P-71

P/00/008
Section 29(1)
Regulation 3.1(2)

AUSTRALIA
Patents Act 1990

NOTICE OF ENTITLEMENT

We TECHNOLOGICAL RESOURCES PTY LTD
A.C.N. 002 183 557
of 55 COLLINS STREET, MELBOURNE, VIC 3000, AUSTRALIA

- and -

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION
of LIMESTONE AVENUE, CAMPBELL, ACT 2601, AUSTRALIA

being the applicants and nominated persons in respect of an application for a patent for an invention entitled A NON-MECHANICAL VALVE (Application No. 51380/96), state the following:

1. The nominated persons have, for the following reasons, gained entitlement from the actual inventors:

   (i) The invention was made by inventor Gregory John HARDIE in the course of his employment with HISMELT CORPORATION PTY LTD

   (ii) HISMELT CORPORATION PTY LTD is a wholly owned subsidiary of RIO TINTO LIMITED (formerly CRA LIMITED), of 55 Collins Street, Melbourne, Victoria

   (iii) The invention was made by inventors Rod James DRY and Colin John BEEBY in the course of their employment with COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANISATION

   (iv) The invention was made pursuant to the terms of an Agreement between CRA SERVICES LIMITED, of 55 Collins Street, Melbourne, Victoria and COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANISATION. The Agreement provides that CRA SERVICES LIMITED and COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANISATION shall jointly own the rights of the invention in Australia.

   (v) CRA SERVICES LIMITED is a wholly owned subsidiary of RIO TINTO LIMITED.

   (vi) TECHNOLOGICAL RESOURCES PTY LTD is entitled to hold all right title and interest of CRA SERVICES LIMITED in the invention by virtue of a policy decision of RIO TINTO LIMITED that TECHNOLOGICAL RESOURCES PTY LTD would hold in its name the property in inventions of RIO TINTO LIMITED Group Companies.

2. We are the applicant of the application listed in the declaration under Article 8 of the PCT.

3. The basic application listed in the declaration under Article 8 of the PCT is the first application made in a Convention country in respect of the invention.

27.11.97

IAN LESLIE FALCONER
Company Secretary
TECHNOLOGICAL RESOURCES PTY LTD

Date

2/12/97

JOHN GRAEME BLAIR
Authorised Signatory of
COMMONWEALTH SCIENTIFIC AND
INDUSTRIAL RESEARCH ORGANISATION

Date

AU9651380

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A NON-MECHANICAL VALVE

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(71) Applicant(s)
TECHNOLOGICAL RESOURCES PTY. LIMITED; COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANISATION

(72) Inventor(s)
GREGORY JOHN HARDIE; ROD JAMES DRY; COLIN JOHN BEEBY

(74) Attorney or Agent
GRIFFITH HACK , GPO Box 1285K, MELBOURNE VIC 3001

(56) Prior Art Documents
FR 2267965
US 4281946
GB 2001862

(57) Claim

1. A non-mechanical valve for controlling the flow of fluidisable solids, the valve comprising:

(i) a pipe having an inlet for solids at one end and an outlet for solids at the other end, the pipe comprising two upstanding legs and a base section connecting together lower ends of the legs;

(ii) a means for introducing aeration gas into each of the legs to maintain fluidised flow of solids through the valve;

(iii) a means for adjusting the flow of aeration gas to the legs to control the flow of solids through the valve.

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(71) Applicant (*for all designated States except US*): TECHNOLOGICAL RESOURCES PTY. LIMITED [AU/AU]; 55 Collins Street, Melbourne, VIC 3000 (AU).

(71) Applicant (*for AU only*): COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANISATION [AU/AU]; Limestone Avenue, Campbell, ACT 2601 (AU).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): HARDIE, Gregory, John [AU/AU]; 77 Petra Street, East Fremantle, W.A. 6160 (AU). DRY, Rod, James [AU/AU]; 58 Cypress Avenue, Glen Waverley, VIC 3150 (AU). BEEBY, Colin, John [AU/AU]; 2 Lendor Court, Cheltenham, VIC 3192 (AU).

(74) Agent: GRIFFITH HACK & CO.; 509 St. Kilda Road, Melbourne, VIC 3004 (AU).

