OPIC
Office de la propriété intellectuelle du Canada

CIPO
Canadian Intellectual Property Office

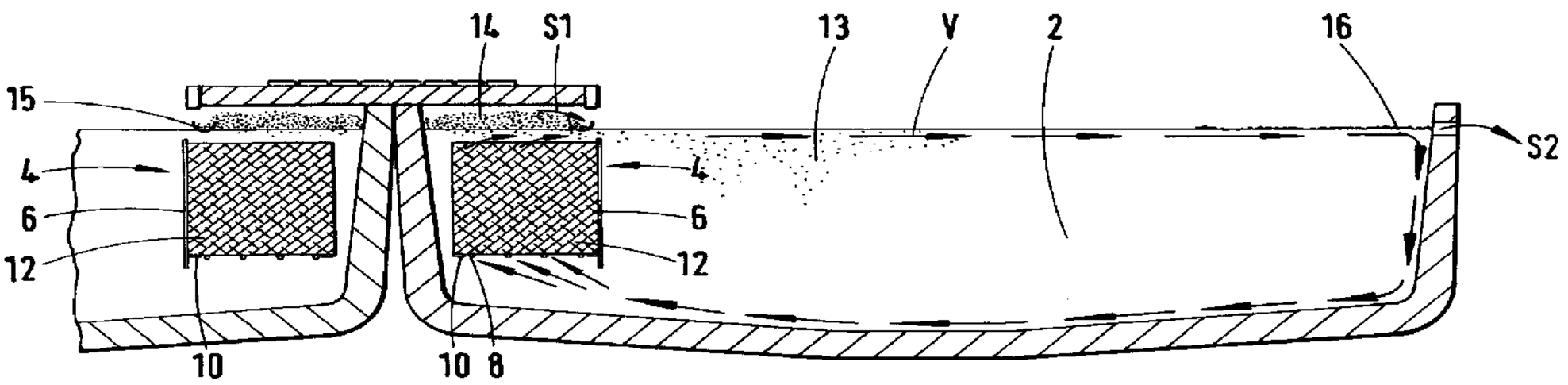
(12) (19) (CA) **Brevet-Patent**

(11) (21) (C) **2,004,817**
(22) 1989/12/07
(43) 1990/06/08
(45) 2000/10/31

(72) Lygren, Eivind, NO
(73) Sunfish Ltd. A.S., NO

(51) Int.Cl.[5] C02F 1/24
(30) 1988/12/08 (88.5455) NO

(54) **METHODE ET APPAREIL POUR LE TRAITEMENT DE L'EAU**
(54) **METHOD AND APPARATUS FOR TREATING WATER**



(57) Contaminated water is caused to flow up through a chamber (4) while aerated to produce all bubbles of a size mainly in the range of 0,03 mm to 1 mm by means of air diffusors (8) disposed at the bottom of the chamber. Organic and inorganic impurities in the water is, by a combination of water flow, flotation and physical adsorption caused by the air bubbles, brought to the surface of the water in the chamber (4) where a foam containing dissolved impurities is formed and instantly removed from the chamber while a mixture of water particles and microscopic air bubbles is allowed to flow over a partition wall (6) into an adjacent basin (2) having a considerably larger volume than that of the chamber (4). In the basin (2) a flotation process will take place causing a slurry (16) to form on the surface of the water in the basin which is removed preferably at the end of the basin opposite the chamber (4). The raising air bubbles from the diffusor (8) in the chamber (4) causes the water to circulate through the chamber (4) and basin (2), said chamber and basin communicating above and below the partition wall (6). Preferably a biofilter medium (12) having upwardly extending, intercrossing channels is disposed in the chamber (4).

2004817

~~18~~

A B S T R A C T :

Contaminated water is caused to flow up through a chamber (4) while aerated to produce air bubbles of a size mainly in the range of 0,03 mm to 1 mm by means of air diffusors (8) disposed at the bottom of the chamber. Organic and inorganic impurities in the water is, by a combination of water flow, flotation and physical adsorption caused by the air bubbles, brought to the surface of the water in the chamber (4) where a foam containing dissolved impurities is formed and instantly removed from the chamber while a mixture of water particles and microscopic air bubbles is allowed to flow over a partition wall (6) into an adjacent basin (2) having a considerably larger volume than that of the chamber (4). In the basin (2) a flotation process will take place causing a slurry (16) to form on the surface of the water in the basin which is removed preferably at the end of the basin opposite the chamber (4). The raising air bubbles from the diffusor (8) in the chamber (4) causes the water to circulate through the chamber (4) and basin (2), said chamber and basin communicating above and below the partition wall (6). Preferably a biofilter medium (12) having upwardly extending, inter-crossing channels is disposed in the chamber (4).

