to claim 1 or 2, characterised in that in the further step the wastewater is treated by ultrafiltration.
4. Process according to claim 3, characterised in that in the third process step the wastewater is treated by nanofiltration or reverse osmosis.
5. Apparatus for implementing the process according to any one of the claims 1 to 4, characterised in that it comprises, connected in series,
 - a microbiological aerobic wastewater cleaning unit
 - a unit for separating biologically not decomposable foreign matter or particles and removing residual biologically decomposable constituents and
 - an afterfiltration unit.
6. Apparatus according to claim 5, characterised in that the afterfiltration unit is a nanofilter or a reverse osmosis device.
7. Apparatus according to claim 5 or 6, characterised in that the unit for separating biologically not decomposable foreign matter or particles

comprises at least one sand filter as well as an activated carbon filter.

8. Apparatus according to claim 7, characterised in that the unit for the first separating of biologically not decomposable foreign matter or particles comprises a dynamic sand filter.
9. Apparatus according to any one of the claims 5 to 8, characterised in that the unit for the first separating of biologically not decomposable foreign matter or particles comprises, connected in series,
 - a dynamic sand filter
 - a further sand filter
 - an activated carbon filter and/or
 - an ultrafiltration filter.
10. Apparatus according to claim 5, characterised in that the unit for separating biologically not decomposable foreign matter or particles comprises a filter which comprises in combination a meander-shaped foam material filter and a sand filter.
11. Apparatus according to claim 10, characterised in that the foam material filter and the sand filter are arranged in a common housing.

FIG.1



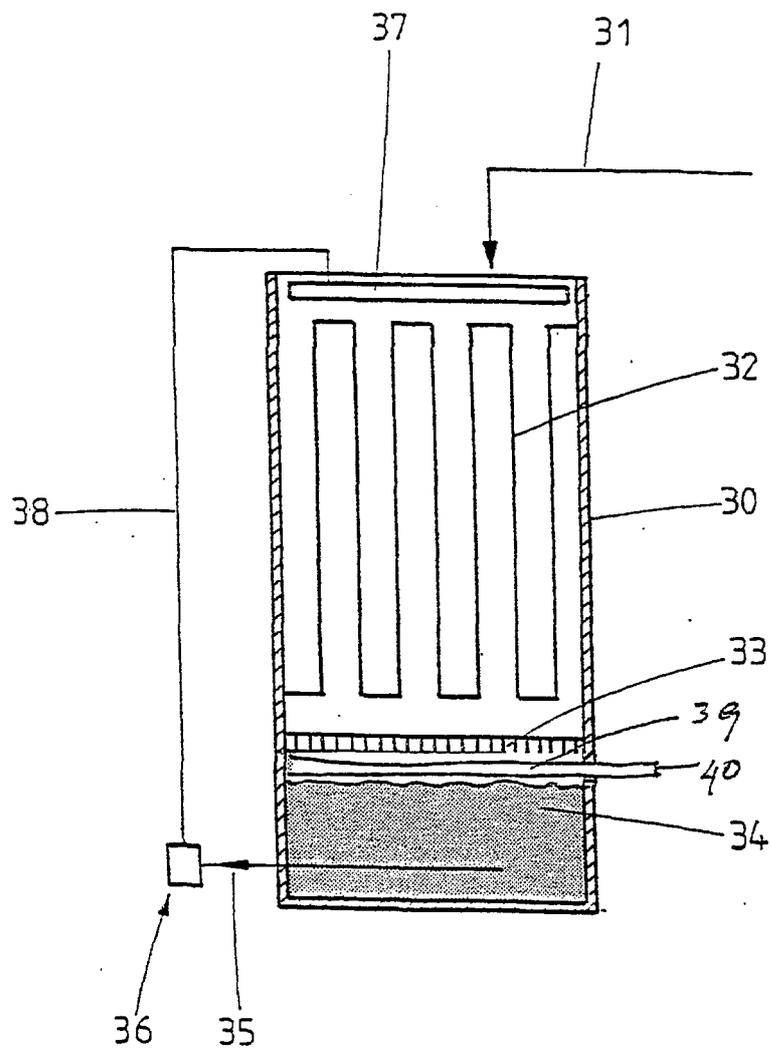


FIG. 2