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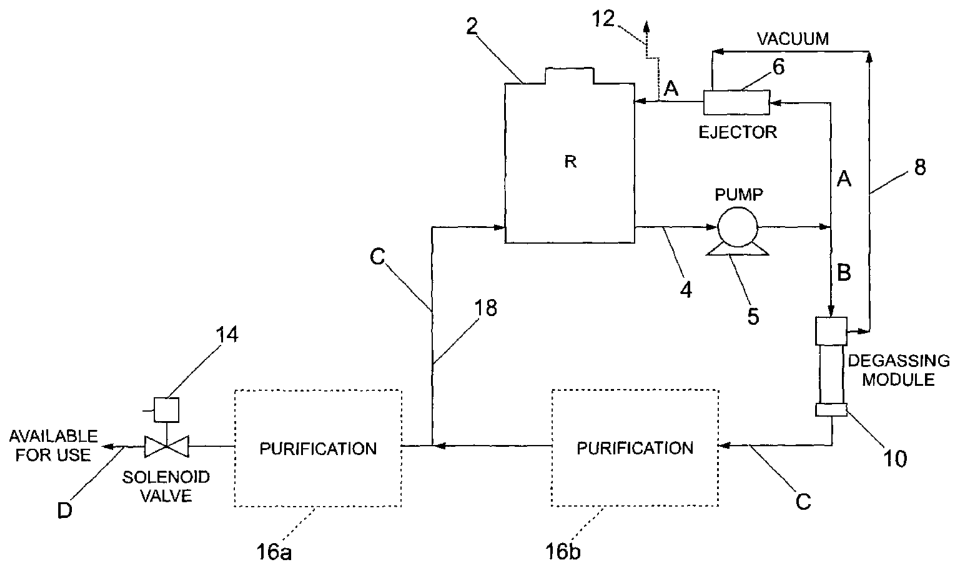
(54) **Title:** IMPROVEMENTS RELATING TO DEGASSING LIQUIDS



(57) **Abstract:** A method of degassing a liquid. Comprising the steps of: (a) drawing liquid from the reservoir/volume to form a degassing stream (4B); (b) using a vacuum to degas the degassing stream; and (c) wholly, substantially or partly returning the vacuum-forming stream A to the reservoir/volume. The effect of the present invention is to provide a system in dynamic equilibrium, in which a stream of liquid is degassed, made available for use and, if not required, re-mixed with a second stream. Thus, a volume of degassed liquid such as water is immediately available on demand; water savings are created compared with operating a separate water as a vacuum-forming (a) supply to power the ejector (6).

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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IMPROVEMENTS RELATING TO DEGASSING LIQUIDS

The present invention relates to methods and apparatus for degassing liquids, particularly but not exclusively water.

For certain uses, it is necessary or desired to reduce the dissolved gas content of liquids where the presence of reactive gases such as oxygen or carbon dioxide might interfere with a chemical reaction or physical properties, or where the release of gas bubbles into a liquid stream might affect volumes and flows. For example, clinical analysers.

Dissolved gases can be removed by exposing large surface areas of the liquid to a vapour phase deficient in the gases to be removed. This is conveniently done by flowing the liquid past a suitable membrane with a vacuum applied to the other side. One method for doing this is shown in EP0535607A2, which describes a system for degasifying water. A high pressure waste water stream is passed through an ejector to produce a vacuum, which vacuum is used to degasify a pure water stream. The waste water is discarded and the degasified water is provided as a constant stream.

It is an object of the present invention to improve the degassing system.

Thus, according to one aspect of the present invention, there is provided a method of degassing a volume of liquid comprising the steps of:

(a) drawing liquid from the volume to form a degassing stream;

(b) using a vacuum to degas the degassing stream; and

(c) wholly, substantially or partly returning the degassing stream to the volume.

Preferably, the vacuum to degas the degassing stream is generated by a vacuum-forming stream, which is also drawn from the volume.

The liquid can be drawn from the volume and/or circulated through the system using any suitable means, generally one or more pump means. The vacuum-forming stream and degassing stream could be separately drawn from the volume, or divided from one stream.

After degassing, the degassed stream could be made immediately available for use, possibly through one or more valves. Alternatively, the degassed stream could undergo further treatment or purification, if required, by one or more means known in the art such as deionisation, UV irradiation or filtration.

The volume preferably is or at least includes a reservoir or other liquid holding means. The degassed stream is preferably wholly, substantially or partly returned to any such reservoir.

The method could include a path for some or all of the vacuum-forming stream to return to the volume as a recirculation loop.

The method could be operated continuously or intermittently.

The rate of flow of each stream, including any recirculation loops, depends upon the desired rate of takeoff of the degassed stream, and/or any rate of intermittent use, and the degree of degassing required.

The method preferably includes one or more locations or arrays able to hold a volume of degassed liquid ready for immediate use, e.g. 5 or 10 litres. Thus, a certain volume of liquid is available 'on demand'. Such locations or arrays include purification units or other tanks, etc, generally being closed to atmosphere or similar.

The pump(s) are preferably used to maintain a certain level of degassed liquid in a recirculating flow, and/or in a location immediately available for use. Liquid to make up for that removed may be added at any part of the volume or circuit, but is preferably added to any reservoir or pump.

The part of any vacuum-forming stream being returning to the volume will be super-saturated with the removed gases (from the degassing stream). Upon its return to the volume, time will provide the possibility of equilibration with the surrounding atmosphere to lose some or all of the excess gas. Other gas-removal methods could also be used, including catalytic nucleation, membranes, thermal effects, or contact with inert gases. If there is a requirement for greater degassing, the returning vacuum-forming stream could be wholly or partly diverted, e.g. to a drain, to reduce the level of gas returning into the volume.

Preferably, the part of the degassed stream being recirculated to a reservoir enters the reservoir at or near the base of the reservoir, and/or near the degassing stream outflow. Thus, the degassing stream outflow should at least partly include some of the incoming degassed stream, thereby using an already partly degassed flow.

