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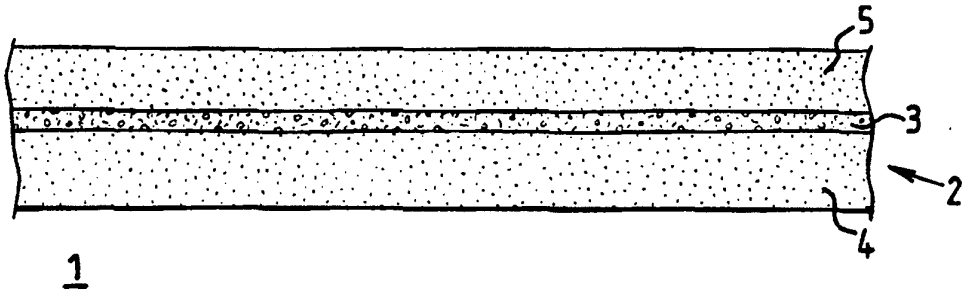

(57) Abstract

The invention relates to a slow sand filter comprising in the embodiment a layer of granular activated carbon (3) sandwiched between two layers (4) and (5) of sand.

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REMOVAL OF IMPURITIES

The invention relates to removal of impurities, particularly to a slow sand filter which removes impurity(ies) from raw feed water.

In recent years drinking water quality has become a major issue for public and political debate with the issue of pesticides in drinking water receiving much attention. The EC Drinking Water Directive (80/778/EEC) included a limit of 0.1 ug/1 for individual pesticides, with the same limit being incorporated in the UK Water Supply (Water Quality) Regulations 1989. For most pesticides this 0.1 ug/1 standard is far more stringent than health-based standards set by such bodies as the World Health Organisation and the US EPA.

Small quantities of pesticides, mainly water soluble herbicides, enter the water environment through run-off to rivers and infiltration to groundwaters. This is predominantly a problem in lowland urban and agricultural catchments, such as that covered by the geographical area of the Applicants.

The need to produce a general reduction in background organics and minimise the use of chlorine and the production of its by-products are also major issues for many European and US water suppliers.

Most lowland water treatment plants fall into one of three groups on the basis of water source and type of treatment:

i) Surface water treatment by storage, chemical coagulation, clarification, rapid sand filtration and chlorination;

ii) Surface water treatment by storage, rapid gravity filtration, slow sand filtration and chlorination;

iii) Groundwater treatment usually by chlorination alone, sometimes with rapid sand filtration.

The Applicants provide an average of 2700 Mld of water to more than seven million customers from a total of 123 water treatment works, falling into all three of these categories. Some 75% of the supply is derived from the River Thames and its tributaries, with the majority being treated by slow sand filtration.

These conventional treatment processes are unable consistently to meet the current standards for pesticides, and additional treatment is therefore required.

Slow sand filtration is usually carried out in slow sand filters which provide a well established means of removing impurities from raw feed water. They have however a high capital cost and require extensive land. As mentioned previously, current filters are unable consistently to meet required standards of removal of impurities such as pesticides, trihalomethane precursors, organic solvents and volatile organic compounds which affect taste and odour, such as geosmin and 2-Methylisoborneol. Similar considerations apply to removal of colour, total organic carbon (TOC) and assimable organic carbon (AOC).

It is accordingly an object of the invention to seek to mitigate these disadvantages.

According to a first aspect of the invention there is provided a filter for removing impurities from a liquid such as water, comprising sand or the like filter medium, and an additive adapted to remove at least pesticides from the liquid.

It will be understood that the term "pesticides" used herein includes fungicides, herbicides, insecticides and the like.

Preferably, the filter may be a slow sand filter for water.

The additive may comprise activated carbon, particularly in the form of at least one layer of granular activated carbon in the filter. This provides for efficient removal of impurities.

There may be a single layer comprising granular activated carbon sandwiched between two layers of sand. This provides for efficient utilisation of the carbon.

There may be a lower layer of sand of thickness in the range of about 200 to 400mm, a layer of activated carbon of thickness in the range of about 200mm, suitably 25 to 200mm, and an upper layer of sand of thickness in the range of about 300 to 500mm.

The lower sand layer may be substantially 300mm thick, the granular activated carbon layer substantially 135mm thick and the upper layer of sand substantially 450mm thick.

Preferably there may be modules of activated carbon, particularly for an activated carbon layer thickness of between 25mm - 50mm thickness. Each module may be a substantially square module, for example of about 1m side.

The modules may then be laid in a slow sand filter as desired, preferably the module may be a mat, bag or strip with a boundary or casing of a suitable material such as geotextile material. Thus the activated carbon may be sandwiched between layers of geotextile material.

In order to obviate an uneven distribution of activated carbon, which may result from handling, so that the activated carbon inadvertently moves to one end of

a bag for example, the bags may comprise compartments, each of which holds a desired quantity of activated carbon in a positive, i.e. non-shifting, way. The compartments can be formed in any suitable way, by stitching, moulding or the like.

Also the bag and contents may be such as to be regeneratable by being placed straight into a regeneration furnace, so that the complete bags can be regenerated, and then reused.

Alternatively, instead of a modular system a slow sand filter may comprise activated carbon as a layer of say 25mm to 50mm thickness, laid or sandwiched between geotextile layers or mats one of which is laid on a (lower) sand layer, the activated carbon is then laid thereon, and an upper (in use) geotextile layer or mat is then laid over the activated carbon, a sand layer then being laid on the upper geotextile layer. The layers of geotextile may overlap, to provide a comprenensive containment for the activated carbon.

