

COMMONWEALTH OF AUSTRALIA

595645

Patents Act 1952

CONVENTION APPLICATION FOR A STANDARD PATENT

20-1-90
EXAMINATION ACCEPTED AND AMENDMENTS FOLLOWED

X/WE, ANTHONY EDWARD WALSBY and EAST ANGLIAN WATER COMPANY
of 27 Old Sneed Park, Stoke Bishop, Bristol, BS9 1RG, England,
and, 163 High Street, Lowestoft, NR32 1HT, England, respectively,
hereby apply for the grant of a Standard Patent for an
invention entitled:
IMPROVEMENTS IN THE TREATMENT OF WATER TO REMOVE GAS VACUOLATE
CYANOBACTERIA

which is described in the accompanying complete specification.

This application is made under the provision of Part XVI of
the Patents Act 1952 and is based on an application for a
patent or similar protection made

in Great Britain

on 30 September 1986

No. (86.23428)

in

on

No. (

My/Our address for service is:

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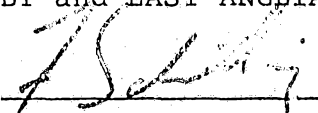
LODGED AT SUB-OFFICE

30 SEP 1987

Sydney

Dated this 29th day of September 1987

ANTHONY EDWARD WALSBY and EAST ANGLIAN WATER COMPANY

By: 

Registered Patent Attorney

To: The Commissioner of Patents

COMMONWEALTH OF AUSTRALIA

Commonwealth of Australia
The Patents Act 1952
DECLARATION IN SUPPORT

In support of the (Convention) Application made by: **ANTHONY EDWARD WALSBY and
EAST ANGLIAN WATER COMPANY**

for a patent for an invention entitled: **Improvements in the Treatment of Water to
Remove Gas Vacuolate Cyanobacteria**

I ~~am~~ ~~(We are)~~ **DAVID CLARK and ANTHONY WALSBY**
of and care of the applicant company do solemnly and sincerely declare as follows:

~~I am (We are) the applicant(s) for the patent~~

or

b) I am ~~(We are)~~ authorised by the applicant(s) for the patent to make this declaration on its behalf.

Delete the following if not a Convention Application.

The basic application(s) as defined by section 141 ~~(142)~~ of the Act was ~~were~~ made

on 30 September 1986 in Great Britain (86.23428)

~~on~~

~~in~~

~~on~~

~~in~~

by

ANTHONY EDWARD WALSBY & EAST ANGLIAN WATER COMPANY

The basic application(s) referred to in this paragraph is (are) the first application(s) made in
a Convention country in respect of the invention the subject of the application.

a) I am ~~(We are)~~ the actual inventor(s) of the invention.

or

b) **Anthony Edward Walsby, 27 Old Sneed Park, Stoke Bishop, Bristol BS9 1RG, England UK**
Keith Brian Clarke, Decoy House, Browston, Great Harmouth, Norfolk NR31 9DP,
England, UK

~~I~~ ~~(are)~~ the actual inventor(s) of the invention and the facts upon which the applicant company
is (are) entitled to make the application are as follows:

By virtue of assignment from the joint inventors in respect of
this invention to the co-applicant.

Declared at Lowestoft this 22nd day of December 19 89
Declared at Bristol this 29th day of December 19 89

Signed *D. Clarke* Status Secretary and Accountant

Signed *A. Walsby* Status Professor

Declarant's Name DAVID CLARK

Declarant's Name ANTHONY EDWARD WALSBY

F. B. RICE & CO PATENT ATTORNEYS

This form is suitable for any type of Patent Application. No legalisation required.

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(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 595645

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REMOVAL OF GAS VACUOLATE CYANOBACTERIA FROM WATER

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(57) Claim

1. A method of treatment of water to remove gas vacuolate cyanobacteria which includes the steps of: hydrostatically subjecting the water removed from a body of water to a predetermined pressure of at least 3 bar in order to collapse the gas vesicles inside the cells of the cyanobacteria; and separating the thus treated cyanobacteria by allowing them to sink to the bottom of settlement means along with any other sediment in the water.