Similarly, the part of any vacuum-forming stream being recirculated to the volume preferably enters the volume at a point distal to the outflow of the liquid drawn to form the degassing stream, such as at or near the top of the reservoir, so as to lessen the use of this stream, being super-saturated, in the degassing stream outflow.

The vacuum-forming stream may be directly or indirectly circulated to the volume. Indirect circulation may include one or more degassing or 'de-supersaturation' treatment steps as previously discussed.

According to a second aspect of the present invention, there is provided apparatus for degassing a liquid comprising a means to hold a volume of liquid, means for drawing liquid from the volume, means to provide a degassing-stream from said drawn liquid, means for providing a vacuum, means for degassing the degassing stream using the vacuum, wherein the apparatus includes means able to wholly, substantially or partly return the degassed stream to the volume.

Preferably, the apparatus includes means for drawing liquid to provide a vacuum-forming stream, which vacuum-forming stream generates the vacuum to degas the degassing stream, and possibly includes means able to wholly, substantially or partly return the vacuum-forming stream to the volume means. The volume means may be a reservoir or similar liquid holding means, and the means for drawing liquid may be one or more pumps.

In particular, the apparatus of the present invention for degassing water comprises a reservoir to hold the water, a pump to draw the water from the reservoir, a first water circuit providing a degassing stream from the pump, a second water circuit providing a vacuum-generating stream from the pump, wherein the first circuit includes a degassing module for degassing the water, a degassed water take-off point, a water take off point and a return to the reservoir, and the second circuit includes an ejector to generate the vacuum for the degassing module.

The present invention is usable with any suitable liquid, including high and low-temperature liquids and solvents. One liquid is water.

An embodiment of the present invention will now be described by way of example only and with reference to the accompanying drawing and graphs in which;

Figure 1 shows a scheme for the system of the present invention; and

Figures 2 to 7 are graphs illustrating aspects of the invention.

Referring to the drawing, Figure 1 shows a reservoir 2 holding a volume of water to be degassed. The water may already have undergone one or more purification operations.

The reservoir 2 has an out-flow 4 to a pump 5. The outflow from the pump 5 is then divided between a vacuum-forming stream A and a degassing stream B. The vacuum-forming stream A provides the motive power for an ejector 6. The ejector 6 is used to produce a vacuum, which vacuum is directed through a vacuum line 8, having at its other end, a degassing module 10.

The degassing stream B passes through the degassing module 10, and the vacuum on the degassing module 10 reduces the dissolved gas content of the stream B to form a degassed stream C.

The operation of the pump 5, ejector 6 and degassing module 10 are known in the art.

The flow of the vacuum-forming stream A after the ejector 6 is returned to the reservoir 2. The return stream A is supersaturated with the removed gasses, and is preferably given the possibility of equilibrating with the surrounding atmosphere to lose some of the excess gas. If necessary, some or all of the returning vacuum-forming stream could be taken through line 12 to a separate location or to a drain to reduce the returning level of gassified water into the reservoir 2. This assists the provision of higher than 'normal' degassed-water if desired or necessary. Other degassing of the super-saturated stream is possible.

Meanwhile, the degassed steam C is available for use through a means such as a solenoid valve 14. Stream C may also undergo further treatment of purification (16), if desired or necessary.

Stream C may also be wholly or partly recirculated back into the reservoir 2 via line 18. Stream C is preferably returned to the bottom of the reservoir 2 to minimise re-solution of gasses from the atmosphere. In practice, it has been found that with water as the fluid, the dissolved oxygen content of the re-circulated water from stream C is decreased.

The split of water between streams A and B is designed such that the flow in stream A is sufficiently great to provide a high and sufficient level of degasification. If necessary, this flow can be reduced when water is being dispensed or otherwise taken off.

Suitable-sized vessels could be included in the circuit to provide the required volume of degassed water. This can be conveniently and economically achieved by positioning some or all of any other purification technologies (16) between the degassing module and the take-off point (D).

As degassed stream C is removed from the system, it may be replaced in the reservoir 2 by water with a higher level of dissolved gas. The present invention uses the release of excess gas from the returning stream A, as described above, to maintain the overall gas content at levels consistent with producing an adequately degassed product stream C. If there is a higher liquid purity requirement, returning stream A could periodically be diverted to drain as described above.

The overall system could be operated on an intermittent basis such as for five minutes every 30 minutes, to minimise energy consumption. The design will permit the maintenance of sufficient volumes of degassed water available for use with no additional delays over the time necessary to restart the pump.

In general, the overall effect of the present invention is to provide a system in dynamic equilibrium, in which a stream of liquid is degassed, made available for use, and, if not required, remixed with a second stream which contains some or all of the gasses which have been removed from the first stream. The general advantages of this arrangement are, firstly, a volume of degassed liquid such as water, is immediately available on demand. Secondly, a vacuum pump is not required, creating savings in energy, noise, cost and reliability. Thirdly, no external processes, such as a reverse osmosis step, need to be operating. Fourthly, water savings are created compared with operating a separate water supply to power the ejector.

Example 1

Using the arrangement shown in Figure 1, the following system was followed.

RESERVOIR R (2) 25 litre
EJECTOR (6) 1.0mm orifice
DEGASSING MODULE (10) Minntech LV-C-030-A
VOLUME (16B) 1.4 litre
VOLUME (16A) 0 litre
Dissolved oxygen content of feed is 9.0 ppm

There are two states of operation, recirculation and dispense. Flow rates are different in the two conditions.

In recirculation (valve 14 closed)

Flow A is 1.2 litre/min
Flow B is 0.5 litre/min
Flow C (line 18) is 0.5 litre/min
Vacuum (line 8) is -0.90 Bar gauge (0.1 Bar absolute)
Dissolved oxygen content of C is 1.1 to 2.0 ppm

In dispense (valve 14 open)

Flow A is 0.7 litre/min
Flow B is 1.0 litre/min
Flow C (line 18) is 0 litre/min
Vacuum (line 8) is -0.65 Bar gauge (0.1 Bar absolute)

Dissolved oxygen content of C is 2.0 to 5.0 ppm
Dispense flow (D) is 1.0 litre/min.