The granular activated carbon may itself be mixed with sand, in suitable predetermined proportions. In such a mixture, sand particles, being of smaller dimension than the activated carbon granules, tend to "plug" gaps between the activated carbon granules. This "plugging" action forces water, in use, in a filter bed, to flow through the adsorbent granular activated carbon. The "plugging" also provides fewer voids for the growth of organisms in the filter.

Each layer of the bed may be levelled relative to a laser datum. This ensures uniform filtering and purification.

The laser datum may comprise a laser transmitter set to a desired height of an upper surface of a layer and a receiver on a mobile device for levelling the

respective layer to that desired surface height.

The mobile device may comprise a bridge or gantry extending across the slow sand filter for levelling and/or laying a layer, or alternatively the mobile device may comprise a motor device adapted to run on a layer of the bed. Again, the device may comprise a boom having an appropriate reach, the boom preferably being mounted on or at, and extending from the side of the filter.

According to a second aspect of the invention there is provided a method of providing a filter, comprising providing sand or the like filter medium providing an additive adapted to remove at least pesticides passing in use through the filter and laying the sand/additive to provide the filter.

The method may preferably comprise providing a slow sand filter.

The step of providing an additive may comprise providing an additive comprising granular activated carbon.

The step of providing granular activated carbon may comprise laying that granular activated carbon in at least a layer in the filter.

There may be the step of laying a layer of sand, laying a layer of granular activated carbon on the layer of sand, and laying a further layer of sand on the layer of granular activated carbon.

There may be the steps of laying the first-mentioned or lower layer of sand of a thickness in the range of about 200 to 400mm, laying the layer of granular activated carbon on a thickness in the range of about 100 to 200mm, suitably 25 to 200mm, and laying the second-mentioned or upper layer of sand on the

granular activated carbon layer of thickness a thickness in the range of about 300 to 500mm.

There may be the steps of laying the lower layer of sand to a substantially 300mm thickness, laying the granular activated carbon to a thickness of substantially 135mm and laying the upper layer of sand to a thickness of substantially 450mm.

The method may include the step of levelling the upper surface of at least the lower sand layer and granular activated carbon layer using a laser datum.

There may be the steps of providing a laser transmitter set to a desired height of an upper surface of a layer, providing a laser receiver on a mobile device for levelling the respective layer, and moving that mobile device to level the layer according to the laser datum.

The method may also comprise providing an indicator of a desired level which indicator is monitored by an operator of the mobile device for adjusting levelling means of the device.

The method may also comprise providing a bridge or gantry extending across the slow sand filter, for levelling and/or laying a layer. The method may provide for provision of a boom having an appropriate reach, the boom preferably being mounted on and extendingfrom the side of the filter.

The method may further comprise providing a motor device adapted to run on a layer of the bed. This method step may suitably provide a mobile device having scraper bars of substantially 90° angular configuration.

The method may comprise laying the layers in sequential part surface areas of the total area of the slow sand filter until the whole surface area is provided with a sandwich of sand and granular activated carbon.

The invention extends to a slow sand filter bed in corporation a filter and method as hereinbefore defined.

A slow sand filter is hereinafter described, by way of example, with reference to the accompanying drawings.

Fig.1 is a cross-section through a slow sand filter according to the invention;

Fig.2 is a schematic perspective view of a method of laying and levelling the slow sand filter of Fig.1;

Fig.3 is a schematic transverse sectional view of an alternative method of levelling and/or laying the slow sand filter of Fig.1;

Fig.4 is a transverse sectional view of a levelling device;

Fig. 5 is a schematic perspective view of a particular embodiment of levelling device of Figs. 2, 3 and 4;

Fig. 6 is a plan view of the levelling device of Fig. 5;

Fig. 7 is a sectional view on line "B"-"B" of Fig. 6;

Fig. 8 shows the step of dressing a surface of a layer of sand and a method of laying a slow sand filter according to the invention;

Fig. 9 shows the step of levelling a layer of granular activated carbon; and

Fig. 10 is a graphical representation of pesticide removal using a slow sand filter according to the invention, against a control bed which did not have any additional layer.

Referring to the drawings in which like parts are shown by like numerals, there is shown a slow sand filter 1 comprising, in the sand 2, an additive 3 in the form of a layer of granular activated carbon operative to remove impurities, at least pesticidal ones, from water (not shown in the filter in the Figs.) passing in use through the slow sand filter to be purified thereby.

The granular activated carbon is in the form of a single layer 3 in the embodiment of about 135mm (uncompacted) thickness sandwiched between a lower (as viewed and in use) layer 4 of clean sand of substantially 300mm thickness and an upper (as viewed and as in use) layer 5 of clean sand of substantially 450mm thickness.