This invention relates to the treatment of water, particularly water intended for use in fish farming plants. More explicititely the invention relates to a method for water treatment comprising aeration of the water to be treated and causing it to circulate to a chamber, into an adjacent basin of considerably larger volume than that of the chamber and back to the chamber, said aeration producing bubbles acting to form a foam containing dissolved impurities at the surface of the water in the chamber, and removing said foam from the chamber as it is formed.

A such method is disclosed in Norwegian patent No. 58 996. According to this patent the circulation of the water is provided by an external water pump in which also the air for aeration of the water is added before the water is ejected into an upper portion of the chamber, closely below the foam formed by the air bubbles.

Here it should be generally noted that water treatment based on air bubbles ricing in water takes place by two strictly distinguished phenomena or mechanisms termed flotation and physical adsorption respectively, which, dependent on the size of the bubbles, take care of different forms of impurities in the water. Thus, flotation is used to remove particulate organic and inorganic material suspended in the water, while physical adsorption extracts dissolved organic and inorganic substances in the water.

Flotation utilizes the ability of the suspended particles to rise to the surface of a liquid. For this to happen the density of the particles must be lower than that of the liquid or they must be able to be lifted to the surface by gas bubbles enclosing or adhering to the material which settles as a slurry deposit on top of the water from where it can be removed. However, the water surface must be relatively calm as otherwise the slurry will disintegrate.

In physical adsorption, polarized compounds dissolved in the water associate with the air bubbles which bring them to the surface where they are collected in a voluminous bubble foam that is easily removed.

The flotation process uses air bubbles ranging from about

0,03 mm up to about 0,12 mm in size, while the pysical adsorption process is most effective with bubbles of a size around 0,8 mm.

Normally the air bubbles for flotation are produces by dissolving air in water that is put under a pressure of several atmospheres, and then releasing the pressure to form slowly rising gas bubbles of the above size due to supersaturation. As an example of this flotation technique it is referred to SE patent No. 169 561 which relay on the use of pumps, valves, water pipes and pressure chamber. Also, in connection with fish farming this conventional flotation method will poison the water if air is used as gas medium, since the water will become supersaturated with nitrogen gas.

The bubbles used in physical adsorption are normally produced by an air diffusor, i.e. a tube, hose or similar having air permeable walls, positioned at the bottom of a column of polluted water. For a more detailed desscription of physical adsorption it is referred to the book "Seawater Aquariums" by stephen Spotte, John Wiley & Sons, 1979, p. 208 - 217.

A closer study of the description of the above Norwegian patent No. 58 996 will make it clear that, although it is not directly mentioned therein, it obviously relies on physical adsorption of the dissolved substances rather than on flotation of particulates. Thus, it mentions that the bubbles in the surface foam easily burst and the foam collapses, which is typical for a foam formed through physical adsorption with large bubbles; and further that the tiny air bubbles (which could cause flotation) are considered as a problem and therefore should be removed by means of a sponge filter in the chamber while particulate material is removed by an external mechanical filter. Furthermore the fact that the water is ejected into the chamber close to the water surface therein will cause a turbulence destroying any flotation effect that might emerge. Consequently the patent teaches that the foam has to be rapidly removed to prevent the impruities from returning into the water. (Physical adsorption in contradiction to chemical adsorption is a reversible process using weak bonds as those formed by van der Waals forces). Therefore this prior water

FROM BRYNHAR 02413823 1989.12. 7 8:53 P. 2

treatment method which, according to the patent was proposed more than 50 years ago, does not produce water of a quality satisfying the demands of modern, full scale fish breeding plant, since the retension time of the particulate material in the system is too long while also the material easily accumulates within the fish basins. Furthermore ammonia will also accumulate in the system.

The object of the present invention is to provide an improved water treatment method that in addition to being less expensive than the prior method according to the above Norwegian patent also give a far better result as to the quality of the water.