Figures 2 to 7 provide graphic information of test data using the arrangement in Figure 1. Figures 2, 4 and 6 show one cycle of the system with water being dispensed at a regular interval. Figures 3, 5 and 7 show several cycles for these conditions.

Figures 2 and 3 show the performance of a system as in example 1 where 1.5 litres of water were taken off every 7.5 minutes. Water was added to the reservoir R (2) to make up for that removed. The dissolved oxygen content of the water varied between a minimum of approximately 0.8 ppm and a maximum of 1.6 ppm through the dispense cycle.

Figures 4 and 5 show the same system with the same dispense but with a longer time between dispenses of 20 minutes. The extra time for recalculation and degassing prior to dispense resulted in the dissolved oxygen content being reduced to 0.35 ppm. Further recalculation could result in even lower dissolved oxygen values.

Figures 6 and 7 show data from the same system with a similar time between dispenses but with significantly larger dispense volumes. Initially the dissolved oxygen levels are low, but once the volume of the purification volume (16B) has been exceeded dissolved oxygen levels increase but remain at a level below that of the feed water.

Figures 2 to 7 confirm the benefits of the present invention, in that a volume of a liquid such as water can be provided 'on tap' with a reduced dissolved gas content, irrespective of any prior withdrawal or a static output situation. The present invention provides a simple and elegant arrangement able to always provide reduced dissolved gas content liquid in situations where demand can be variable.

Claims

1. A method of degassing a volume of liquid comprising the steps of:

(a) drawing liquid from the volume to form a degassing stream;

(b) using a vacuum to degas the degassing stream; and

(c) wholly, substantially or partly returning the degassing stream to the volume.

2. A method as claimed in Claim 1 further comprising the steps of drawing liquid from the volume to form a vacuum-forming stream, and using the vacuum-forming stream to generate the vacuum to degas the degassing stream.

3. A method as claimed in Claim 2 which further comprises the step of returning at least some of the vacuum-forming stream to the volume after degassing.

4. A method as claimed in any one of Claims 1 to 3 wherein the liquid is drawn from the volume using a pump.

5. A method as claimed in any one of Claims 2 to 4 wherein the vacuum-forming stream and degassing stream are drawn separately from the volume.

6. A method as claimed in any one of Claims 2 to 4 wherein the vacuum-forming stream and degassing stream are drawn together from the volume and then divided into the two streams.

7. A method as claimed in any one of the preceding Claims wherein after degassing, the degassed stream undergoes further treatment or purification.

8. A method as claimed in any one of the preceding Claims wherein the volume includes a reservoir.

9. A method as claimed in Claim 8 wherein the degassed stream is wholly, substantially or partly returned to the reservoir.

10. A method as claimed in Claim 9 wherein the degassed stream being returned to the reservoir enters the reservoir at or near its base.

11. A method as claimed in any one of the preceding Claims wherein the degassed stream being returned to the volume enters the volume at or near the outflow of the liquid drawn to form the degassing stream.

12. A method as claimed in any one of the preceding Claims wherein the liquid drawn from the volume for the degassing stream is at least partly some of the incoming degassed stream.

13. A method as claimed in any one of Claims 3 to 12 wherein the vacuum-forming stream being returned to the volume is wholly or partly degassed, de-supersaturated or both before being returned to the volume.

14. A method as claimed in any one of Claims 3 to 13 wherein the vacuum-forming stream being returned to the volume enters the volume at a point distal to the outflow of the liquid drawn to form the degassing stream.

15. A method as claimed in any one of the preceding Claims wherein at least some of the degassed stream flows through or is held by a separate reservoir so as to be available on demand.

16. A method as claimed in any one of Claims 2 to 15 wherein at least some of the returning vacuum-forming stream is diverted to a drain.

17. A method as claimed in any one of the preceding Claims wherein the method is continuous.

18. A method as claimed in any one of Claims 1 to 16 wherein the method is intermittent.

19. A method as claimed in any one of the preceding Claims wherein the liquid to be degassed is water.

20. Apparatus for degassing a liquid comprising a means to hold a volume of liquid, means for drawing liquid from the volume, means to provide a degassing-stream from said drawn liquid, means for providing a vacuum, means for degassing the degassing stream using the vacuum, wherein the apparatus includes means able to wholly, substantially or partly return the degassed stream to the volume.

21. Apparatus as claimed in Claim 20 wherein the means for drawing liquid also provides a vacuum-forming stream, which vacuum-forming stream generates the vacuum to degas the degassing stream.

22. Apparatus as claimed in Claim 21 which includes means able to wholly, substantially or partly return the vacuum-forming stream to the volume means.

23. Apparatus as claimed in any one of Claims 20 to 22 wherein the volume means is a reservoir.

24. Apparatus as claimed in any one of Claims 20 to 23 wherein the means for drawing liquid from the volume is one or more pumps.

25. Apparatus as claimed in any one of Claims 20 to 24 further comprising one or more means for separately holding at least some of the degassed liquid.

26. Apparatus as claimed in Claim 25, wherein at least one said means is a purification means.

27. Apparatus as claimed in any of Claims 20 to 26, wherein the means for providing a vacuum is an ejector.

28. Apparatus as claimed in any one of Claims 20 to 27 for degassing water comprising a reservoir to hold water, a pump to draw water from the reservoir, a first water circuit providing a degassing stream from the pump, a second water circuit providing a vacuum-generating stream from the pump, wherein the first circuit includes a degassing module for degassing the water, a degassed water take-off point, and a return to the reservoir, and the second circuit includes an ejector to generate the vacuum for the degassing module.