The lower layer 4 of clean sand is firstly laid and levelled. It is delivered to the bed of the filter by suitable means such as a series of motor devices such as dumper trucks, or an overhead bridge or gantry 6 to the bed. In either embodiment, the layer 4 is spread out to the required thickness and with a relatively smooth and level upper surface by a laser datum in the form of a laser transmitter 7 which is set to a required height and a laser receiver 8 which is mounted on a levelling device in the form of a levelling device 9 which has a frame 10 with transverse substantially parallel bars 11 of substantially 90° angular configuration as shown in Figs. 4, 5 and 7. As can be seen (Figs. 5 and 7) the bars 11 are mounted on the frame 10 such that their lower limbs are inclined at about 20° to the horizontal. The laser datum 7, 8 is such that as the

device 9 is dragged over the sand 4, to spread and smooth it out, the receiver 8 passes up and down through the laser beam 12 from the transmitter 7, monitors whether it is too high or low and provides a signal to the operator of the gantry 6 or device 9 so that he or she can make appropriate adjustment of the levelling device as it is moved back and forth and up and down (arrow 'X') until the height of the upper surface of the layer 4 is smooth, level, and of the required height, in other words the layer is of the required thickness, any tyre marks being smoothed out where dumpers are used. The laser receiver 8 is mounted in one or other of two sockets 9' mounted on the frame 10 (Fig.5).

The layer of granular activated carbon 3 is then laid on the lower layer of sand, using a similar method. Thus, in the embodiment of Fig.2, the granular activated carbon is delivered to the bed by a series of dumper trucks (not shown) which delivers a pile 13. A mobile grader 14 or tractor with the levelling device 9 of Fig.4 (which has a pivotal connection 15 for connection with a tractor raising and lowering mechanism 15') is then brought up and spreads out the granular activated carbon to form the layer 3 of the required thickness using the laser datum 7,8 as before. In the Fig.2 embodiment, the laser receiver 8 has a direct visual indicator showing the operator 16 in the cab whether the thickness is too great or too little so that he can manoeuvre the levelling device 9 as desired until the required thickness and smoothness is achieved.

It will be understood that the levelling operation is carried out automatically under say hydraulic operation of the levelling device 9.

The upper layer 5 of sand is then applied using a similar laser datum method to achieve a desired thickness and smoothness of the upper layer of sand.

The slow sand sandwich filter of the invention is suitably laid in sections,

suitably half at a time as shown in Figs. 8 and 9. Thus the lower layer of clean sand is laid in its entirety. Then half the sandwich is built up as described above. Thus in a rectangular bed, half of a longitudinal extent is laid. The tyre marks of dumpers or the like of the other half are then eradicated from the layer 2 using a bar scraper and smoothing mat arrangement, and then the other half of the sandwich is built up. In building up the sandwich the first application of clean sand of the upper layer 5 is applied relatively gently to the laid layer of granular activated carbon 3 so as not to disrupt the smooth surface or alter the thickness.

The granular activated carbon is also covered with the upper layer of sand 5 as quickly as possible after laying so that it is protected from dispersion by wind, degradation or attrition by frost, or disturbance or depradation by animals or birds.

The granular activated carbon is also delivered dry to a holding store, usually in tankers, from which it is pumped out to a washing plant to remove fines, the washing medium being water. The water drains away, but the carbon remains damp and is laid like this, so helping to avoid dispersion by wind, and also assisting in improving the process of compression of the granules.

The water to be treated may also be pre-treated with ozone (O_3) which can enhance the life of the granular activated carbon prior to exhaustion. It is envisaged however that with or without O_3 pre-treatment a slow sand filter embodying the invention and as described herein with reference to the drawings will remove individual pesticide levels from surface waters to below 0.1 ug/l and total pesticide levels to below 0.1 ug/l for between 12 to 60 months before regeneration of the granular activated carbon falls due. Moreover, a pesticide resistant to ozone such as atrazine can be virtually totally removed using a slow

sand filter embodying the invention which is double the removal rate by ozone.

It will be understood that the invention can be applied to existing slow sand filters, or to new ones being installed and commissioned.

In the embodiments, the laser transmitter 7 is portable, being mounted on a tripod 17 which can be set up where required in the bed 2, whichever part of the bed is being laid. The tripod 17 is light and can be moved by one operator, the laser being battery driven. The laser datum can be utilised to map the filter surface, and the height can be adjusted using a telescopic mast or support on which the actual laser transmitter is mounted. Alternatively the laser transmitter can be on a fixed support such as a stainless steel stand on the side of the filter bed.

When the filter 2 is required to be cleaned, the top layer of sand 5 is progressively skimmed down by about 2.50cm, and replaced, therefore with a 450mm thickness top layer, 14 skims or cleans will take place before a thickness of about 100mm sand above the granular activated carbon is reached using a mobile "dry" cleaning machine. This thickness is about the minimum thickness before disruption of the carbon layer ensues. Thus 14 "cleans" can be effected prior to topping up with new sand or removing the granulated activated carbon layer if exhausted, thereby greatly reducing operating costs.

Typical slow sand filters as operated by the Applicants are typically rectangular, 80-120m long and 20-35m wide. Within the filter a 0.7-1.0m deep layer of 0.3mm effective size (ES) sand overlies a layer of drainage gravel and an underdrain system constructed from porous concrete.

During normal operation silt, clay and biological detritus collects gradually at

the surface of the filter, increasing the filter headloss and reducing the hydraulic capacity. Slow sand filters are not backwashed, but at intervals of 3-10 weeks each filter is taken out of service, drained down, and the top 25-40mm of sand removed by mechanical skimming plant. The "dirty" sand is cleaned by washing for re-use, while the slow sand filter is returned to service, with the flow being gradually increased over a period of days. When the depth of sand in the filter reaches the operational minimum of 300mm, the filter is taken out of service and re-filled with clean sand. Periodically the bottom 300mm layer is also replaced by clean sand. Using the invention, in a test, a granulated activated carbon sandwich filter was constructed in a 2m x 1m steel tank. A 150mm thick layer of granular activated carbon F400 GAC (ES = 0.7mm) produced by Chemviron Carbon Ltd., was placed on 150mm of 0.3mm ES sand over a gravel underdrain. A further 450mm of sand was placed on top of the granular activated carbon.