4. Apparatus for the treatment of water to remove gas vacuolate cyanobacteria which float on the surface of the water, said apparatus comprising:

pump means for extracting the water to be treated from a reservoir;

a steel lined bore-hole sunk into the ground;

a centrally located vertical pipe contained within said bore-hole, the lower end of which is open and located a short distance above the bottom of the bore-hole;

pipe means for connecting the top of said centrally located pipe to the outlet of said pump means, the depth of said bore-hole being sufficient to enable the natural hydrostatic head of water contained with said centrally located pipe to provide sufficient pressure to collapse the gas vesicles inside the cells of the cyanobacteria;

a settling tank located adjacent said bore-hole;

and pipe means connecting the top of the bore-hole with the settling tank to convey water which has passed down the centrally located pipe to the settling tank, whereby the collapsed gas vacuolate cyanobacteria settle at the bottom of the settling tank thus providing an output of water from the settling tank which is free of gas vacuolate cyanobacteria.

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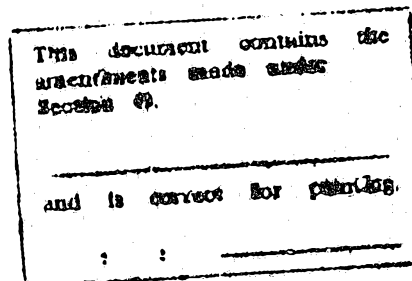
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C O M P L E T E S P E C I F I C A T I O N

(ORIGINAL)

Application Number :
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Priority : 30 September 1986

Related Art :

Name of Applicant : ANTHONY EDWARD WALSBY and EAST
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Complete Specification for the invention entitled:

IMPROVEMENTS IN THE TREATMENT OF WATER TO REMOVE GAS VACUOLATE
CYANOBACTERIA

The following statement is a full description of this invention
including the best method of performing it known to us:-

The present invention relates to a method of and
5 apparatus for the treatment of water to remove gas
vacuolate cyanobacteria.

In some water treatment processes at present in
operation, the water to be treated before being supplied
to the customer is first allowed to stand in settlement
10 tanks where the sediment and foreign bodies in the water
taken from the reservoir or lake is allowed to settle to
form a sludge at the bottom.

However, in certain areas and at certain times of
the year gas-vacuolate cyanobacteria otherwise known as
15 blue-green algae can form in a lake or reservoir. These
cyanobacteria cannot be removed in settlement tanks
because they float upwards and on the surface of the
water.

It is well known that these cyanobacteria float
20 because they contain gas vesicles that is they embody
microscopic gas filled structures which ensure that they
float rather than sink.

The gas vesicles of cyanobacteria are hollow,
cylindrical structures with cone shaped ends. When a gas
25 vesicle is subjected to a moderate pressure (up to 1 bar)

it shows only a small volume change (shown to be about 1 part in 650 per bar for gas vesicles of cyanobacterium Anabaena flos-aquae in a report by A.E. Walsby in the Proceedings of the Royal Society of London, Volume 216, pages 355-368) but at a certain critical pressure the structure collapses flat. A.E. Walsby, in a paper in the Proceedings of the Royal Society of London, Volume 178, pages 301-326, showed that the average critical collapse pressure of gas vesicles in Anabaena flos-aquae varies from 4 bar to 8 bar with a mean value of about 6 bar. When the gas vesicle collapses the conical ends flatten to sectors of circles and pull away from the central cylinder, which flattens to a rectangular envelope. The contained gas diffuses out of the structure and dissolves in the surrounding water as the gas vesicle collapses.