29. A method of degassing a liquid substantially as hereinbefore defined with reference to Figure 1.

30. Apparatus for degassing a liquid substantially as hereinbefore defined with reference to Figure 1.

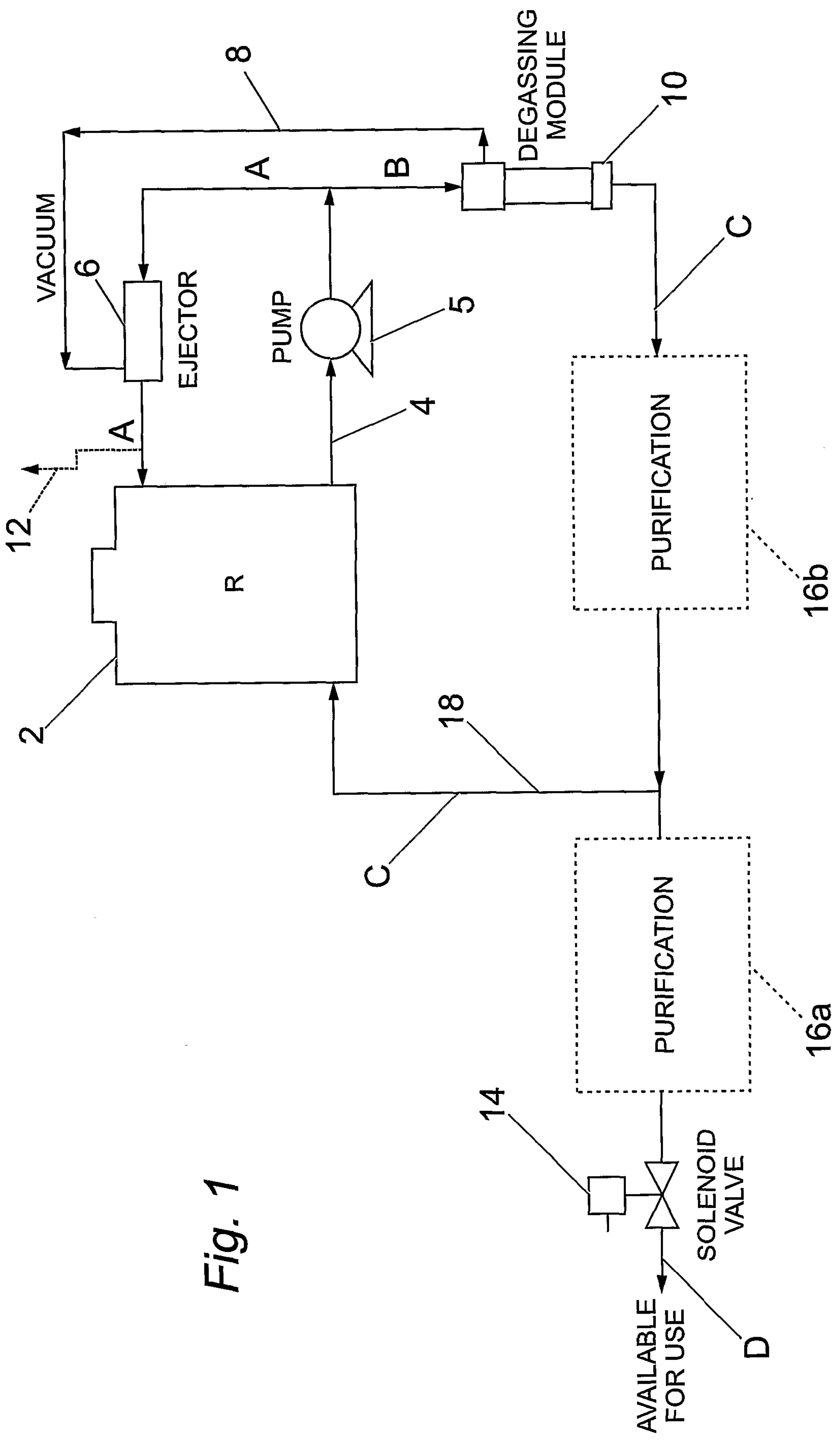

8
VACUUM
DEGASSING MODULE
10
A
B
6
EJECTOR
PUMP
5
C
A
4
12
R
PURIFICATION
16b
2
18
C
PURIFICATION
16a
14
SOLENOID VALVE
AVAILABLE FOR USE
D