The granular activated carbon sandwich filter followed pre-ozonation, primary rapid gravity filtration with (dual media filter with ferric sulphate dosing) and main ozonation. A second pilot slow sand filter, constructed without the granular activated carbon but otherwise identical, was operated in parallel as a control. The target filtration rate for both filters was 0.3 m/hr.

Filtrate samples from both the granulated activated carbon sandwich filter and the control bed have been analysed for pesticides and a range of other organics related parameters. Pesticide analysis was carried out on a periodic basis, with the following pesticides being included in the analysis suite:

Atrazine	Chlortoluron	Mecroprop (MCPP)	Dicamba
Simazime	Linuron	MCPA	Bromoxynil
Propazine	Propyzamide	MCPB	Ioxynil

Diuron	Prometryne	2,4-D	Dalapon
Isoproturon	Terbutryne	2,4,5-T	Pentachlorophenol

On regular occasions the chlorine demand and trihalomethane (THM) formation potential of the feed and treated waters were determined in laboratory tests, using chlorine contact times from 0.5 hours to 6 days.

A range of other physical/chemical, biological and microbiological parameters were monitored on a twice weekly basis, as follows:

Table 1 - Full Scale Process Trial, Routine Monitoring

Parameter Type	Parameter	Unit
Organics related:	Total Organic Carbon (,TOC) UV Absorbance @ 254 nm Colour	MG/l Abs/m Hazen
Physical:	Turbidity Particle number analysis (4-80 um) Particle volume analysis (4-80 um)	NTU No/ml ppm
Biological	Particulate organic carbon (POC) Chlorophyll-a General biology	ug/l ug/l No. animals/m3
Microbiological:	E.coli (presumptive & confirmed) Total coliforms (presumptive & confirmed) Coliform species Coliform No. types Aeromonas	No./100ml No./100ml No. No. No./100ml

During the course of the trials a number of pesticides have been found in the raw water on a regular basis. These include the herbicides atrazine, simazine, diuron and mecoprop. Other herbicides have been detected on a seasonal or occasional basis.

Results of four individual pesticides are shown in Fig. 10, which compares concentrations in the filtrate from the full scale granular activated carbon sandwich and control beds.

To date no pesticides have been detected in the filtrate from the granular activated carbon sandwich (15,000 bed volumes treated).

Tests have shown that for the variation in feed water total organic carbon (TOC) concentration, and the TOC removal by the granular activated carbon sandwich and control beds, incoming TOC varied from 4 to 8 mg/l, being generally higher in the summer months. TOC removal by the control bed varied between 0 and 40%, with a mean removal of 20%. TOC removal by the granular activated carbon sandwich was 60% after six months operation (5000 BVs).

The granular activated carbon sandwich has also maintained a high degree of colour removal throughout, dropping only 20% over the period of the trial.

Furthermore for all chlorine contact times between 0.5 hours and 6 days the granular activated carbon sandwich bed filtrate had a 60% lower chlorine demand and THM formation potential than the control bed filtrate.

Using the invention described herein with reference to the drawings, has the following advantages:

1. Conventional granular activated carbon media of effective size (ES) 0.7mm can be placed as a 25-200mm sandwich layer within conventional slow sand filter media, ES 0.3mm, with no detriment to normal filter operation or water quality.

2. Removal of organics and non-biodegradable micropollutants such as pesticides is considerably enhanced by the granular activated carbon slow sand filter sandwich adsorber process.

3. The bed and process offers economic benefits compared to conventional solutions, and is rapidly incorporated in existing structures.

CLAIMS

1. A filter for removing impurities from a liquid such as water, comprising sand or the like particulate filter medium, characterised by an additive (3) adapted to remove at least pesticides from the liquid.

2. A filter according to Claim 1, characterised by the filter comprising a slow sand filter (1).

3. A slow sand filter according to Claim 2, characterised by the additive (3) comprising activated carbon.

4. A slow sand filter according to Claim 3, comprising at least one layer of granular activated carbon in the filter.

5. A slow sand filter according to Claim 4, characterised by a single layer comprising granular activated carbon (3) sandwiched between two layers (4, 5) of sand (2).

6. A slow sand filter according to Claim 5, characterised by a lower layer (4) of sand (2) of thickness in the range of about 200 to 400mm, by a layer (3) of activated carbon of thickness in the range of about 25 to 200mm, and by an upper layer (5) of sand (2) of thickness in the range of about 300 to 500mm.

7. A slow sand filter according to Claim 6, characterised by the lower sand layer (4) being substantially 300mm thick, by the granular activated carbon layer being (3) substantially 135mm thick, and by the upper layer (5) of sand being substantially 450mm thick.

8. A slow sand filter according to any of Claims 5 to 7, characterised in that each layer (3, 4, 5) of the bed (1) is levelled relative to a laser datum (7, 8).

9. A slow sand filter according to Claim 8, characterised by the laser datum (7, 8) comprising a laser transmitter (7) set to a desired height of an upper surface of a layer and by a receiver (8) on a mobile device (6, 9) for levelling the respective layer to that desired surface height.