When the gas vesicles inside cells of cyanobacteria are collapsed the cyanobacteria lose their means of buoyancy and sink. This is illustrated in figure 1 of a paper by A.E. Walsby in Bacteriological Reviews, Volume 36 pages 1-32, an article which contains much other information on gas vesicles and their properties. It has been established from research carried out by P.K. Hayes and A.E. Walsby in a paper in the British Phycological Journal, Volume 21, pages 191-197 that the median critical pressure of gas vesicles

from different species of cyanobacteria varied from about 5-9 bar and were inversely correlated with the mean diameters.

Various methods of treating cyanobacteria or dispersing them have not been found to be successful and the most practical method of removal would be to cause them to sink, by collapsing their gas vesicles, whereby they could be removed along with the rest of the sediment in the water.

10 There have been two previous attempts to do this. The first involved an attempt to collapse gas vesicles in cyanobacteria by subjecting them to ultra sound as described in the discussion section of a paper by A.J. Brook in water treatment and examination, Volume 8 pages 15 133-137.

 The second involved attempts to collapse gas vesicles by explosions detonated under water, described by A.E. Walsby in the New Scientist of 21 November 1968 pages 436-437, and by D- Menday in Water Research Volume 20 6, pages 279-284.

 Neither of these methods have proved to be practicable in a method of removing cyanobacteria from water. We describe here a new method of collapsing gas vesicles of cyanobacteria with a hydrostatic head of 25 water, and the subsequent removal of these pressure-

treated organisms from water by sedimentation.

Although not directly relevant to the treatment of water to remove gas vacuolate cyanobacteria, a method for the disposal of solid wastes has been disclosed in
5 British Patent Specification No. 1,163,494. The method for disposing of solid biologically activated waste materials disclosed in this Specification, includes the steps of:

- 10 (a) providing the waste materials in an aqueous slurry;
- (b) pumping the slurry to a well;
- (c) transporting the slurry in the well to a porous and permeable underground formation; and
- 15 (d) pressure injecting the slurry under positive well head pressure directly into the porous and permeable underground formation at a pressure which the formation readily accepts the slurry without fracturing it.

Such a method would be totally unsuitable for the treatment of water to remove gas vacuolate cyanobacteria,
20 in view of the following:

- (a) the earlier Specification teaches the disposal of waste solids and not purification of water; and
- 25 (b) the various steps proposed in the earlier Specification are costly and time consuming and could in

no way be technologically adapted to the treatment of water.

Other methods not directly relevant to the treatment of water to remove gas vacuolate cyanobacteria have been disclosed in British Patent specifications 1,521,258; 1,527,731; 1,540,065; and 1,573,907. All of these relate to the treatment of waste water and sewage by injection of gas containing free oxygen under pressure. The method employed in each of these specifications is such that it would prevent the collapse of the gas vesicles in gas vacuolate cyanobacteria as described by A.E. Walsby in the paper in the Proceedings of the Royal Society Volume 178 pages 301-326 and further, as is made clear in the last of these specifications No. 1,573,907, the addition of oxygen under pressure would cause the material to float rather than to sediment out.

It is an object of the present invention to overcome the above problems by providing a method of and apparatus for the removal of gas vacuolate cyanobacteria from water.

According to one aspect of the present invention there is provided a method of treatment of water to remove gas vacuolate cyanobacteria which includes the steps of: hydrostatically subjecting the water removed

from a body of water to a predetermined pressure in order to collapse the gas vesicles inside the cells of the cyanobacteria, and separating the thus treated cyanobacteria by allowing them to sink to the bottom of settlement means along with any other sediment in the water.

Preferably the said predetermined pressure is approximately six bar, but may be as much as ten bar. A pressure exceeding 10 bar may be used but it is normally more than is needed to collapse the gas vesicles inside the cells of cyanobacteria that live in fresh water.

According to another aspect of the present invention there is provided apparatus for treatment of water to remove gas vacuolate cyanobacteria, including: means for hydrostatically subjecting the water removed from a body of water to a predetermined pressure in order to collapse the gas vesicles inside the cells of the cyanobacteria; and settlement means for separating the thus treated cyanobacteria that sink to the bottom of said settlement means along with any other sediment in the water.