Fig. 1

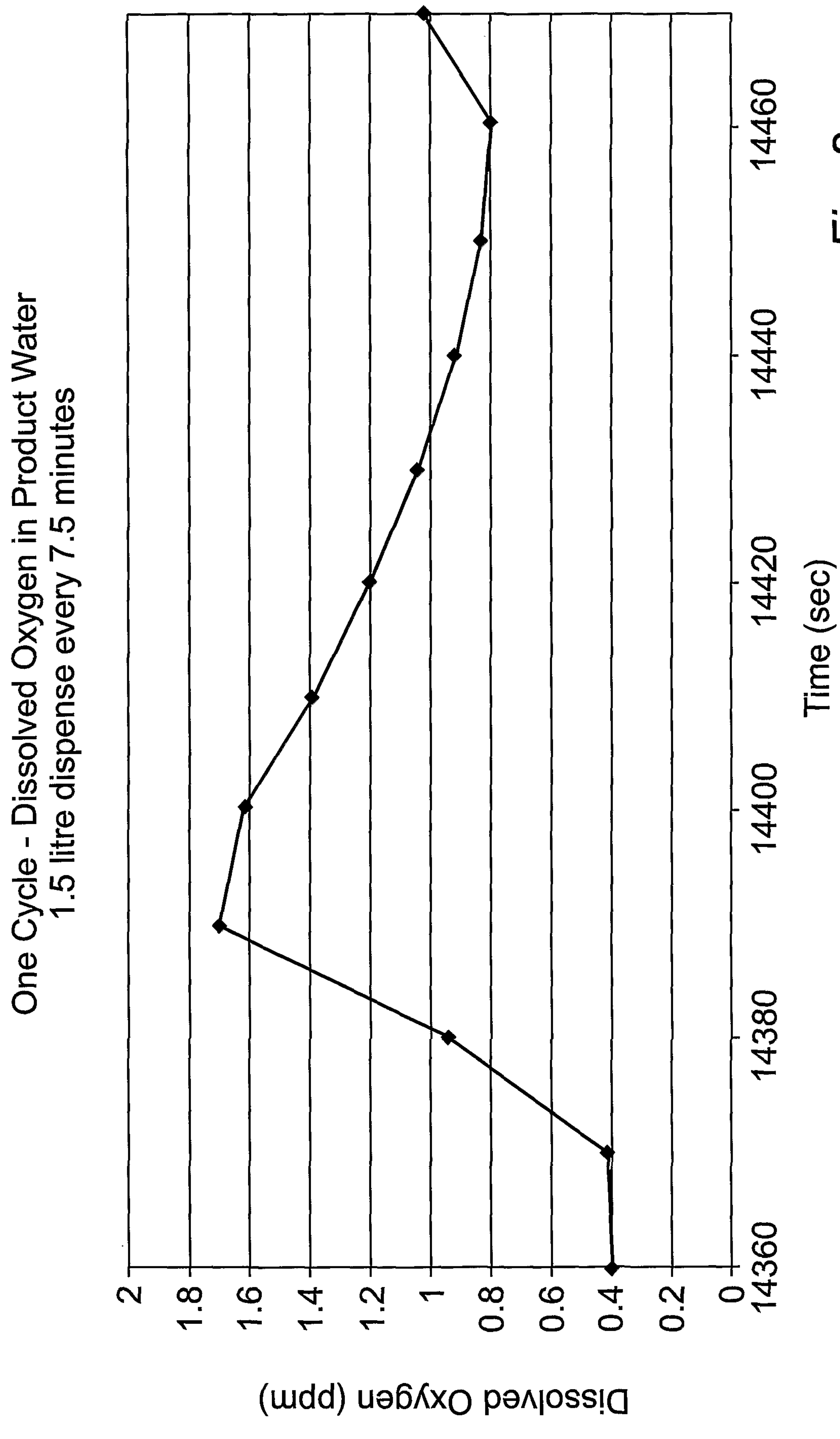

One Cycle - Dissolved Oxygen in Product Water
1.5 litre dispense every 7.5 minutes
Dissolved Oxygen (ppm)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
14360
14380
14400
14420
14440
14460
Time (sec)

Fig. 2

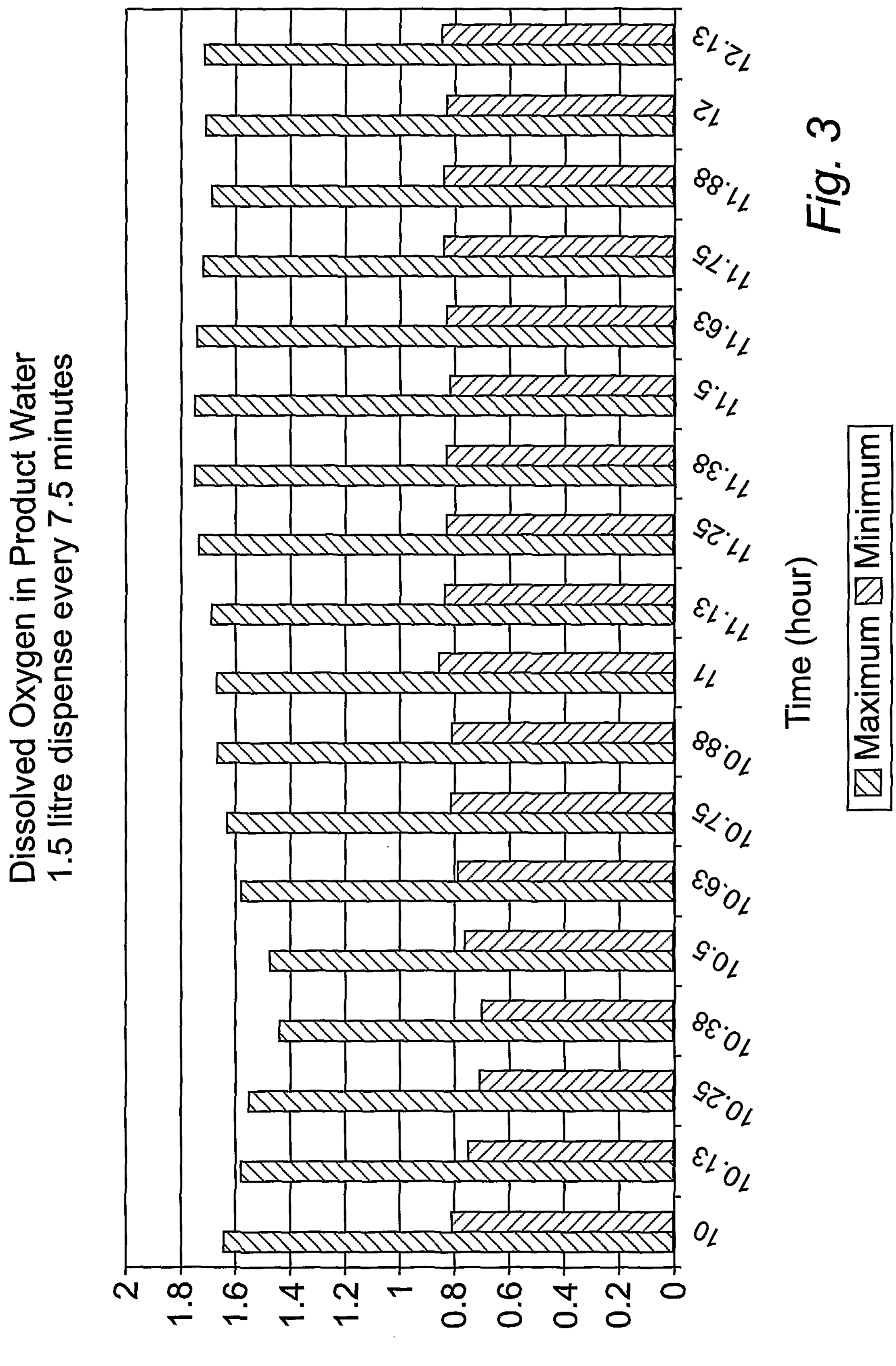

Dissolved Oxygen in Product Water
1.5 litre dispense every 7.5 minutes
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10
10.13
10.25
10.38
10.5
10.63
10.75
10.88
11
11.13
11.25
11.38
11.5
11.63
11.75
11.88
12
12.13
Time (hour)
Maximum
Minimum

