

PATENT SPECIFICATION

DRAWINGS ATTACHED

890,133



*Date of Application and filing Complete Specification :
September 28, 1959.*

No. 32861/59.

Application made in Netherlands on September 29, 1958.

Application made in Netherlands on April 1, 1959.

*Application made in United States of America on
July 1, 1959.*

Complete Specification Published February 28, 1962.

**Index at Acceptance: Classes 46, D1(B2:B3A:E:U), D2(D:F3:K2A K2C); and 8(2), D3E2C2.
International Classification: B01d.**

The inventor of this invention in the sense of being the actual deviser thereof within the meaning of Section 16 of the Patents Act 1949 is Pieter Smit, of Roosenbeeklaan 45, Santpoort The Netherlands, a Dutch subject.

A process and device for contacting fluids with granular solids.

COMPLETE SPECIFICATION

We, N.V. OCTROOIEN MAATSCHAPPIJ "ACTIVIT" of Nieuwendammerkade 1-3, Amsterdam, The Netherlands, a Dutch Limited Liability Company, do hereby
5 declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

10 The present invention relates to a process and apparatus for contacting fluids with granular solids, whereby the fluids are passed through a body of the granular solid material. By the expression "fluids" liquid
15 and gases in the full sense of the words are meant, amongst which are polluted air or gases of all sorts, water, waste water, sugar- and glucose solutions, solutions of acids, salts, lyes, mixtures of gases and liquids etc.
20 Contracting fluids with granular solid material by passing these fluids through a layer of granular solid material in itself has been known for years, but if these fluids are turbid and deposit part of the solids on the
25 surface of the solid material, these solids will clog it after a short time.

It is now an object of the present invention to provide a method for intensive contact between the fluids and the solids,
30 whereby the clogging of the solid material is prevented and thus a high capacity and efficiency is attained.

It is another object of the present invention to distribute the solid material, which is
35 deposited by the fluid, between the interstices of the entire body of solid material.

It is still another object of the present invention to provide for efficient cleaning of the solid material in such a way that the
40 capacity of the device is not decreased and a good classification of the particles of the solid is obtained.

It is a further object of the present invention to provide a method for contacting
45 fluids with solid material of granular

character by passing the fluids over the solid, whereby any breaching of the material at a pressure difference between influent and effluent of 1 meter of watercolumn or more
50 does not occur, so that the rate of flow of the liquid can be increased considerably above the normal rate.

It is a further object of the present invention to provide a method in which a systematic contact between the fluid and the solid
55 medium is ensured so that the most impure fluid is in contact with the most impure solid and the most purified fluid is in contact with the most purified solid (counter-current principle).
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It is still another object of the present invention to obtain a better classification of the body of granular solid material by avoiding in an expanded bed of the solid
65 material the phenomenon of closed circuits of particles.

The invention consists in a process for contacting fluids with granular solids wherein the fluids are passed through a layer of the granular solid material and the direction of
70 flow is defined by the difference of specific gravity between the fluid and solid medium so that the lighter fluid is passed in an upward direction and breaching or formation of channels in the body of granular solid
75 material by lateral migration of the granules is prevented by the provision therein of a fixed framework of elements extending over the cross-section of flow to allow movement of the material in its entirety only in a
80 vertical direction and thus to ensure the uniform dispersion of the fluid over the cross-section of the body of granular material and uniform distribution of the upward forces tending to move the solid material in
85 the upward direction.

These and other objects are accomplished by the present invention, a description of which will follow now.

In the process according to the invention 90

the body of granular solid material can be composed of the most differing materials, such as grains of sand, coal, cokes, bauxite, magnesite, metallic oxides or materials of vegetable or of animal origin e.g. to be extracted by some solvent in filtering. Also adsorbents like bone-black, active carbon, decolorizing resins, granular compositions of mineral origin or mixtures of two or more of these ingredients and further ion exchangers and catalysts in the full sense of the words are usable. Also the medium can be a biologically active one, or have a flocculating action on the solid materials in the fluid.

15 The particle size of the granules of the components of the medium can vary widely, e.g. it can even be powdery or fibrous. Usually the solid material has a higher specific gravity than the liquid which is contacted with the same. The opposite however can also be the case, e.g. if a solid material of low specific gravity is chosen for the purpose. The flow of fluid will then be in the opposite direction, as compared with the case when the solid material is of high specific gravity.