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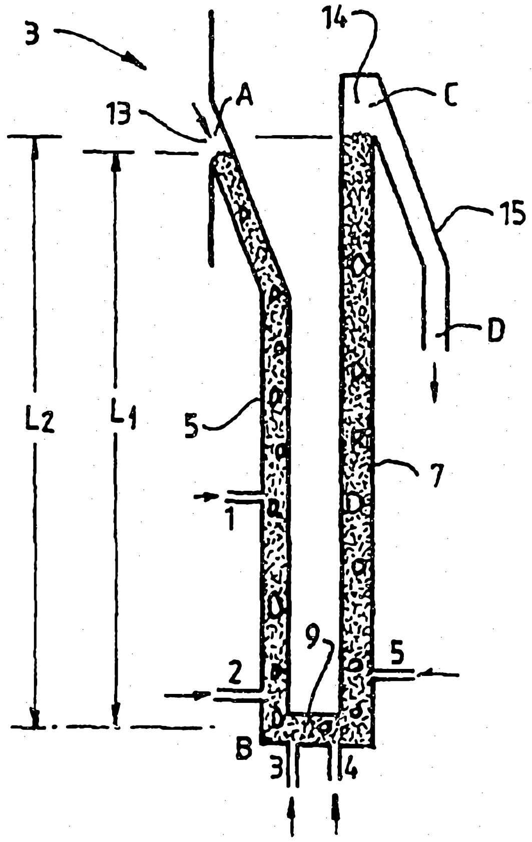
(54) Title: A NON-MECHANICAL VALVE

(57) Abstract

A non-mechanical valve (3) for controlling the flow of fluidisable solids is disclosed. The valve (3) comprises a pipe having an upstream leg (5) with a solids inlet (13) at an upper end, a downstream leg (7) with a solids outlet (14) at an upper end, and a base section (9) interconnecting lower ends of the legs (5, 7). The valve (3) further comprises a means for introducing aeration gas into each of the legs (5, 7) to maintain fluidised flow of solids through the valve (3) and a means for adjusting the flow of aeration gas to the legs (5, 7) to control the solids flow through the valve (3).



A NON-MECHANICAL VALVE

The present invention relates to a non-mechanical valve for fine-grained solids materials.

Controlled solids feed into and from a fluidised bed processing unit is often a dominant requirement for successful operation of the unit. Failure to achieve controlled solids flow can render the unit inoperable. Therefore, the development of a reliable solids handling system represents a strong economic leverage point in the development of a fluidised bed processing unit. The same applies to other types of processing unit (eg rotary kiln) which treat fluidisable materials, even if the solids are not fluidised whilst being treated.

In general, difficulties with solids handling are compounded by temperature effects. If the feed solids of a process are at (or close to) ambient temperature then conventional solids handling strategies can be applied with modest risk. For a low-temperature (i.e. less than 750°C) fluidised bed process mechanical valves can be employed for controlled removal of solids provided the fluidised bed material is not unduly sticky, chemically aggressive, or difficult to handle in terms of fouling of the valve mechanism.

The same is not true for solids removal from a fluidised bed process which operates at temperatures above 750°C. In this temperature range it is generally not advisable to use mechanical valves even though such valves are used in a number of industrial applications and in some cases with satisfactory results. In general, mechanical valves for hot solids applications need to be re-developed for each application and this is both time-consuming and costly. A further factor is that on-going maintenance is expensive. In the final analysis, if a simple non-mechanical alternative was available, it would be a preferable option to a mechanical valve.

Non-mechanical valves for fluidised beds have been reviewed in an article entitled "Non-mechanical Solids Feed and Recycle Devices for Circulating Fluidised Beds" by T.M. Knowlton published in the Proceedings of the Second International Conference on Circulating Fluidised Beds, Compiegne, France, 14-18 March 1988, pp 31-41. In discussing L-valves, J-Valves, and V-valves, T.M. Knowlton concludes that operation in "valve" mode (ie controlled solids flow) requires the presence of a defluidised, packed bed of solids. By way of example, in an L-valve a packed bed is formed in the horizontal section and aeration gas is admitted a short distance above the elbow. Gas drag through the packed bed causes the solids to move in the direction of discharge and the efflux rate is sensitive to how much gas flows through the packed bed in this manner. By modulating the amount of aeration gas it is possible to vary the discharge rate of solids.