This object is achieved by a method as mentioned in the introduction, characterized by causing said aeration and circulation by means of an air diffusor located near the bottom of the chamber to produce bubbles therein of a size substantially in the range of 0,03 mm to 1 mm, the larger size bubbles of which are effective to form said foam on top of the chamber, transferring the remaining smaller size bubbles together with particulates into the basin entrained in the water flow to form at the surface of the water in the basin a flotation slurry containing particulate impurities, and removing said slurry from the basin.

Thus, contrary to what happens in the prior process of the Norwegian patent, according to the present invention the particulate material is continuously removed as soon as it is formed and is not allowed to disintegrate or accumulate in the fish tanks or basins.

Further advantages compared to the above prior technique is elimination of the need for any mechanical pumpe to circulate the water or to pressurize the water to cause flotation. Also, the water layer at the top of the basin in which the flotation slurry containing the impurities is formed is not subject to turbulence interfering with the flotation process. By allowing the top water layer in the chamber to flow over into the adjacent, considerably larger basin, the flotation effect is optimized under the calm flow conditions prevailing in the basin, and preferably the flotation slurry is not removed until

it has reached the other side of the basin opposite from the chamber.

In a preferred embodiment of the method according to the invention the water in the chamber is caused to flow upward through a biological filter medium (biofilter) further acting to remove dissolved organic matter in the water and to transfer ammonium into nitrate. (The latter effect is the most important one in this case since, as explained above, the dissolved organic matter is removed through physical adsorption.) Further, ammonia is removed by the biofilter.

Admittedly, utilizing a such biofilter is not a new concept in connection with water treatment plants, in which the deposit on the filter, upon reaching a certain thickness, is broken away in smaller or larger bits or fragments that are entrained in the water stream to partly settle at the bottom of a suitable container or the like from which they may be removed together with other settle foreign particles settled from the water. However, in a conventional installation 70 - 90 % of the capacity of the biofilter is used to decompose dissolved organic matter while 10 - 30 % is used to remove ammonium. Also, some of the broken away material will tend to resist settling and therefore flow with the discharge water to the recipient, or result in a poor quality of the water in the fish tanks. By using a biofilter in combination with the above described adsorption and flotation processes according to the invention most of the capacity of the biofilter is utilized for removing ammonium, and consequently the size of the filter may be considerably reduced. Further, the cleaning effect of the filter is obtained without the need for a separate settling basin since all of the material which is detached from the filter will be entrained in the upflowing water and consequently collected in the foam and flotation slurry which is removed at a later stage.

Treating water by means of air diffusors of the type used in the invention is known per se, but only with a view to oxygenation and stripping of undesireable gasses such as CO_2 and nitrogen gas and for breaking away mat-growth on the biofilter. Examples of conventional biofiltering are also

found in SE patents No. 169 561, 442 744, 386 658 and 382 321. However, none of these patents suggest biofiltering used in an advantages combination with other water treatment processe, such as in the present invention.

The invention is based on the idea that the use of a particular air diffusor of a type known per se, which produces air bubbles of a size varying over a relatively wide range, will result in physical adsorption in addition to oxygenation, gas-stripping and mat-growth detachment, while the diffusor also serves to provide the required circulation of the water. In the preferred version of the invention, in which the water is caused to flow through a biofilter, the diffusor automatically tends to reduce the load on the biofilter with respect to decomposition of organic matter owing to the physical adsorption effect and also provides for the required removal of mat-growth on the biofilter. Discharging the water from the chamber into a larger basin results in the further advantage that also the polluted fragments that are broken away from the biofilter will be entrained in the natural water flow and be floated in the basin allowing the fragments to be removed by conventional weir technique rather than having to pump the water to a separate processing unit for separation i.e. by settling or mechanical filtration. This, in turn, results in a lower pump energy demand than in a conventional water treatment plant based on separate processes with the pumping of water between the various processes. also should be mentioned here that the treatment efficiency achieved by flotation on this type of particles, (mat growth particles and crushed organic small size particles) is extremely high compared to i.e. conventional sedimentation, and a sedimentation basin doinbg something close to the same jod would normally have to be 10 - 20 times bigger. Thus, the invention provides a simple, compact and effective water treatment system basically consisting of a single processing unit, with exceptionally low investments and operational costs, compared to prior water treatment systems of more recent type based on the normal use of sequential arranged unit processes.