Usually in the known filtering methods the liquid passes over a granular medium in a downward direction through the bed, as in the conventional method of filtering water over a bed of sand. However it has already been suggested to filter in an upward direction. This is basically not a successful method because, unavoidably, local breaches in the solid medium will occur during which the liquid passes through the medium without any filtration effect at all. At a very slow rate of contact, e.g. of filtration, it may have only temporary success without this inconvenience, but at a high rate of flow the bed can become homogeneous by fluidisation. Usually in either case a proper filtration effect is not obtained.

In British Patent Specification No. 692,704 a method is suggested, in which the filtration does take place, at least partly, in the upward direction through the medium. For this method, however, the filtrate has to be drained off below the surface of the bed by means of a draining system disposed in the medium while, in addition, an external pressure has to be applied over the bed in order to prevent a breach of the bed. This however often brings along undesirable complications.

If the pressure is applied by means of the unfiltered liquid, which is the most practical and simple solution, part of the filtration of the liquid will also take place through a thin layer of the medium disposed over the draining system, often with insufficient purification. Such a filtration method is always undesirable in view of the capacity of the filter; whilst in adsorption-, decolorizing- and deionizing-processes it cannot be allowed to

take place, because these processes would then become inefficient. Furthermore the drainage systems are situated in the top-layer of the medium which layer is composed of the finest grains of the solid material. This is the reason why the technical design of the draining system often becomes more difficult on account of the great danger of clogging and loss of head.

As already stated, in the present invention when using solid filtering media of high specific gravity the liquid is carried through the medium in an upward direction exclusively, without local breaches taking place causing the filtration to become ineffective. For this purpose a fixed grid or web system is placed in the medium. The construction is not arbitrary, however, but adapted to the purpose of the method and to the particular circumstances under which it is applied. A simple, horizontal grate could alone be effective under favourable circumstances, but in practice it proves to be usually insufficient. An assembly of grates built up from individual elements is better. In some cases several of these grates are required and then are placed at different heights in the medium. In extreme cases these may even form a series extending for the total height of the medium or a part of the same.

Not every element in the medium has the same function. The highest elements in the medium must prevent the formation of breaches. A breach will always be local; but, at a great speed of the liquid stress, this breach will extend over the bed. Generally, a breach during the filtration must be prevented by the application of the above-mentioned elements which, when the medium is moving, apply a reaction which prevents the formation of the breach and therefore may be regarded as reaction-elements or a system of reaction-elements.

The elements or system of elements which have been applied lower down or even at the bottom of the solid medium fulfil a quite different function. These have to distribute the liquid in such a way that filtration and/or contact will be as uniform as possible all over the solid medium. These elements or systems of elements may be regarded as "dispersion elements."

It is not the case, however, that all of the elements have only one of these functions. They all serve more or less the two functions of applying a pressure upon the medium and distributing the liquid, although the first function preponderates at the higher placed elements and the second at the lower placed ones. In many cases one element is sufficient, which in this case fulfils both functions.

For the construction of the elements various methods are possible to serve each

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specific case, and it is not possible to indicate a uniform construction. This construction will vary for the different types of filtration, and even in one filter this will often be the case for the elements among themselves. Consequently for a given filtration problem, for which insufficient data are given, a few simple, obvious experiments will have to be carried out.

The mesh width, or, more clearly expressed, the dimensions of the cells formed by the webs of the elements, are extremely important, inasmuch as the pressure of the liquid applied under the medium can be the higher, the smaller are these dimensions. Often, instead of one web-element with narrow webs, two or more web-elements with broader meshes a short distance above each other can be applied with the same result.

Generally speaking, for instance using a normal medium consisting of sandgrains, even in an open filter, a pressure as high as several atmospheres can be applied, the weight of sand and liquid in the filter forming in this case only a negligible counter-pressure thus demonstrating the surprisingly novel result of the invention. In this connection it is understandable that demands are made on the strength of the web-system. Examples of apparatus for carrying out the process will now be described with reference to the accompanying diagrammatic drawings in which:—

Fig. 1 is a diagram of one form of draining device, which construction may also be applied to reaction and dispersion elements:

Fig. 2 is an elevation of part of a multiple grate structure for fixing in a body of granular solid material;

Fig. 3 is a perspective view of the filter;

Fig. 4 is a perspective view of the structure of fig. 2 installed in an apparatus for contacting fluids with solids;

Fig. 5 shows a structure which may be used instead of that shown in figs. 2 and 4.

Referring now to figures 2 and 4, a grate structure is shown with a mesh or cell dimension H.