This type of non-mechanical valve works well when the solids are coarse (sand-like) and non-sticky. However, any stickiness will result in the packed bed forming an immovable solid plug and the valve will cease to function. Conversely, if the solids are too fine (eg fluidised cracking catalyst), they will not defluidise fast enough to form a packed bed when required. As a consequence, solids flow through the valve will be high and uncontrolled. The valve may be turned off by stopping aeration gas flow, but the flow rate will return to a high-rate condition as soon as aeration is restarted. The result is a loss of flow-rate control and the valve functions only as an "on-off" device. If the de-aeration time of the solids is high enough (as is the case with high fines levels in the powder) then the flow of material will not stop at all when aeration gas is turned off.

T.M. Knowlton describes loopseals and seal-pots as "automatic" devices which do not have a solids flow control function. Most modern circulating fluidised bed (CFB) systems use loopseals for returning solids from the cyclone to the riser. Solids pass through a loopseal at whatever rate they approach the loopseal inlet and overall solids circulation rate control is achieved by other means. In this case the loopseal operates purely as a pressure balancing device, receiving solids from a CFB cyclone underflow at one pressure and delivering the solids to the bottom of the riser at a higher pressure. In this context, it can only operate correctly if the solids feed is "non-flooded", ie limited by an external constraint rather than by flow resistance within the loopseal itself. For a "flooded" solids feed application the loopseal would give an uncontrollably high solids discharge.

There is currently no suitable non-mechanical solids flow control valve for fine, hot powders which can form lumps if they are not fully fluidised at all times. The L-valve family of valves is unsuitable due to the need for a packed bed and the lack of control for fine powders. The loopseal and its relatives do not offer scope for flow modulation via aeration control.

An object of the present invention is to provide a non-mechanical valve that is not subject to the above described shortcomings and allows non-mechanical flow control for fine, sticky solids.

According to the present invention there is provided a non-mechanical valve for controlling the flow of fluidisable solids, the valve comprising:

(i) a pipe having an inlet for solids at one end and an outlet for solids at the other end, the pipe comprising two upstanding legs and a base section connecting together lower ends of the legs;

(ii) a means for introducing aeration gas into each of the legs to maintain fluidised flow of solids through the valve;

(iii) a means for adjusting the flow of aeration gas to the legs to control the flow of solids through the valve.

The term "pipe" is understood herein to mean any form of duct, of circular or non-circular cross-section, that is capable of conveying fluidisable solids.

It is preferred that the aeration gas introduction means comprises at least one aeration gas inlet in each leg.

It is preferred that the aeration gas introduction means comprises a means for delivering aeration gas to each aeration gas inlet.

It is preferred that the aeration gas introduction means comprises at least one aeration gas inlet in the base section.

It is preferred that the aeration gas delivery means be adapted to deliver aeration gas to the or each inlet in the base section.

The base section may be horizontal, angled or any other suitable geometry.

According to the present invention there is also provided a method of flow control of fluidisable solids by means of a non-mechanical valve comprising a pipe having a solids inlet and a solids outlet, the pipe comprising two upstanding legs and a base section connecting together lower ends of the legs, the method comprising:

(i) maintaining the valve flooded with solids;

(ii) injecting aeration gas into each leg to maintain solids flowing in the valve from the inlet to the outlet in a fluidised state; and

(iii) controlling aeration gas injection into the legs to control the flow of solids through the valve.

It is preferred that step (iii) comprises increasing or decreasing the flow of aeration gas into one leg compared with the other leg to control the flow of solids through the valve.

The present invention is described further by way of example with reference to the accompanying drawing, in which:

Figure 1 is a partly diagrammatic vertical section of a preferred embodiment of a non-mechanical valve of the present invention;

Figure 2 is a graph which shows the variation of pressure in the valve shown in Figure 1; and

Figure 3 is a partly diagrammatic vertical section of a graph illustrating the pressure variation for two non-mechanical valves of the type shown in Figure 1 having different depths.

With reference to Figure 1, the preferred embodiment of the non-mechanical valve 3 comprises a generally U-shaped pipe having two legs 5, 7 interconnected by a horizontal base section 9. The leg 5 includes a solids inlet 13 and the leg 7 includes a solids outlet 14 that is connected to a solids outlet chute 15.

The valve 3 further comprises:

(i) aeration inlets, Port 1 and Port 2, for introducing aeration gas into the leg 5;

(ii) aeration inlets, Port 3 and Port 4, for introducing aeration gas into the horizontal section 9; and

(iii) an aeration inlet, Port 5, for introducing aeration gas into the leg 7.