10. A slow sand filter according to Claim 9, characterised by the mobile device comprising a bridge, boom or gantry (6) extending across the slow sand filter (1) for levelling and/or laying a layer (3, 4, 5).

11. A slow sand filter according to Claim 9, characterised by the mobile device comprising a motor device (14) adapted to run on a layer (3, 4, 5) of the bed (1).

12. A slow sand filter according to any of Claims 3 to 11, characterised by the granular activated carbon (3) including a geotextile.

13. A slow sand filter according to Claim 10, characterised by the geotextile comprising two spaced layers.

14. A slow sand filter according to Claim 12 or Claim 13, characterised by the geotextile comprising a bag.

15. A slow sand filter according to Claim 14, characterised by the bag having an internal partition.

16. A method of providing a filter, comprising providing sand or the like filter medium, characterised by providing and additive (3) adapted to remove at least a pesticide passing through the filter and by laying the sand additive to provide the filter.

17. A method of laying a filter, characterised by providing a slow sand filter (1).

18. A method according to Claim 17, characterised by the step of providing an additive (3) comprising granular activated carbon.

19. A method according to Claim 18, characterised by laying at least one layer (3) comprising granular activated carbon in the filter (1).

20. A method according to Claim 19, characterised by laying a layer (4) of sand (2), by laying a layer (3) of granular activated carbon on the layer (4) of sand, and by laying a further layer (5) of sand on the layer (3) of granular activated carbon.

21. A method according to Claim 20, characterised by the steps of laying the first-mentioned or lower layer (4) of sand of a thickness in the range of about 200 to 400mm, by laying the layer (3) of granular activated carbon of a thickness in the range of about 25 - 200mm, and by laying the second-mentioned or upper layer (5) of sand on the granular activated carbon layer (3) of thickness a thickness in a range of about 300 to 500mm.

22. A method according to Claim 21, characterised by the steps of laying the lower layer (4) of sand to a substantially 300mm thickness, by laying the

granular activated carbon layer (3) to a thickness of substantially 135mm, and by laying the upper layer (5) of sand to a thickness of substantially 450mm.

23. A method according to any of claims 19 to 22, characterised by the additional step of levelling the upper surface of at least the lower sand layer (4) and granular activated carbon layer (3) using a laser datum (7, 8).

24. A method according to Claim 23, characterised by the steps of providing a laser transmitter (7) set to a desired height of an upper surface of a layer (3, 4, 5), by providing a laser receiver (8) on a mobile device (6, 9) for levelling the respective layer, and by moving that mobile device (6, 9) to level the layer according to the laser datum (7, 8).

25. A method according to Claim 24, characterised by providing an indicator (12) of a desired level which indicator is monitored by an operator of the mobile device (6, 9) for adjusting levelling means of the device.

26. A method according to Claim 24 or Claim 25, characterised by providing a bridge, boom or gantry (6) extending across the slow sand filter, for levelling and/or laying a layer.

27. A method according to Claim 25 or Claim 26, characterised by providing a motor device (14, 16) adapted to run on a layer (3, 4, 5) of the bed (1).

28. A method according to Claim 25 or Claim 26, characterised by providing a mobile device having scraper bars (11) of substantially 90° angular configuration.

29. A method according to any of Claims 19 to 28, characterised by the steps of laying the layers (3, 4, 5) in sequential part surface areas of the total area of the slow sand filter (1) until the whole surface area is provided with a sandwich of sand and granular activated carbon.

30. A slow sand filter bed, characterised in that it incorporates a filter (1) and method according to any preceding claim. .