It is not desirable to make the dimensions of meshes or cells unnecessarily small, for the filter must be capable of being cleaned, for which cleaning backwashing of the medium is one of the steps in the treatment. In this treatment the medium has to be penetrated. In difficult cases this can be effected with the aid of air or by rinsing loosely with a liquid or even mechanically from the top. It is better however to have the reaction-element breached by an increased rate of flow of the upwardly directed liquid. This breach can be used for two reasons, viz. the medium over the element is removed by the liquid at a high flow rate or the vault, or downwardly curved arch formation, in the cell-system which is the

primary cause of spreading the upwardly directed forces in the medium breaks down. It is clear that a large vault breaks down sooner than a small one, from which it is obvious that the dimensions of cells and meshes must not be too small. Also account must be taken that liquid and medium are dispersed, as there is the possibility of the elements forming a labyrinth. In determining the mesh-or cell width of the web-elements, the mesh-width must, in principle, be chosen much smaller at higher filtration speeds and finely granulated material. In the first case, dimensions of 25 mm and lower are chosen, while the mesh-width in circumstances where no expansion occurs, can be 10 to 100 times as large.

It is impossible to give a full enumeration of the factors fixing these dimensions but amongst others the following can be stated: particle size of the medium, specific gravity, elasticity, compressibility, cohesion, adhesion of same, form and coefficient of friction between these and with the liquid, thickness of bed over the element, total thickness of bed, specific gravity of the liquid, viscosity, difference in pressure of the liquid under and over the element and the shape of the element; the extent of the impurities in the medium, the number of elements.

Concerning the shape attention has to be paid when vault-forming that the ends of the vault fluid a solid base. If profile-shaped iron of triangular profile is used for the construction material, with a topcorner directed downwardly or whose profile is broadened at the top the structure is more efficient. Furthermore, perforated sheets, wire netting, angle iron, bulb-or-T-iron or other profile material can be used.

However, it is more practical to employ a construction as indicated in figure 2. This represents an element completely composed of flat iron. The vaults can in this construction have their bases on the other end of an adjacent vault, while these bases are locked between two parallel bars. Besides, when rinsing this has the advantage that as soon as one vault breaks down the others do as well, which is necessary for the obtaining of a good backwashing effect. Also when rinsing the filter for cleaning, the web-like elements play an important part, in particular the lower ones in the medium. They prevent, or at least diminish, the circulation length, which is unfavourable to rinsing operation.

In a good backwashing operation this circulation of particles may not occur because a classification of particle size would be prevented. In a well classified medium the coarse particles are below and the fine ones higher up in the medium but this is mostly not the case on account of the circulation in the "upflow" stream occurring at the time

of the backwash operation.

In the process according to the invention biological, catalytic and other reactions may appropriately take place in an expanded medium, since this is extremely efficiently classified and does not have too many difficultly passable or unpassable places on account of the lack of the circulation-stream. In the cleaning of the filter, water, air, steam, solution of electrolytes, detergents etc. may be used.

In the filtration according to the method of the present invention a draining system can in most cases be omitted. This can, however, cause difficulty in filtering through finely granulated material of low specific gravity, for example through granulated ion exchangers or if the liquid, that has to be treated, has a high specific gravity. The particles of the medium over the vaults in the reaction-element will then be carried on with the stream and the arches in the web-system will break down non-uniformly. However, by carrying away the effluent through drains situated immediately above or below the reaction-element, possibly with the aid of a vacuum, and therefore not conducting it over the surface of the medium, or at least only partly and at a low speed, so that the medium cannot expand considerably, the method still remains a possible one. In that case special design must be adopted for the discharge elements, i.e. the drains, for these will clog if not of special construction. This can be corrected, however, if so-called "breathing" drains are fitted, which at varying internal or external pressures suffer a shifting of the boundary walls of the discharge interstices of the drains with respect to each other so that clogged matter is removed. These "breathing" drains are constructed such, that the elasticity of the two long walls of the same slot is different, e.g. because they are constructed from different materials, or from the same material with different thickness or otherwise. By putting on pressure, the one wall will open relatively to the other with the effect that imprisoned particles will be removed by the pressure.

In fig. 1 such a drain device is represented; there are, however, many constructions according to this principle, but this drain device has proved to be very efficient. It consists of a round or conical tube, closed at the top, at the bottom connected with the outlet-system and provided with slots at varying distances so that more and less wide lamellae are formed, which, under internal or external pressure, flex differently.