The recirculation type water treatment plants for fish farming used until now normally are based on separate units for

biofiltering, oxygenation, degassing of CO_2 and nitrogen gas and particle separation through mechanical filter mesh or by sedimentation. The costs of installation of such plants are very high and the energy consumption due to pumping is relatively large. As a typical example Europe's largest recirculation fish farm plant of this kind (built in Farsund, Norway 1985 - 86), having an effective fish basin volume of 1000 m^3, costed 28 millions NOK and demands an energy consumption of about 300 - 400 kW for operation.

In comparison a plant based on the present invention, which at present is being built with an effective fish basin volume of 2500 m^3 (i.e. about 2,5 times larger than said prior plant) will cost about 11 million NOK and have an energy consumption of approximately 50 kW.

The invention also comprises an apparatus for carrying out the method according to the invention, as defined in the accompanying patent claims.

An example of the invention will now be described more fully with reference to the accompanying, partly schematic drawing in which:

Fig. 1 is a plan view of a turbot fattening plant based on the method and plant according to the invention, and

Fig. 2 is an enlarged scale cross-sectional view through the plant taken on the line II-II in fig. 1.

The plant illustrated in fig. 1 is conveniently comprised of i.e. four, substantially identical, rectangular, water filled basins or tanks 2 each comprising an independent fattening unit. Associated with each basin 2 is a chamber generally denoted by numeral 4 situated at one long side of the basin. In the embodiment as shown the chamber 4 is laterally defined by the one long wall and two end walls of the basin and an independent, longitudinal, impervious partition wall 6. However, if desirable, it may of course be defined by four separate walls independently of the walls of the basin. The upper and lower surface of the partition wall 6 are spaced from the upper edge and bottom respectively of the basin 2, so that the chamber 4 communicates with the basin 2 at the top as well as at the bottom thereof.

Disposed at the bottom of the chamber 4 there is, according to an important feature of the invention, an air diffusor 8 consisting e.g. of several pipes or hoses of which the walls are provided with a large number of minute apertures or pores capable of producing air bubbles in the range of about 0,03 mm to about 1 mm. Thus, the diffusor wall apertures should be microscopic, i.e. 0,1 - 0,3 µm, normally requiring the air blown therethrough to be pre-filtered in order to prevent clogging of the apertures or pores. As an example of a diffusor well adapted for use with the invention it is referred to that which is sold under the trade name "Oxyflo", delievered by Gardentec of Sweden among others, which consists of stretched and oriented polyethylene fibres bonded together in a random pattern.

Preferably the chamber 4 is filled with a biological filter medium 12 (indicated by hatching in the drawings) held in place by support members 10, e.g. in the form of a screen. The surface area of the filter medium 12 should be as large as possible relative to its volume, with a view to microbiological growth. Preferably, the filter medium 12 is of a type which incorporates upwardly extending, intercrossing channels ("cross flow system") in order to secure conditions promoting physical adsorption, to prevent the smallest air bubbles from attaching to the biofiltermedium, and to secure supply of water and air to all parts of the filter. As an example of a suited filter medium it is referred to the product sold under the trademark "Munters" supplied by AB Carl Munters, Sweden or "Terrapac" supplied by Terracon, West-Germany.

The purpose of the basin 2 is partly to provide a retention time for the dirty water sufficient to secure an effective flotation process, partly to effect bi-processing purposes and partly to serve as a fattening tank etc. The volume of the basin will depend on the water quality characteristic, the desired rest concentration etc, and it has to be individually dimensioned in each separate case. Its shape will depend on the purpose, on whether the basin is outdoor or indoor, in existing buildings or whether the process is to be placed in existing basins etc. Thus, although the shape of the basin 2

shown in the drawings is rectangular it is also possible to use i.e. a circular configuration, in which case also the chamber 4 normally will be circular and centrally areanged in the basin. When used for internal water treatment in fish farming the water basin 2 normally will function as a breeding tank.

Somewhat simplified, what happens in the chamber 4 is as follows:

Owing to the air diffusor 8, polluted, low oxygen water is drawn (by means of the "mammut pump" or "air pump" principle) from the bottom of the basin 2 under the partition wall 6 and into the bottom of the chamber 4. The water passes up through the chamber and provides nourishment for a microorganism flora on the surface of the filter medium 12. This microorganism flora converts biodegradable dissolved organic matter to a mat-growth on the surface of the medium and transforms ammonium into nitrate form. The microscopic air bubbles from the diffusor 8 oxygenate the water and provides an ample supply of oxygen to the microorganism flora and breaks away the mat-growth when the latter has reached a certain thickness. (Ample oxygen supply and limited mat-growth thickness are essential factors in order to achieve maximum microbiological growth.) Physical adsorption of dissolved organic compounds is obtained (according to the litterature reference mentioned in the introduction most effectively on bubbles with a size of 0,8 mm) to form a bubble foam 14 containing dissolved substances from the water. The foam 14 is lead by gravity into a channel 15 as indicated by arrow S1 and is then discharged from the plant for further sludge treatment. The strong water-air stream thus formed (which breaks away the mat-growth and also contains the particulate impurities that are drawn in at the bottom as indicated by the arrow V in fig. 2) will also contain a large percentage of bubbles having an optimum size for flotation (0,03 - 0,120 mm). Even within the chamber some of those bubbles will attach to the particulate material while the remaining minute bubbles will flow with the water-particle stream into the basin 2. In the latter basin the remaining minute bubbles will attach to particulate material 13 and, in addition, in the basin there are calm hydraulic conditions ideal for

flotation of the particulate impurities which ultimately will form a flotation slurry 16 which, owing to the natural flow of water in the basin, will flow to a place where it can be skimmed off by weir technique as indicated with the arrow S2. When the water flow (provided by the air bubble pumping effect) reaches a wall surface in the basin 2 it will follow the wall down toward the bottom (see fig. 2) and in the same manner return along the bottom back to the inlet of the chamber 4 under the partition wall 6. This bottom flow will pick up the particles settled on the bottom and bring them into the chamber 4 in which they, due to the above described processes, ultimately are incorporated in the flotation slurry. It should also be noted that owing to the physical adsorption of dissolved organic substances a considerable reduction of the size of the biofilter will be possible since the load on the biofilter will be reduced. As explained above, normally 70 - 90 % of the capacity of the biofilter is used to break down organic matter, while only 10 - 30 % is used to transform ammonium into nitrate.

All in all a number of biological and physical-chemical fenomena interact in this method and provides a combined treatment result that until now no prior unit process has been able to provide.

The invention is applicable to virtually all types of waters in which it is desirable to remove biologically decomposable unstable organic matter, non-decomposable dissolved organic matter and particulate organic and/or inorganic suspended particles (even if these are microscopic and not easily settled). In addition the process transforms the toxic ammonium compound into the more non-toxic nitrate form. The water should however not contain any compounds toxic to bacteria. The water treatment according to the invention is suitable for internal or external water treatment in fish farming plants and in treatment of municipal and industrial waste waters.

P a t e n t C l a i m :

1. A method for water treatment comprising

aeration of the water to be treated and causing it to circulate to a chamber, into an adjacent basin of considerably larger volume than that of the chamber and back to the chamber, said aeration producing bubbles acting to form a foam containing dissolved impurities at the surface of the water in the chamber, and

removing said foam from the chamber as it is formed, c h a r a c t e r i z e d by

causing said aeration and circulation by means of an air diffusor located near the bottom of the chamber to produce bubbles therein of a size substantially in the range of 0,03 mm to 1 mm, the larger size bubbles of which are effective to form said foam on top of the chamber,

transferring the remaining smaller size bubbles together with partculates into the basin entrained in the water flow to form at the surface of the water in the basin a flotation slurry containing particulate impurities, and

removing said slurry from the basin.

2. A method according to claim 1, c h a r a c t e r i z e d by causing the water to flow through a biofilter medium disposed in said chamber.

3. A method according to the claims 1 or 2, c h a r a c t e r i z e d by removing said flotation slurry near the end of the basin opposite the chamber.

4. An apparatus for carrying out the method according to claim 1 - 3, for water treatment, comprising an open top chamber (4), a basin (2) of a substantially larger volume than that of the chamber (4) separated from said chamber by a partition wall (6), means for circulating the water to be treated through said chamber, means (8) for aeration of the water flowing through the chamber and means (15) for removing from the surface of the water in the chamber foam formed by the larger

air bubbles produced by the aeration, c h a r a c t e r i z e d by said aeartion means being an air diffusor (8) placed at the bottom of said chamber (4) and adapted to produce air bubbles of a size substantially in the range of 0,03 mm to 1 mm, said chamber (4) communicating with the adjacent basin (2) at the top and bottom thereof, and by means (16) for removing particulate impurities from the surface of the water in the basin.

5. An apparatus according to claim 4, c h a r a c t e r i z e d in that said air diffusor (8) is a hose having pore apertures of 0,1 - 0,3 µm.