The means for applying a hydrostatic pressure to the water may comprise firstly a lined bore-hole sunk in the ground, or secondly a tower case located above the ground, or thirdly a pump delivery pipe having at its

remote end a diffuser or pressure relief valve necessary to ensure that the pump produces the required additional hydrostatic pressure in the pipe, or fourthly any combination of the bore-hole, the tower case and the pump delivery pipe with diffuser or relief value. In the case of the bore-hole and tower, the water is preferably applied through a centrally located pipe extending down the lined bore-hole or tower case to the bottom thereof. The minimum depth of the bore-hole or height of the tower case lies in the range of 31m to 102m, the preferred depth or height being 60m.

Preferably the bore-hole is steel lined, but other designs of bore-hole, such as a down pipe linked to an up pipe in the form of a U-tube, may be used instead.

The present invention will now be described in greater detail by way of example with reference to the accompanying drawings, wherein;

Figure 1 is a diagrammatic representation of one preferred form of apparatus for the treatment of water to remove cyanobacteria;

Figure 2 is an elevation view of one preferred apparatus for hydrostatically subjecting the water to a predetermined pressure in order to collapse the gas vesicles in the cyanobacteria;

Figure 3 is a diagrammatic representation of a

first alternative form of the apparatus shown in Figure 1; and

Figure 4 is a diagrammatic representation of a second alternative form of the apparatus shown in Figure

5 1.

Referring first to Figure 1, the apparatus for the treatment of water to remove cyanobacteria comprises: a pump 10, a steel-lined bore hole 12 and a settling tank 14. Water from a lake or reservoir 16 is pumped by the pump 10 through a pipe 18 having an appropriate filter in its nozzle inlet section 20. The pumped water is passed to the bore-hole 12 via a pipe 22. As mentioned above the bore-hole 12 is lined with a steel lining to contain the water under pressure. A pipe 24 extends centrally down the bore-hole 12 to within a short distance from the bottom. Any other suitable lining material may be used instead of steel.

The preferred depth of the bore-hole 12 is about 60m. However, the actual depth for any particular set of conditions is quite critical and has to be determined by experiment. Sufficient pressure must be generated, by the hydrostatic head at the bottom of pipe 24, to collapse enough gas vesicles to cause loss of the cyanobacteria's buoyancy. The minimum pressure required depends on the species of cyanobacterium present and may

be from 3 bar to 10 bar. Since a pressure of 1 bar is generated by a vertical water column of 10.2m the required depth of pipe 24 below the surface is, correspondingly, about 31m to 102m. According to the nature of the cyanobacteria and the location, the preferred depth may therefore lie in the range of from 31m to 102m.

The water from the reservoir 16 is thus pumped by the pump 10 down to the bottom of the pipe 24, where for a depth of 60m the hydrostatic pressure of the water at the bottom of the bore-hole 12 is approximately 6 bar. The water which flows out of the top of the bore-hole 12 is passed to the settling tank 14 by means of a pipe 26.

The construction of the bore-hole 12 is shown in greater detail in Figure 2. After the bore-hole 12 has been dug in the ground it is sealed against penetration of liquid from the ground by being steel lined with a series of plates 13 or annular rings which are welded together. A circular steel plate 15 is provided at the bottom of the bore-hole 12. As shown, the pipe 22 from the pump 10 is connected to the centrally located vertical pipe 24 by means of an elbow joint 28 and flanges 30 and 32. The pipe 24 is centrally located within the steel-lined bore-hole by means of locating spiders 34 which are provided at equi-spaced intervals

from top to bottom of the bore-hole 12.

In operation, water from the lake or reservoir 16 containing cyanobacteria is pumped to the bottom of the bore-hole 12 by means of the pipe 24, where the hydrostatic pressure builds up to about 6 bar. This pressure is sufficient to collapse the gas vesicles in the cyanobacteria, so that when they are carried out of the bore-hole 12 and into the settling tank 14 via the pipe 26, their specific gravity is now greater than unity so that they sink with the other sludge and foreign bodies to the bottom of the settling tank leaving clean treated water at the top of the settling tank from which it can be drawn for further treatment before being supplied to the customer.