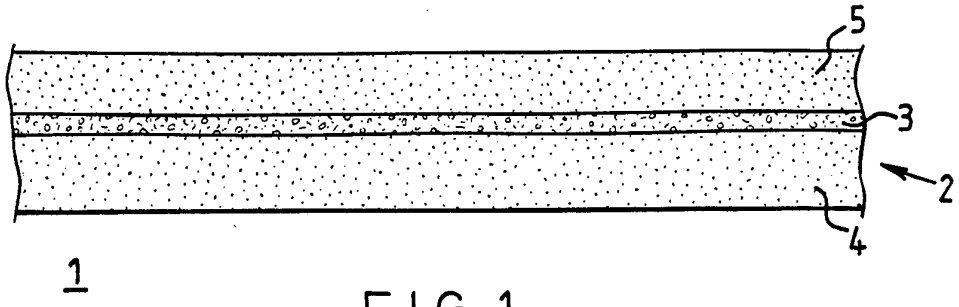


FIG.1

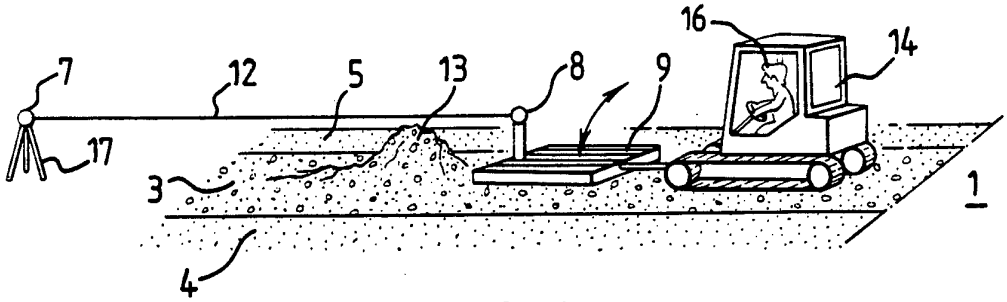


FIG.2

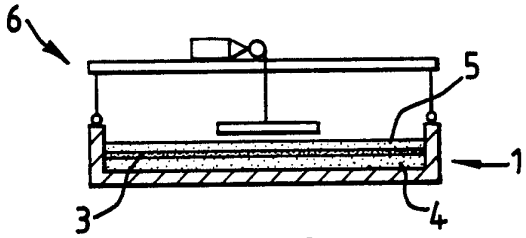


FIG.3

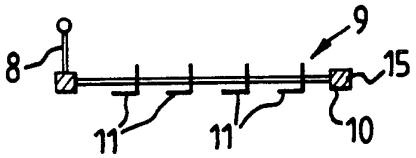


FIG.4