Fig. 3

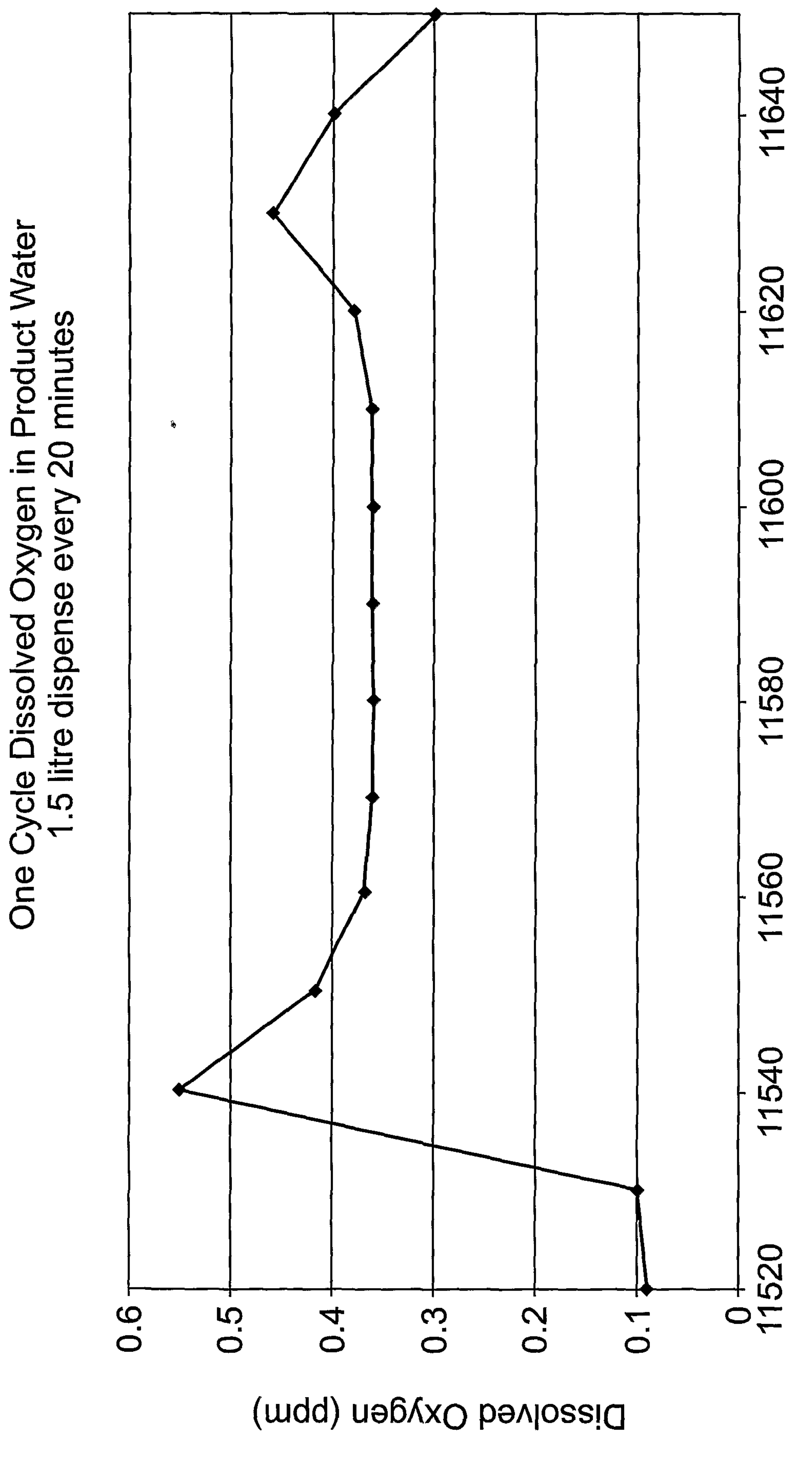
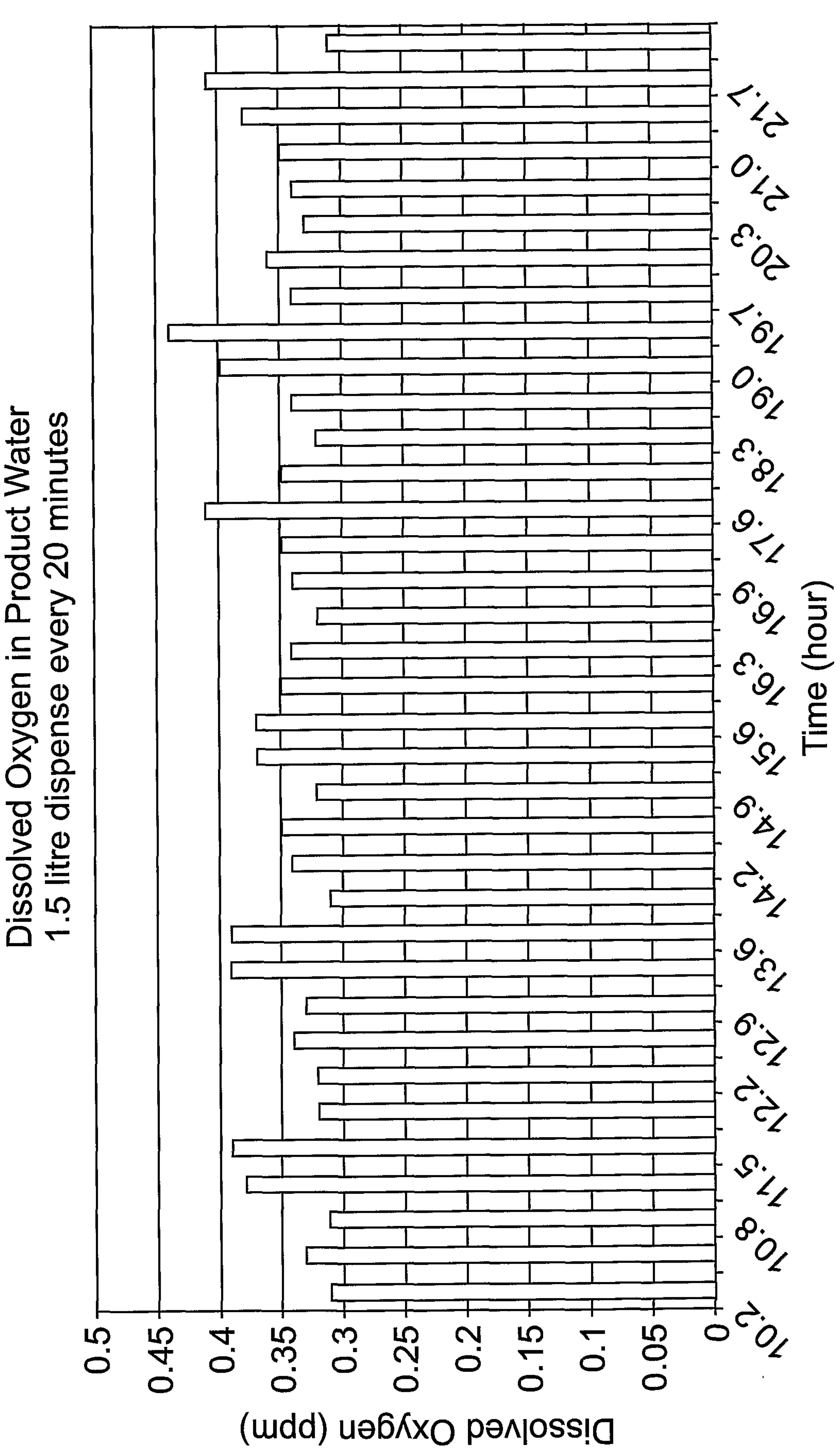
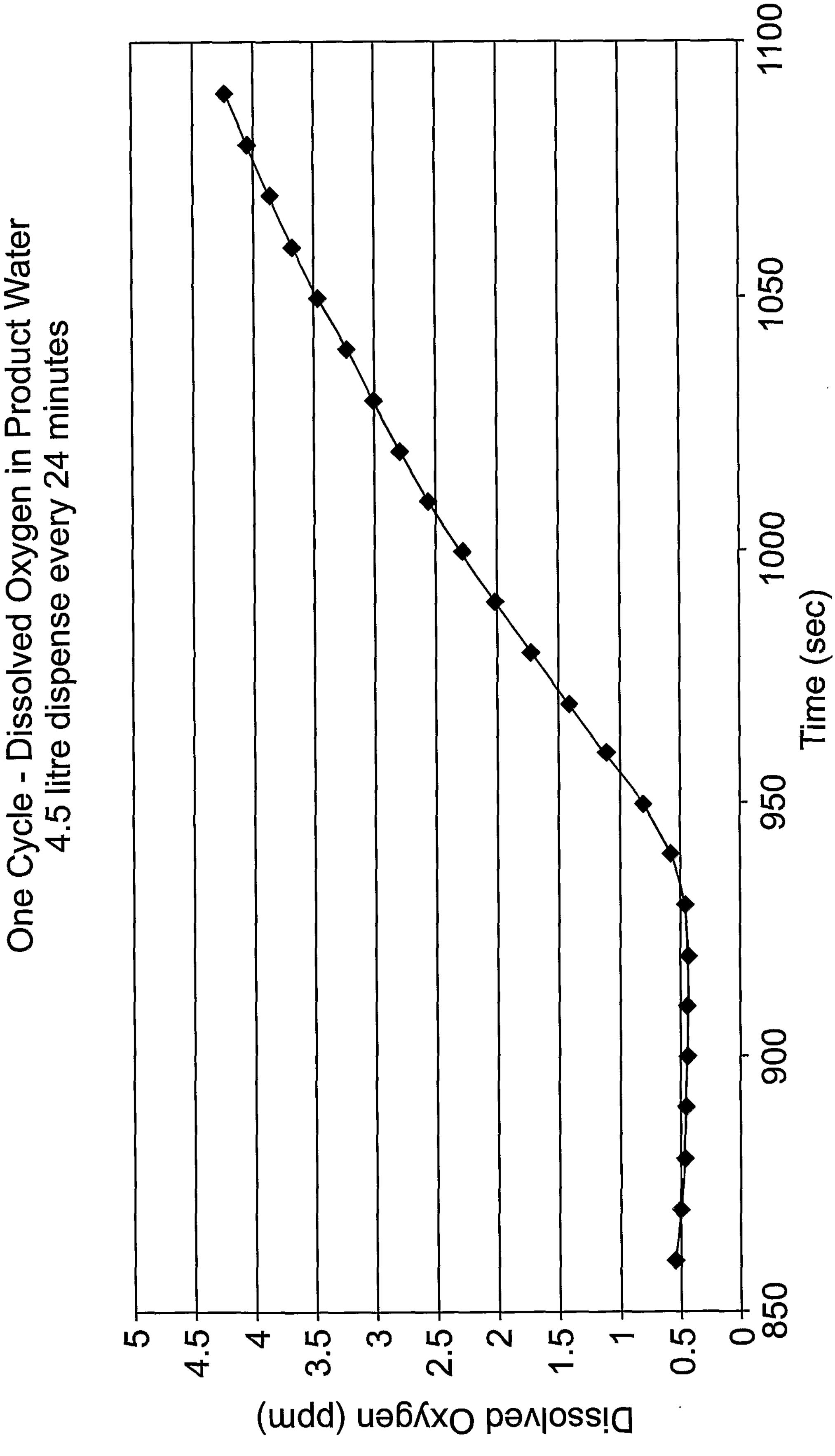

One Cycle Dissolved Oxygen in Product Water
1.5 litre dispense every 20 minutes
Dissolved Oxygen (ppm)
0.6
0.5
0.4
0.3
0.2
0.1
0
11520
11540
11560
11580
11600
11620
11640
Time (sec)