When using the present day ion exchangers having small round particle size which, moreover, have a very small co-efficient of friction, the slot width of the drains must be very small. They let pass only a small

quantity of liquid so that many of them are necessary and therefore the plant becomes expensive and the loss of pressure at the drains is high. According to the invention, however, the use of an auxiliary medium is then a good solution of the trouble. This auxiliary medium is applied over the actual filtration medium in the reaction element and consists of a material which has a lower specific gravity and a larger particle size, thus fixing itself in the reaction-element without requiring the size of the cells to be extremely small.

In this case the draining system can be placed in the auxiliary medium so that the discharge openings can now be much larger and no obstruction and excess loss of pressure can take place. Constructionally, the draining system can then form one body with the reaction-elements. Also the regeneration of a so-called "mixed bed" is technically made possible in an efficient manner. When using a mixed bed one filters through a mixture of different kinds of resins, for instance cation and anion exchangers. In the regeneration those kinds having a different specific gravity or grain size, are separated with an upwardly directed stream of liquid, after which the layers are settled on top of each other.

Between the layers there is now a discharge system for the regeneration and wash-liquids which are supplied both under and over the layers and consist e.g. respectively of an acid and a lye solution. A difficult problem is that of defining the position between the two ion exchangers because usually it does not coincide with the position of the discharge elements. The result is amongst others bad regeneration efficiency as the regeneration liquids are in part applied at the wrong places. In the present invention this fault is completely abolished by introducing a bed of an auxiliary medium of sufficient thickness preferably in a reaction-element between the other layers. This makes it possible to vary the thickness of the layers of the active components slightly, if this seems necessary by reason of changes in working conditions, and to compensate the disadvantages effect of an irregular swelling of these components at the time of the regeneration and washing.

It is evident that one has to determine carefully by experiment the grain size and the specific gravity of the auxiliary medium. One can make use of coarsely grained material, of an appropriate porosity as is often available as a trade product. The material itself can also fulfil the function of a corrective agent of the reaction at the time of the filtration, being e.g., amphoteric or decolorizing.

The advantages of the method and equipment according to the invention are mani-

fold. On account of the entrance of the liquid at the bottom of the medium between the coarsest grains and by the possibility of expansion which the medium allows, the filter can be many times more heavily loaded with the substances which are separated from a liquid or other fluid than when filtering over a conventional filter. Also the hourly capacity per sq. meter cross-section is much greater. The separation of substances in a conventional filter takes place in the main at one level, whereas in the method according to the invention this takes place in three dimensions, in space. This also offers the opportunity for separating solid substances by adsorption on the particles of the medium. It has therefore become clear that by the method of the present invention filtration problems can be solved which in other ways obviously would not be possible, e.g. the separation of colloids which clog the media in known devices. Also, in the passing of a liquid through a medium in which separation of solid substances is of secondary importance but decolorizing, ion exchanging, catalytic action or flocculation is aimed at, the method is of big advantage as it makes possible the application of the efficient counter-current principle and the loss of pressure is less.

If the effluent does not have to be discharged under pressure, one can use—even although the influent is supplied under high pressure—cheap open filters, which moreover have the advantage of easy control and inspection of the process. The application of the method of the present invention to closed filters however will meet no difficulty whatever.

Contrary to a conventional sandfilter a complete cleaning of a clogged up medium is not necessary and often even not desirable. The classification of the sand by rinsing only with water is also often superfluous. In a conventional filter a normal filtration would otherwise be precluded by the danger of clogging of the surface.

For this reason and also because of the filter's high capacity the consumption of rinsing water for the filter according to the present invention is very small. Also a concentrated effluent at the rinsing is obtained, which mostly is desirable.

If the effluent has to be very concentrated, then it is appropriate to make use of a filter medium which is lighter than the fluid with which it comes into contact, e.g. granules of porous resin, wood, or pumicestone. In this case however all flow directions and elements of the filter have to be reversed. The distributing system for liquid, rinsing liquid and rinsing gas is at the top of the filter, and the expansion space below, whilst the reaction web-system is placed internally at the bottom of the medium, the introduc-

tion of the liquid to be treated is at the top of the filter and the outlet at the bottom. As the separated solids settle at the bottom in the filter, the effluent is very concentrated, the more so because during the filtration part of the liquid can be drained away at a higher level in the filter. The sediment in the filter according to the present invention is more concentrated than is the sediment obtained in the conventional concentration- and settling-devices.

In another method for obtaining an effluent of high concentration in cleaning a filter with upflow filtration, air may be introduced under the medium and during the time it is in motion, the effluent may be drawn off at the bottom of the filter. This method can be applied when concentration of the impurities is the object of the filtration and not the obtaining of an entirely clear filtrate.