A first alternative construction is shown in Figure 3, wherein the height of the level of the lake or reservoir is above the location of the treatment apparatus and part of the hydrostatic head can be supplied by the difference in vertical level between the reservoir surface and the top of the bore-hole or between the top of a tower 44 and the top of a bore-hole 40. The required depth of the bore-hole 40 is reduced accordingly. As shown in Figure 3, water from a reservoir 16 is pumped up to the top of a tower 44 by means of the pump 10 through a pipe 46. The bottom of

the tower 44 is connected to the pipe 24 of the bore-hole 40 by a pipe 42.

Water is pumped into the top of the tower through the pipe 46 at a rate so as to maintain the level of water near the top of the tower 44. In this case the
 5 desired pressure of 6 bar can be produced by ensuring that the total head between the top of the tower 44 and the bottom of the pipe 24 is 60m.

A second alternative construction is shown in
 10 Figure 4 in which necessary to collapse the gas vesicles inside the cells of the cyanobacteria can be generated in a water container or pipe. As shown a pump 50 takes water from the reservoir 16 via the pipe 18 and supplies it to a horizontal cylindrical container or pipe 52 which
 15 is provided with a diffuser or pressure relief valve 54 at the other end. Water passing through the valve 54 is collected in the settling tank 14. The pressure which builds up in the container or pipe 52 is sufficient to collapse the gas vesicles inside the cells of the
 20 cyanobacteria which then sink to the bottom of the settling tank 14. Lastly a combination of the constructions shown in Figure 3 and 4 is possible.

Whilst the above constructions have been described in connection with the treatment processes
 25 for public water it will be appreciated

that the same method and apparatus could be used to decrease the amount of cyanobacteria that contain gas vesicles in natural lakes or other water impoundments, and thereby to improve the water quality. In this case

5 the pressure-treated water is returned to the lake either directly from the bore-hole, in which case the cyanobacteria will settle out on the lake bottom, or after removing the cyanobacteria by sedimentation in a settling tank. The preferred method would be to withdraw

10 water from a particular depth at one end of the lake and to return it after treatment to the lake at another depth at a point remote from the withdrawal site, so as to minimize mixing of the treated and untreated water.

Regard would be paid to the patterns of water circulation

15 in the lake so that withdrawal occurred at a site, such as at lee shores, where the cyanobacteria tended to accumulate.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A method of treatment of water to remove gas
5 vacuolate cyanobacteria which includes the steps of:
hydrostatically subjecting the water removed from a body of
water to a predetermined pressure of at least 3 bar in order
to collapse the gas vesicles inside the cells of the
cyanobacteria; and separating the thus treated cyanobacteria
10 by allowing them to sink to the bottom of settlement means
along with any other sediment in the water.

2. A method according to claim 1, wherein said
predetermined pressure is in the range of 3 to 10 bar.

3. A method according to claim 1, wherein said
predetermined pressure is approximately 6 bar.

4. Apparatus for the treatment of water to remove gas
20 vacuolate cyanobacteria which float on the surface of the
water, said apparatus comprising:

 pump means for extracting the water to be treated
from a reservoir;

 a steel lined bore-hole sunk into the ground;

25 a centrally located vertical pipe contained within
said bore-hole, the lower end of which is open and located a
short distance above the bottom of the bore-hole;

 pipe means for connecting the top of said



centrally located pipe to the outlet of said pump means,
the depth of said bore-hole being sufficient to enable the
natural hydrostatic head of water contained with said
centrally located pipe to provide sufficient pressure to
5 collapse the gas vesicles inside the cells of the
cyanobacteria;

a settling tank located adjacent said bore-hole;
and pipe means connecting the top of the bore-hole
with the settling tank to convey water which has passed
10 down the centrally located pipe to the settling tank,
whereby the collapsed gas vacuolate cyanobacteria settle at
the bottom of the settling tank thus providing an output of
water from the settling tank which is free of gas vacuolate
cyanobacteria.