6. An apparatus according to claims 4 or 5, c h a r a c t e r i z e d in that said biofilter medium (12) is of a type having upwardly extending, intercrossing channels.

Fetherstonhaugh & Co.,
Ottawa, Canada
Patent Agents

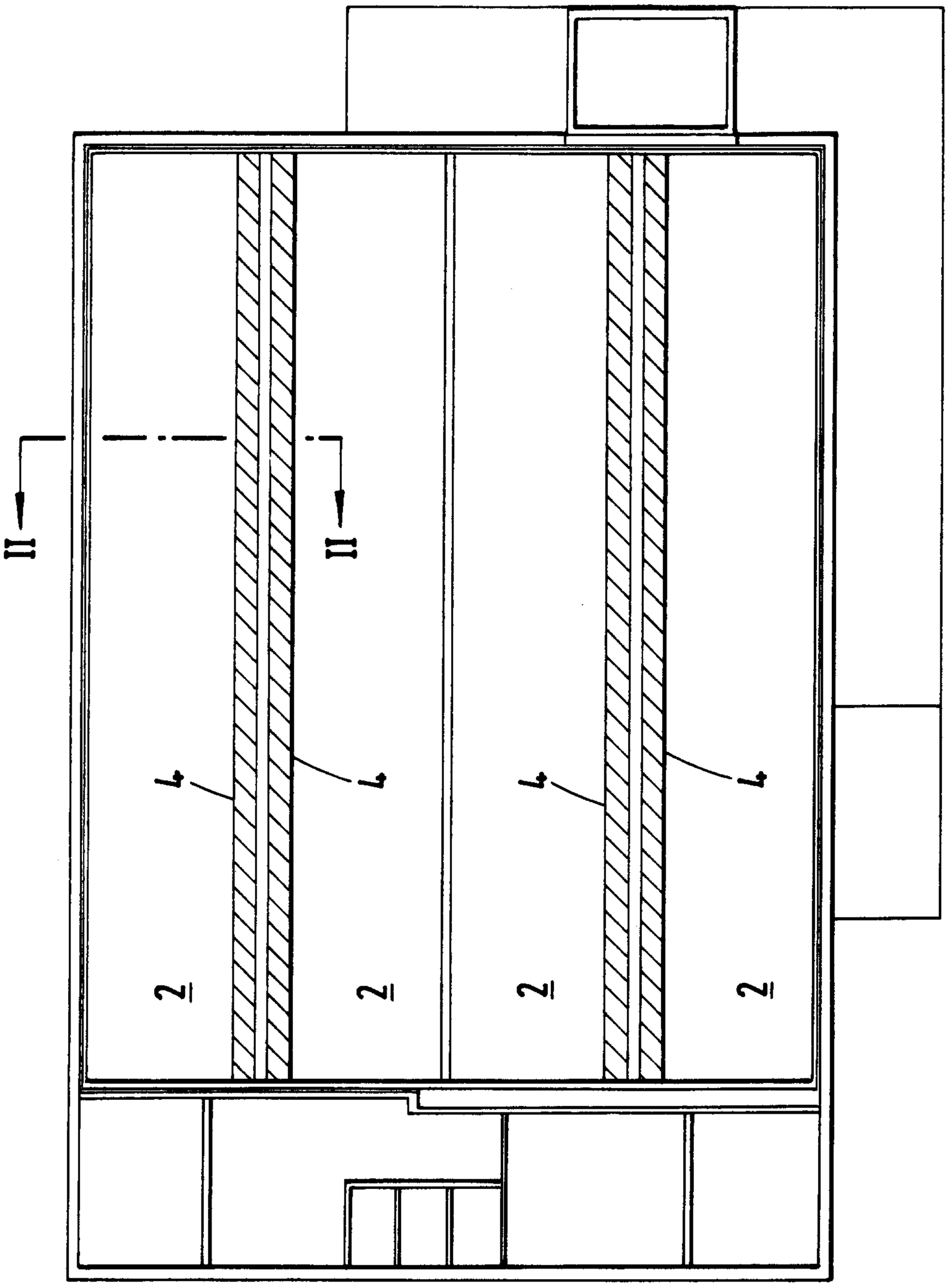


Fig. 1

Patent Agents
Fetherstonhaugh & Co.