It may be mentioned that in the regeneration or cleaning of the filter eventually the filter material in its entirety would be moved in a vertical direction, but not when the apparatus is in use for filtration.

An interesting application of the method according to the present invention is the injection of liquids in the soil, either for disposing of the liquids, or for correcting the structure of the soil. The possibility of disposing of adsorbents infected with radioactivity by this means, by pumping them away in suspension is realisable in this way, also waste water can be removed. The reaction-element is placed preferably at those places where the liquid can emerge again, as a consequence of the particular layering of the soil, or by making suitable tunnellings. The principle of the present invention also can be applied to the catching of water at bubbling wells, the winning of subsoil water, oil, or natural gas, in particular for the regulating of the fluids and preventing of clogging of the filtration media.

As in any filtration system one has to avoid as much as possible an irregular supply of the influent. De-aeration of the influent is usually desirable. Besides the obtaining of an efficient and proper operation of the filter by the elements used according to the invention, it is recommended to promote a good distribution of rinsing air and water by placing a suitable supporting and distributing construction under the medium. One can use the distribution systems as used in conventional filters. However, one has to take account of the fact that during the filtration a liquid loaded with solid substances must often be carried through.

The examples of the mode of carrying out the process and the description of constructional details of the apparatus used are given by way of example.

Reaction and dispersion elements can be

made according to the construction of figure 1. The dimensions of the construction-ion and the mesh-width can vary as may be clear from the examples. However, the parallel rods can also be staggered instead of being installed one beneath the other.

In figure 3 is shown the construction of a filter of rectangular cross-section, e.g. 2 m. long, 1 m. broad and 2 m. high.

10 In the length-wise direction of the bottom B four distributing devices A are placed which are provided on the undersides with triangular gaps at distances of 10 mm. to obtain a regular distribution of air, water, rinsing water and rinsing air over the whole medium lying above these distributing gaps. These devices eventually are welded to the bottom of the filter to strengthen it. Also other distributing systems can be used, e.g. those with the conventional rinsing heads (nozzles) in a double bottom or with perforated conduit-pipes. Water and gas are supplied at C and D.

25 The filter has at the top in the gutter an outlet E for the effluent or the rinsing water; at F the outlet pipe can be connected. The surface of the filter medium G is at some distance below the outlet. It rests on a support-layer of more coarse material.

30 In the medium the web-system is embedded. As an example in figure 2 an element W of the web-system is indicated. It is wholly made of flat iron strip 30 by 6 mm. It is composed of 4 grates which are welded one above the other. The strips of the first and the third grates run parallel, likewise the second and the fourth, but they are directed normal to the direction of those of the first and the third grates.

40 The element is arranged in such a way in the filter, that it cannot move. The distance H is chosen in dependence on the working conditions.

45 In figure 4 a spatial view of the web-system W of figure 2 is given in such a way, that it can be mounted in the rectangular filter of figure 3. Here also the distance H is chosen in dependence on the working conditions. In figure 5 conical coils (I) are shown, which can be mounted in the filter in place of the grates of figures 2 or 4.

EXAMPLE I.

55 River water containing up to 40 mg of solids per liter is filtrated with an apparent rate of flow of 8 m. per hour in upward direction (8 m³ liquid per m² cross-section per hour). The filter medium consists of sand with a grainsize of 1 to 2 mm. The supporting layer is as follows:

60 16 cm, 10-15 mm, 6 cm, 6-10 mm.
6 cm, 3-6 mm, 6 cm, 2-3 mm.

The medium of 1-2 mm is 1,4 thick. The effluent contains 4 to 6 mg of solids per liter. The filter may run 160 hours on the

average. For obtaining this an element 65 according to figure 2 is fitted in the medium, of which the upperside lies 100 mm beneath its surface. The run can be increased considerably, up to 220 hours on the average, if a second element is fitted in the medium 70 300 mm under the first one, the distance H is in both cases 60 mm.

At the end of the run the filter resistance has increased from 250 to 2000 mm. The cleaning of the filter is done as follows: 75 First during 10 minutes a mixture of 2 m³ of air and 0,5 m³ of water per minute are introduced, thereafter during four minutes only water is introduced at a rate of 1,5 m³ per minute. Then the filter can 80 be used again.

EXAMPLE II.