15 5. Apparatus according to claim 4, wherein the depth
of the bore-hole lies in the range of 31m to 102m.

20 6. Apparatus according to claim 4, wherein said
pressure at the bottom of the bore-hole provided by the
hydrostatic head of water is in the range of 3 to 10 bar.

25 7. Apparatus according to claim 4, wherein said
pressure at the bottom of the bore-hole provided by the
hydrostatic head of water is approximately 6 bar.

8. Apparatus according to any one of the preceding
claims 4 to 7, wherein substantially the total pressure



applied to collapse the gas vacuolate cyanobacteria comes from the bore-hole and the natural hydrostatic head of water contained with said centrally located pipe.

- 5 9. Apparatus for the treatment of water to remove gas vacuolate cyanobacteria which float on the surface of the water, said apparatus comprising:

pump means for extracting the water to be treated from a reservoir;

- 10 a tower having inlet means at the top connected to the outlet of the pump means and outlet means at the bottom;

a steel lined bore-hole sunk in the ground;

a pipe extending vertically down the central zone of said bore-hole;

- 15 a pipe means connecting the outlet means of the tower to the top of the pipe extending down the bore-hole;

outlet means at the top of the bore-hole; and

- 20 a settling tank connected to receive water from the outlet means of the bore-hole; the combined height of the tower and depth of the bore-hole being sufficient to enable the natural hydrostatic head of water provided by said tower and bore-hole to provide sufficient pressure to collapse the gas vesicles inside the cells of the cyanobacteria, whereby the collapsed gas vacuolate

- 25 cyanobacteria settle at the bottom of the settling tank thus providing an output of water from the settling tank which is free of gas vacuolate cyanobacteria.



10. Apparatus according to claim 9, wherein said hydrostatic head provided by the combined height of the tower and depth of the bore-hole is 60m to provide a pressure of 6 bar.

5

11. Apparatus according to claim 9 or 10, wherein substantially the total pressure applied to collapse the gas vacuolate cyanobacteria comes from the bore-hole and the natural hydrostatic head of water contained with said centrally located pipe.

10

Dated this 30 day of November 1989

EAST ANGLICAN WATER COMPANY & ANTHONY EDWARD WALSBY

Patent Attorneys for the Applicant:

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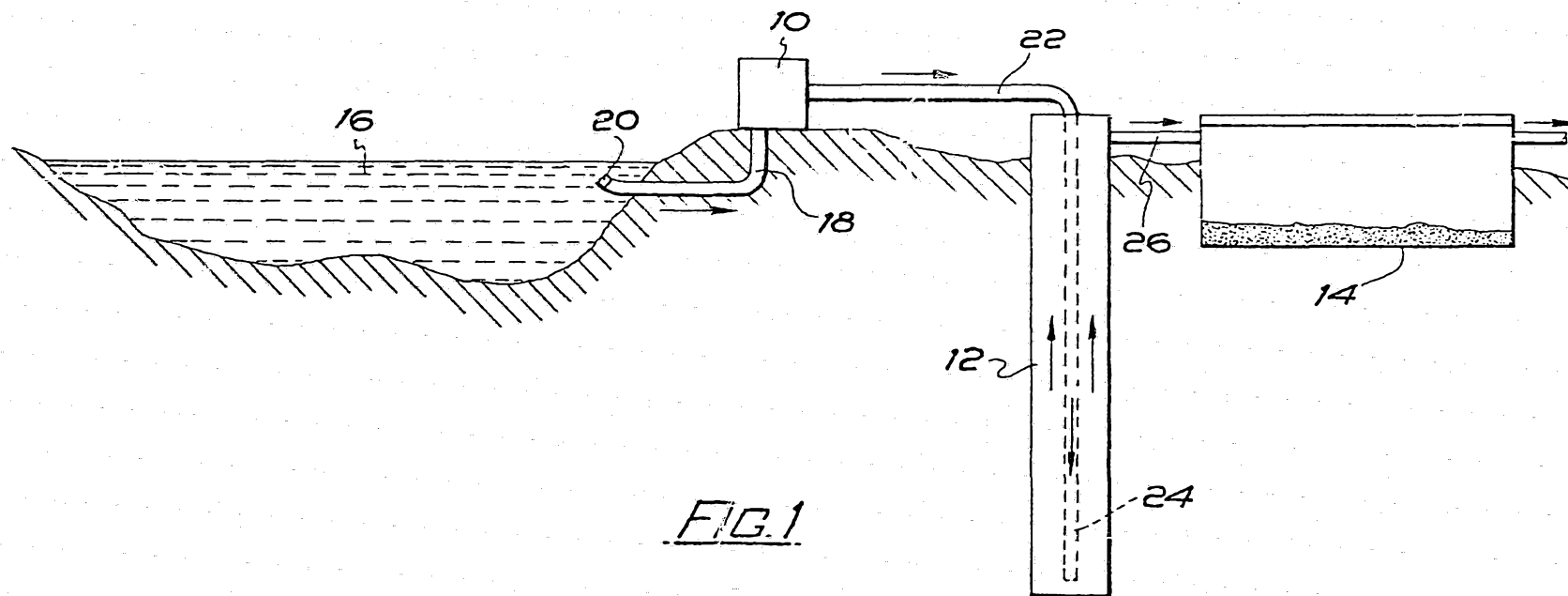