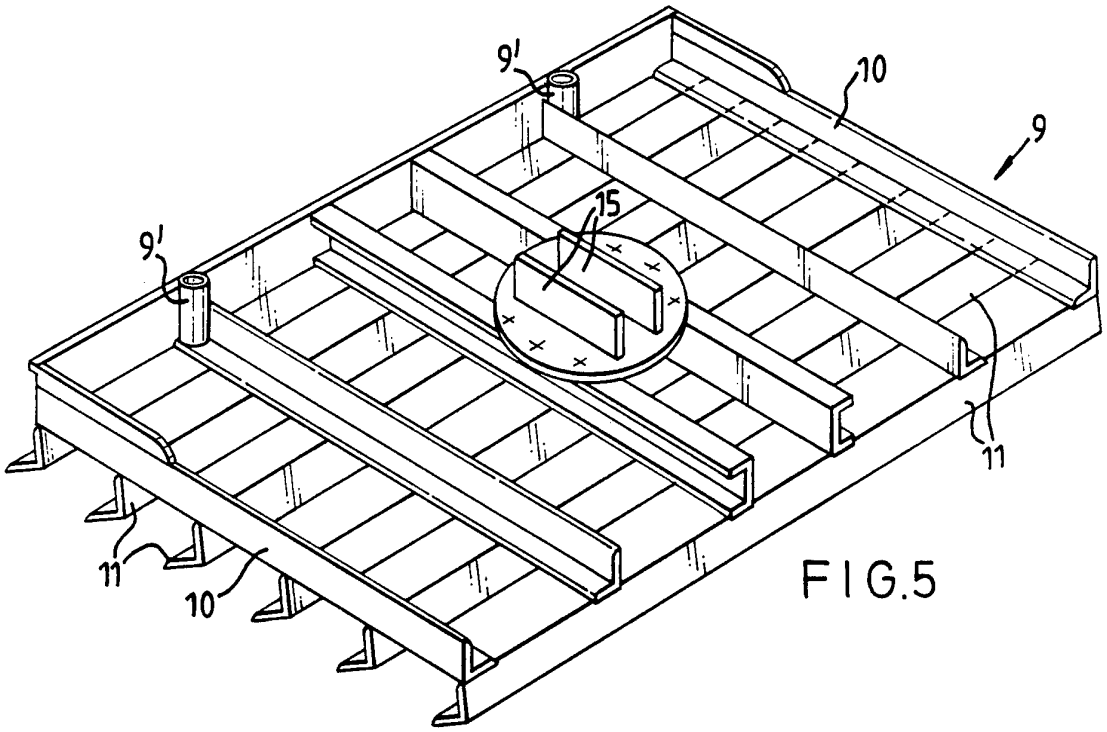


FIG.5

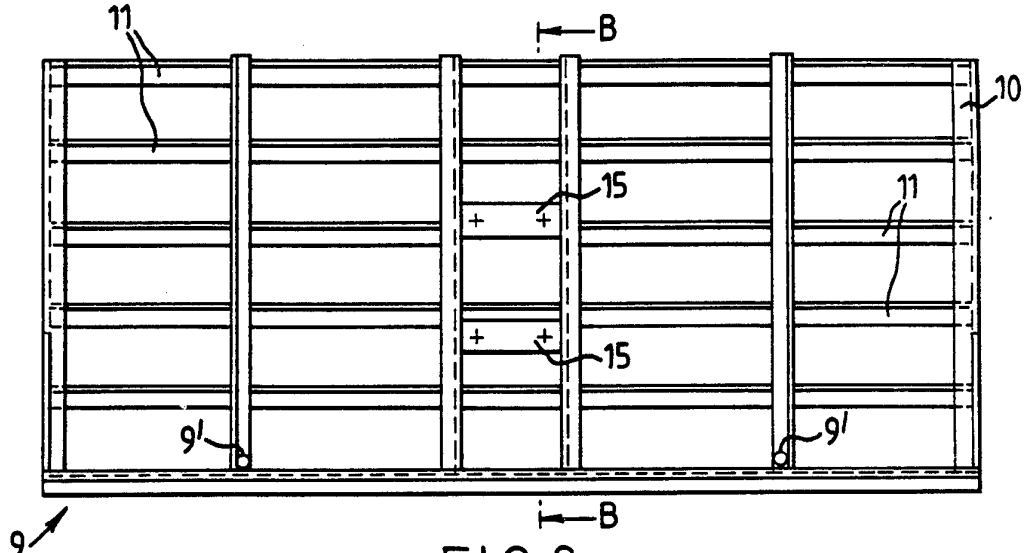


FIG.6

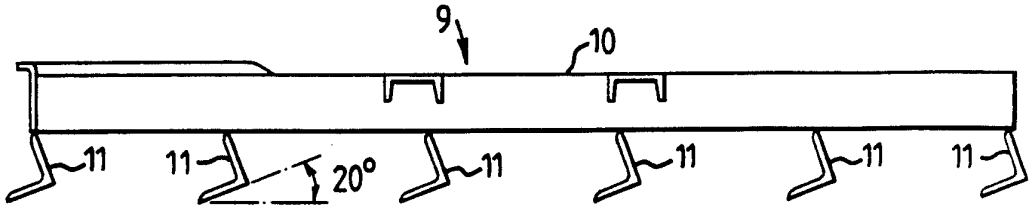


FIG.7

FIG.8

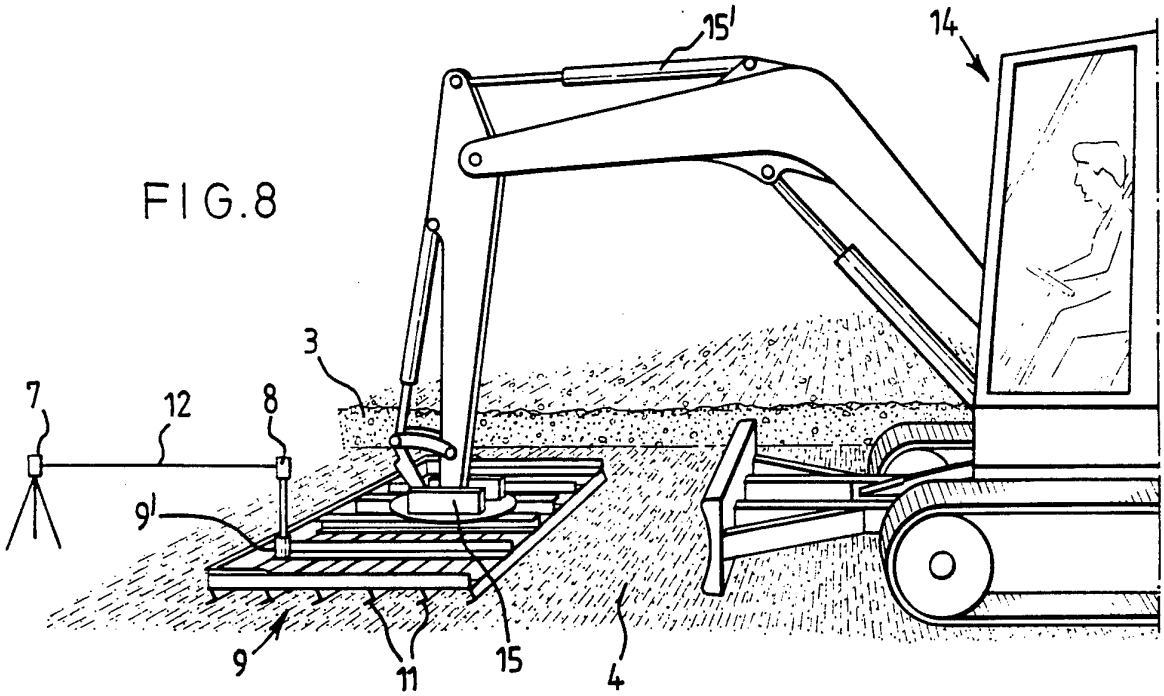
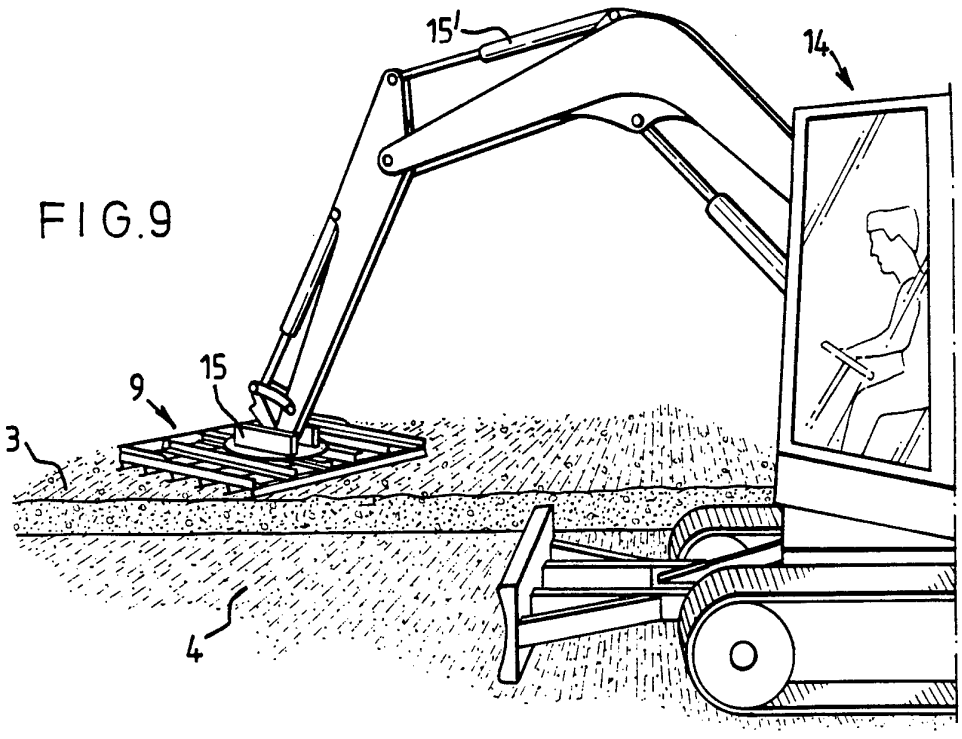