Instead of river water, aerated iron-containing subsoilwater is filtered according to the method of example I. The filtration- 85 speed is 10 m, the ironcontent is diminished from 8 to 0,1 mg Fe per liter.

EXAMPLE III.

In the filtration according to example I the distance H of the web is decreased to 30 mm. Now about 3000 m³ of water can be filtered, the pressure-loss however increasing tot 3900 mm without any breaching of the medium. 90

EXAMPLE IV.

95 Purified thin juice of a beetsugarplant is conducted over a filter according to example I in which 40 mm beneath the surface of the solid medium a web-system of 25 mm mesh-width, and 200 mm beneath this a web-system of 50 mm mesh-width are placed. The filter is filled over the support-layer with a cation exchanger "Imac C 12," loaded with Na-ions, of a grainsize of 0,6-0,9 mm. The juice must be decalcified by this operation. The apparent rate of flow is 8 m. per hour. The upperlayer of 200 mm of the medium consists however of an auxiliary medium of granules of polyvinyl-chloride with a grainsize of 3-5 mm. 100 105

The regeneration of the filter is preceded by backwashing after sweetening off of the medium with water from top to bottom. Finally a 10-percent solution of NaCl is passed through from top to bottom followed 110 115 by washing out.

EXAMPLE V.

Waste water of a papermill is treated in a filter according to example I. The support layer and the medium however are 120 composed as follows:

100 mm grainsize 8-15 mm
100 mm grainsize 5- 8 mm
500 mm grainsize 2- 5 mm
1300 mm grainsize 2- 3 mm

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EXAMPLE VI.

River water, containing 20-30 mg of suspended materials, is passed over an open filter according to the invention. It has a length of 3 m, a width of 2 m and a height of 1.50 m. On a height of 20 cm above the bottom a supportbottom is fixed, wherein 250 so-called rinsing heads (nozzles) are fitted. These nozzles have on the under-
 5 side tubes of 12 mm internal diameter, protruding 150 mm under the bottom and cut in an oblique manner. Above the tubes there is a cap of 30 mm diameter, at a distance of 10 mm from the bottom welded
 10 with some little bars to the support plate. These rinsing heads (nozzles) work as follows.

When under the support plate air is introduced under this plate an air cushion is generated: as soon as it is sufficiently thick, air is regularly tapped from this air cushion through all rinsing heads. This air is further dispersed under the medium by the cap. Also the nozzles bring about a regular
 20 dispersment of the influent to be treated and of the rinsing water. Furthermore upon the support plate there is a layer of sand and gravel in a depth of 1000 mm, composed as follows:

- 30 100 mm grainsize 8- 1 mm
- 80 mm grainsize 5- 8 mm
- 80 mm grainsize 2- 5 mm
- 740 mm grainsize 1- 2 mm
- 150 cm under the surface of the medium
- 35 100 drains are fitted, regularly divided over the surface. These drains are made of vertical stainless steel tubes with a diameter of 100 mm, 1 mm thick and 100 mm of length, provided in the length-direction with slits 1 mm wide and 90 mm long. There are in total 19 slits, forming 19 lamellae, which are large and narrow in turn, the wide lamellae 2 mm larger than the small ones. The filter is furthermore provided with the necessary in- and outlet tubes and valves.
- 45 Hourly 50 m³ water is introduced beneath the bottom, the effluent is drained away by the outlet on which the drains are erected. A vacuum of 2 m. water column is maintained in A. The filter is cleaned when the pressure-loss amounts to 10 m. water column. The effluent contains 1-4 mg suspended materials per liter. The cleaning of the filter occurs by first introducing 6 m³ of
 50 air within 30 seconds and thereafter rinsing with 4 m³ of water per minutes during 5 minutes. Thereafter the filter can again be used for filtration.

EXAMPLE VII.

- 60 An open filter has the following main dimensions: 8 m. long, 3 m. wide, 2,5 m. high, it is equipped according to figure 3.

The composition of support-layer and filtration medium is thus from bottom to top:

- 100 mm 30-40 mm particle size 65
- 100 mm 20-30 mm particle size
- 150 mm 10-20 mm particle size
- 1800 mm 6-10 mm particle size
- 150 mm beneath the surface of the medium is the upper rim of a reaction-element with a mesh-size of 200 mm, for the rest it is constructed according to figure 2, but suitably reinforced. 500 mm lower a second web-system is fitted with a mesh-size of 300 mm.
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The filter is used for the filtration of the circulation water, with which the sugarbeets at a beetsugarplant are transported. This water contains 35 g. solids per liter, the contents have to be reduced to 1 to 2 g. The circumstances under which this is accomplished are as follows: The apparent rate of filtration is 5-6 m. linear per hour, 8-10 m³ can pass before cleaning becomes necessary. The loss of pressure in the filter is then 5 m. of water column. At the cleaning, during 2 minutes simultaneously the effluent is drained off to a basin. The outlet is at 100 mm above the medium. If necessary chlorine gas is added to the effluent for controlling fermentation in medium and liquid.