Fig. 4



Dissolved Oxygen in Product Water
1.5 litre dispense every 20 minutes
Dissolved Oxygen (ppm)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10.2
10.8
11.5
12.2
12.9
13.6
14.2
14.9
15.6
16.3
16.9
17.6
18.3
19.0
19.7
20.3
21.0
21.7
Time (hour)

Fig. 5



One Cycle - Dissolved Oxygen in Product Water
4.5 litre dispense every 24 minutes
Dissolved Oxygen (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
850
900
950
1000
1050
1100
Time (sec)

Fig. 6

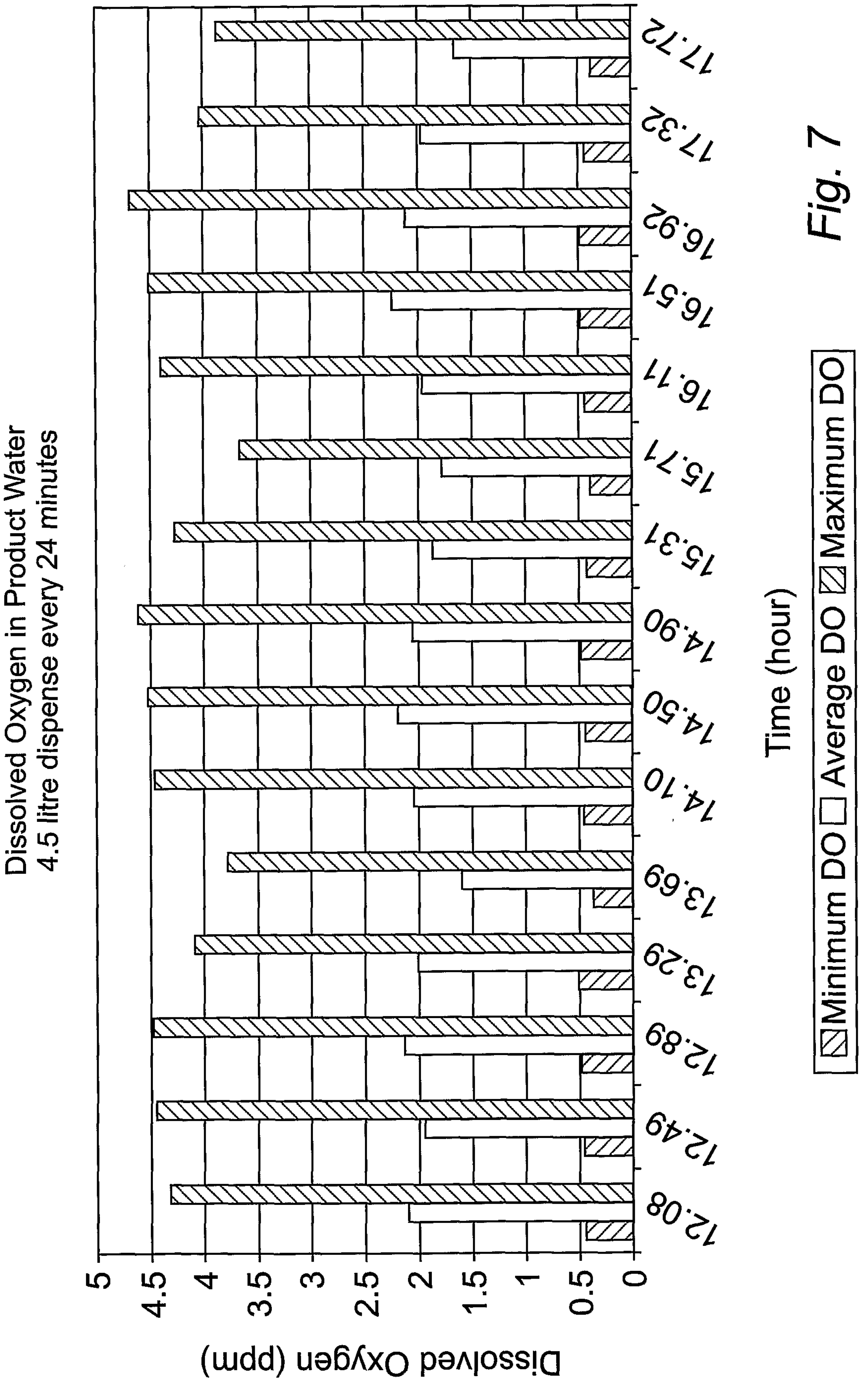

Dissolved Oxygen in Product Water
4.5 litre dispense every 24 minutes
Dissolved Oxygen (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
12.08
12.49
12.89
13.29
13.69
14.10
14.50
14.90
15.31
15.71
16.11
16.51
16.92
17.32
17.72
Time (hour)
Minimum DO
Average DO
Maximum DO

Fig. 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/02447

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D19/00 C02F1/20

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)
IPC 7 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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 029 405 A (THIBONNET JEAN PIERRE) 23 October 1970 (1970-10-23)	1-4,6,8, 13-18, 20-30
A	the whole document	19
X	US 3 783 108 A (SAARI R ET AL) 1 January 1974 (1974-01-01) figures	1-4,7, 15-17, 19-22, 24-30
X	EP 0 240 427 A (KHALFI HABIB) 7 October 1987 (1987-10-07) column 2, line 47 - line 55 column 4, line 25 - line 43; figures 4,8	1-5, 20-22, 24-27, 29,30

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 September 2002	07/10/2002

Name and mailing address of the ISA	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	Van Belleghem, W

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/02447

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 416 499 C (ATLAS WERKE AKT GES FA) 21 July 1925 (1925-07-21) the whole document	1,9,12
A	DE 483 213 C (ATLAS WERKE AKT GES) 2 October 1929 (1929-10-02) the whole document	1,9-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 02/02447

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
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			EP	0240427 A2	07-10-1987
			JP	62241591 A	22-10-1987
DE 416499	C	21-07-1925	NONE		
DE 483213	C	02-10-1929	NONE		