FIG.9



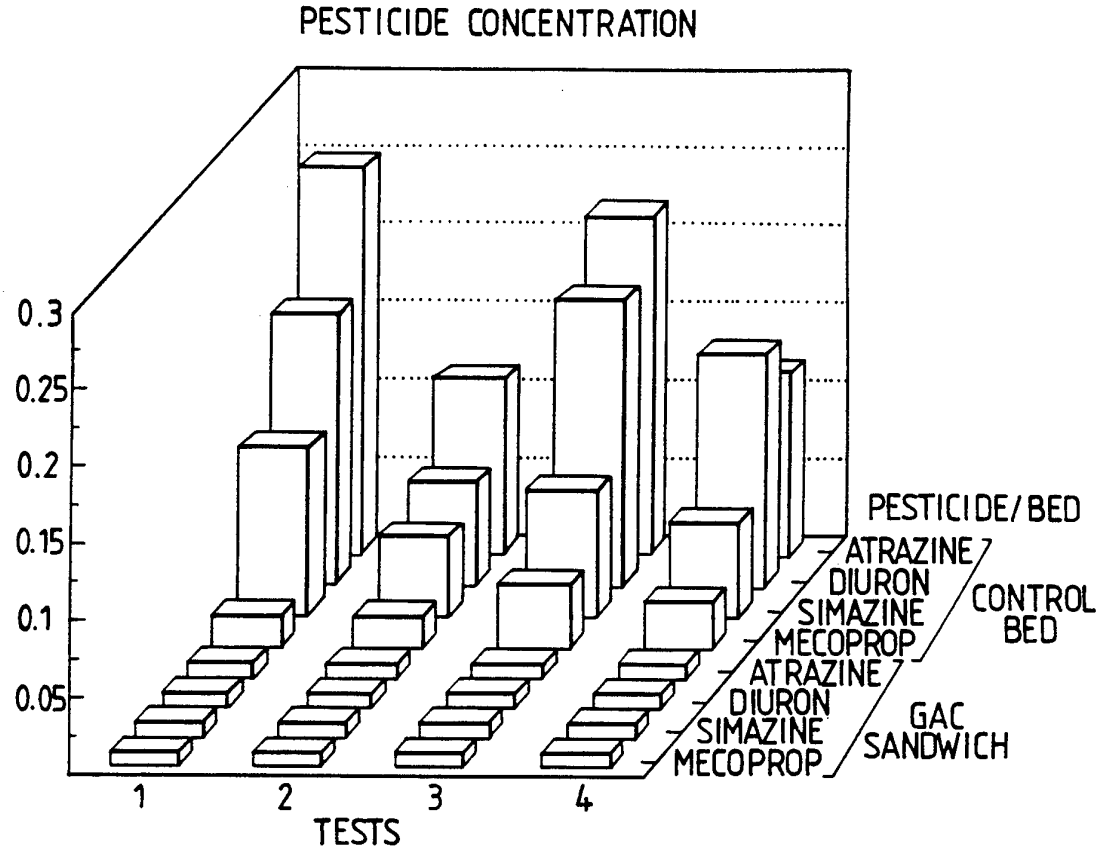

PESTICIDE CONCENTRATION
0.3
0.25
0.2
0.15
0.1
0.05
1
2
3
4
TESTS
PESTICIDE/BED
ATRAZINE
DIURON
SIMAZINE
MECOPROP
CONTROL BED
ATRAZINE
DIURON
SIMAZINE
MECOPROP
GAC SANDWICH

FIG.10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 93/02511

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B01D 24/20, C02F 1/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: B01D, C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, CLAIMS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4663047 (EDMUND KRAUTHAUSEN ET AL), 5 May 1987 (05.05.87), column 1, line 32 - line 62 --	1-4,16-19
Y	FR, A1, 2662454 (RONSIN, JEAN CLAUDE), 29 November 1991 (29.11.91), page 6, line 1 - line 23 --	1-4,16-19
A	US, A, 5182018 (MARK A. LANGSTON), 26 January 1993 (26.01.93), figure 1, abstract --	12-14

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 March 1994	13. 04. 94

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Jan Carlerud

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 93/02511

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR, A1, 2656813 (HEBRAOUI, M. F. ET AL), 12 July 1991 (12.07.91), page 4, line 32 - page 6, line 27 -- --------	1

SA ?733

INTERNATIONAL SEARCH REPORT

Information on patent family members

26/02/94

International application No.
PCT/GB 93/02511

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4663047	05/05/87	DE-A- 3436453	17/04/86
		EP-A,B- 0176912	09/04/86
		JP-A- 61090787	08/05/86
FR-A1- 2662454	29/11/91	NONE	
US-A- 5182018	26/01/93	NONE	
FR-A1- 2656813	12/07/91	NONE	