EXAMPLE VIII.

Water is softened with brine regenerated cationexchanger of strong acid character, consisting of round globules with a diameter of 0.4-0.9 mm. In the bed on a height of 5 cm below the level a horizontal plate is fitted, on the upperside provided with conical coils.
 95 100 These coils link up with their bases; there are 1600 of these per m² cross-section of the filter (figure 5). The coils are wound each from a wire with a gauge of 3 mm and 1 m. of length, beneath first 3 windings of 25 mm external cross-section, thereafter conically shaped; the upper one has a cross-section of 11 mm externally. Between neighbour windings a space of 0.2-0.4 mm is left.
 105 In regenerating the bed part of the coarse medium from below is drained off to the above coils by a tube of 50 mm diameter, thereafter backwashing with a linear speed of about 10 m. per hour is applied during 3 minutes, at which the bed expands normally. The remaining manipulations are as usual. The filtration from top to bottom of the water to be softened takes place with a rate of 20 m. linear per hour, at which rate the bed is fixed in the lower part of the filter. During the regeneration and backwashing in downward direction the cation exchanger again is brought together to a compact bed beneath the reaction element.
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This bringing together of the medium to a compact bed under the reaction element as mentioned in Example VIII is nearly always desirable, especially if the medium consists of fine material.

The coils mentioned in Example VIII are also perfect drains and work in some degree as back pressure valves.

Special attention is required for the nature and the degree of the medium's loading with solid materials, which are separated from the liquid to be treated.

At a low filtration speed and a finer granulation of the medium these are separated lower in the medium. At too high a filtration speed and/or coarse filter material the separation can be insufficient, so that no well-cleaned effluent is obtained and the deposit occurs too high in the medium and a big part of the pressure loss takes place there. This may locally be even much higher than anywhere else at the same horizontal level.

Under these circumstances an untimely breach of the medium may occur because locally too high speeds of the liquid take place or because the pressure loss becomes too high. Selfevidently the mesh-width of the web plays an important part here.

One can, if one does want to keep the speed very high, increase the medium's layer thickness or take care that the medium is well pressed before the filtration starts, for instance amongst others by filtering temporarily from top to bottom, by having the medium well precipitated or by eventually vibrating it. The latter is an imperative demand if one applies a very finely granulated or powdery medium. The above-mentioned measures for that matter are also often to be recommended.

The web system generally is fixed to the filter. In special cases however it may be optional, that the system is not fixed and if this is the case there can occur a supplemental expansion possibility of the bed by the possibility of this bed to move in respect of the filter.

WHAT WE CLAIM IS:

1. A process for contacting fluids with granular solids, wherein the fluids are passed through a layer of the granular solid material and the direction of flow is defined by the difference of specific gravity between the fluid and solid medium, so that the lighter fluid is passed in an upward direction and breaching or formation of channels in the body of granular solid material by lateral migration of the granules is prevented by the provision therein of a fixed framework of elements extending over the cross-section of flow to allow movement of the material in its entirety only in a vertical direction and

thus to ensure the uniform dispersion of the fluid over the cross-section of the body of granular material and uniform distribution of the upward forces tending to move the solid material in the upward direction.

2. A process according to claim 1, wherein the framework comprises at least one fixed element in the form of a series of parallel rods, which are mounted horizontally.

3. A process according to claim 1, wherein the framework comprises fixed elements in the form of vertically mounted conical coils.

4. A process according to claim 1, wherein there is provided above the body of granular material a layer of an auxiliary material of coarser granulated but specifically lighter solid material, in which auxiliary layer the fixed elements are situated.

5. A process according to claim 1, wherein the body of granular solid material consists of components of different dimensions.

6. A process according to Claim 1, wherein the body of granular solid material consists of components of different composition.

7. A process according to Claim 1, wherein the body of granular solid material consists of components of different specific gravity.

8. A process according to Claims 1 to 7, wherein the effluent is drained off above the surface of the solid material.

9. A process according to Claims 1 to 7, wherein the effluent is partly drained off below the surface of the granular solid material and partly above the same.