FIG. 1

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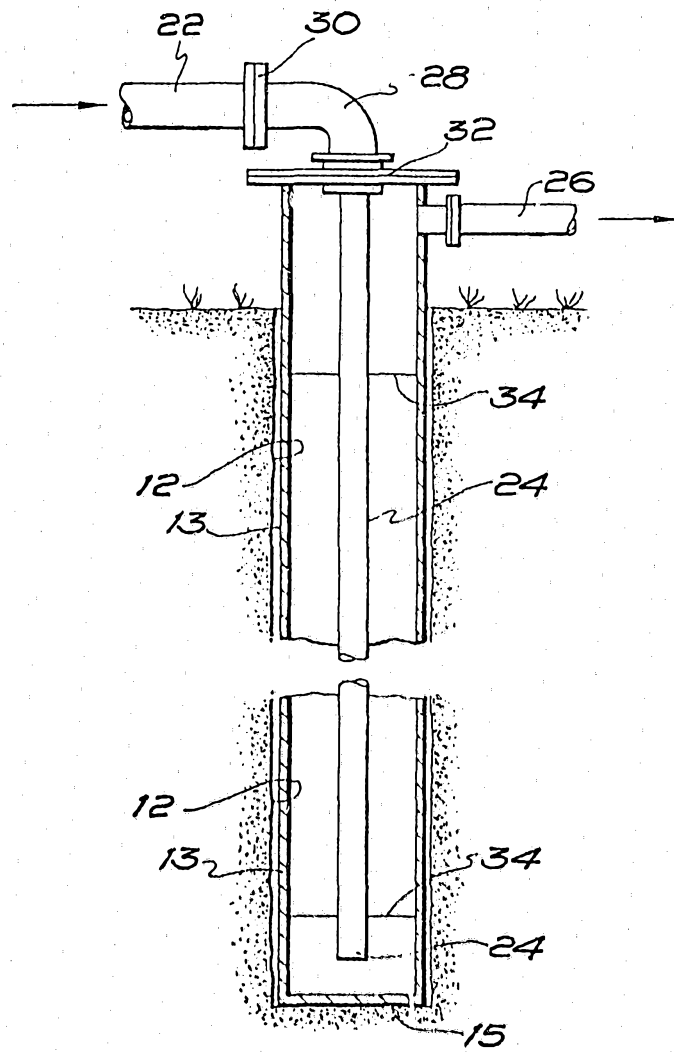


FIG. 2.

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