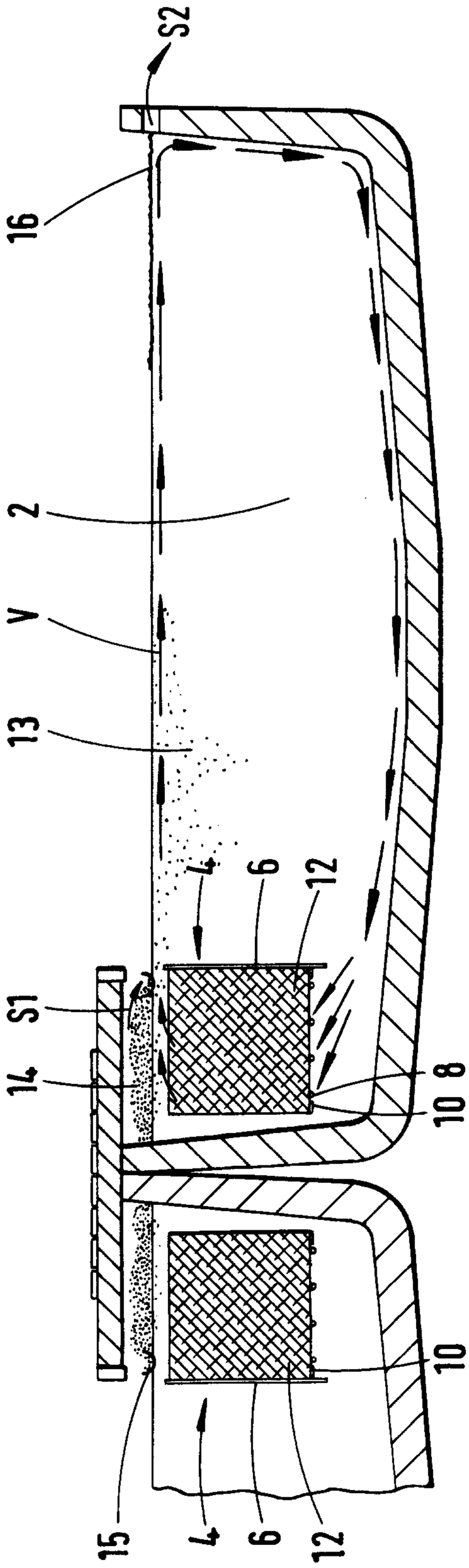
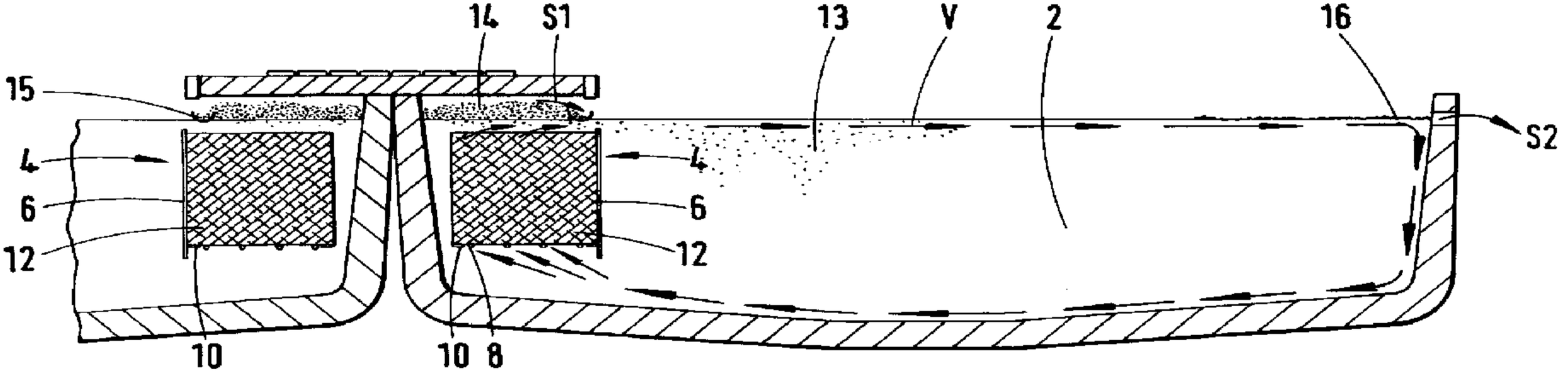


Fig. 2

Patent Agents
Fetherstonhaugh & Co.


14
S1
13
V
2
16
15
S2
4
4
6
6
12
12
10
10
8