10. A process according to Claims 1 to 7, wherein the effluent is wholly drained off below the surface of the solid medium.

11. A process according to Claims 1 to 10, wherein there is a difference in pressure between the influent and effluent of at least 1 meter of water column.

12. A process according to Claims 1 to 11, wherein the outflow of the effluent takes place through a draining system comprising separate draining elements forming slots in which the edges of the slots can move relatively to each other, by which movement any clogged particles of the solid medium can be freed.

This bringing together of the medium to a compact bed under the reaction element as mentioned in Example VIII is nearly always desirable, especially if the medium consists of fine material.

The coils mentioned in Example VIII are also perfect drains and work in some degree as back pressure valves.

Special attention is required for the nature and the degree of the medium's loading with solid materials, which are separated from the liquid to be treated.

At a low filtration speed and a finer granulation of the medium these are separated lower in the medium. At too high a filtration speed and/or coarse filter material the separation can be insufficient, so that no well-cleaned effluent is obtained and the deposit occurs too high in the medium and a big part of the pressure loss takes place there. This may locally be even much higher than anywhere else at the same horizontal level.

Under these circumstances an untimely breach of the medium may occur because locally too high speeds of the liquid take place or because the pressure loss becomes too high. Selfevidently the mesh-width of the web plays an important part here.

One can, if one does want to keep the speed very high, increase the medium's layer thickness or take care that the medium is well pressed before the filtration starts, for instance amongst others by filtering temporarily from top to bottom, by having the medium well precipitated or by eventually vibrating it. The latter is an imperative demand if one applies a very finely granulated or powdery medium. The above-mentioned measures for that matter are also often to be recommended.

The web system generally is fixed to the filter. In special cases however it may be optional, that the system is not fixed and if this is the case there can occur a supplemental expansion possibility of the bed by the possibility of this bed to move in respect of the filter.

WHAT WE CLAIM IS:

1. A process for contacting fluids with granular solids, wherein the fluids are passed through a layer of the granular solid material and the direction of flow is defined by the difference of specific gravity between the fluid and solid medium, so that the lighter fluid is passed in an upward direction and breaching or formation of channels in the body of granular solid material by lateral migration of the granules is prevented by the provision therein of a fixed framework of elements extending over the cross-section of flow to allow movement of the material in its entirety only in a vertical direction and

thus to ensure the uniform dispersion of the fluid over the cross-section of the body of granular material and uniform distribution of the upward forces tending to move the solid material in the upward direction.

2. A process according to claim 1, wherein the framework comprises at least one fixed element in the form of a series of parallel rods, which are mounted horizontally.

3. A process according to claim 1, wherein the framework comprises fixed elements in the form of vertically mounted conical coils.

4. A process according to claim 1, wherein there is provided above the body of granular material a layer of an auxiliary material of coarser granulated but specifically lighter solid material, in which auxiliary layer the fixed elements are situated.

5. A process according to claim 1, wherein the body of granular solid material consists of components of different dimensions.

6. A process according to Claim 1, wherein the body of granular solid material consists of components of different composition.

7. A process according to Claim 1, wherein the body of granular solid material consists of components of different specific gravity.

8. A process according to Claims 1 to 7, wherein the effluent is drained off above the surface of the solid material.

9. A process according to Claims 1 to 7, wherein the effluent is partly drained off below the surface of the granular solid material and partly above the same.

10. A process according to Claims 1 to 7, wherein the effluent is wholly drained off below the surface of the solid medium.

11. A process according to Claims 1 to 10, wherein there is a difference in pressure between the influent and effluent of at least 1 meter of water column.

12. A process according to Claims 1 to 11, wherein the outflow of the effluent takes place through a draining system comprising separate draining elements forming slots in which the edges of the slots can move relatively to each other, by which movement any clogged particles of the solid medium can be freed.



13. A process according to one or more of the foregoing claims applied to the purifying of cloudy or polluted water.
14. A process according to any one of the claims 2 to 5 applied to the cleaning of a solid medium that has been used for filtering.
15. An apparatus for use in the process according to one or more of the foregoing claims, characterised by the use of a frame-work comprising one or more fixed elements in the form of grates as described with reference to fig. 4 or conical coils as described with reference to fig. 5 mounted horizontally above each other.
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Sheerness: Printed for Her Majesty's Stationery Office, by Smiths Printers and Duplicators.—1962.
Published at the Patent Office, 25 Southampton Buildings, London, W.C.2., from which copies may be obtained.