The valve 3 further comprises a means (not shown) for supplying aeration gas to each of the aeration inlets, Ports 1 to 5. The purpose of the aeration gas is to maintain solids in the valve 3 in a fluidised state and to allow the valve 3 to be operated on the principle of differential pressure gradients in each of the legs 5, 7 in order to control the flow of solids in the valve 3.

In accordance with this principle, solids entering solids inlet 13 at point A are kept fluidised as they pass down leg 5 to point B by gas from the aeration inlets Port 1 and Port 2. The fluidisation regime is such that gas bubbles/slugs pass upward from the elbow (point B) inside leg 5 toward point A, countercurrent to the passage of solids.

From point B the solids pass along the horizontal section 9 and then upwards in leg 7 to point C, again being kept fluidised by the aeration inlets Port 3, Port 4, and Port 5. The leg 7, viz point B to point C, operates with solids and gas bubbles/slugs flowing in co-current upflow. From point C the solids pass via the solids outlet chute 15 to the valve outlet at point D.

With reference to Figure 2, the pressure on solids in the valve 3 increases as the solids flow downwardly through leg 5 from point A to point B and thereafter decreases as the solids flow upwards through leg 7 from point B to point C. The slope of the lines shown in Figure 2, which determines the extent of pressure variation of the valve 3, is a function of the amount of aeration gas supplied to valve 3 via the Ports 1 - 5.

The control of solids flow is achieved by varying the amount of aeration gas supplied to each of the legs 5, 7. The extent of aeration in each leg 5, 7 determines the voidage, with an increase in aeration translating to a monotonic, predictable increase in time averaged voidage. Since pressure differential across a fluidised bed is a strong function of voidage, the driving force for solids to move through the valve 3 can be controlled directly by controlling the pressure differential.

Specifically, increasing the flow of aeration gas to leg 7 reduces the pressure gradient in leg 7 and therefore increases the driving force in upstream leg 5. As a consequence, there is an increased flow of solids through the valve 3. Furthermore, increasing the flow of aeration gas to leg 5 reduces the pressure gradient in leg 5 and therefore reduces the driving force in upstream leg 5. As a consequence, there is a decreased flow of solids through the valve 3.

The pressures at points A and D will generally not be the same. If points A and D are at the same pressure, then the length (L_1) of leg 5 and the length (L_2) of leg 7 will be approximately the same. Assuming that the diameters of the legs 5, 7 are the same, if point A is at a higher pressure than point D, then dimension L_1 will be longer (compared with the equal-pressure case) by an amount which corresponds to the height of fluidised bed needed to generate the difference in pressures. Furthermore, with the same assumption, if point A is at a lower pressure than point D, then dimension L_2 will be longer by the corresponding amount.

Control sensitivity of the system will be proportional to the depth of the valve 3, where "depth" is defined as the vertical distance over which the fluidised bed is common to both legs 5, 7. This can best be illustrated by reference to Figure 3 which shows two valves 3a, 3b of the type shown in Figures 1 and 2 of different depths and the same diameter for each leg 5, 7, and graphs of the variation of pressure along the length of each valve 3a, 3b. It can readily be appreciated from a comparison of the graphs that the pressure range of each valve 3 is directly proportional to the depth of the valve 3, with the valve 3b having the higher common length of legs 5, 7 have a higher pressure variation.

The pressure variation is an important parameter because it is an indication of the operating pressure range of the valve. Specifically, if the depth is insufficient, then the range over which the pressure driving force for solids flow can be varied is small. The result is a poor control range. In general it is desirable to operate the valve 3 of the type shown in Figures 1 to 3 with a fluidised bed depth greater than 1m, preferably greater than 3m.

The valve 3 has a significant self-stabilising feature which makes it particularly attractive for control purposes. If the valve 3 is at a stable flow condition and an external fluctuation causes solids flow rate into the valve 3 to increase, the response is a decline in pressure rise A-B and a corresponding increase in pressure drop B-C. The net driving force for solids to pass through valve 3 is thus decreased and solids flow rate is perturbated back toward its pre-upset condition. A mirror image of this operates when solids flow rate decreases into the valve 3. This self-stabilising feature imparts good operating characteristics and makes valve 3 well-suited for automatic flow control.

In order to evaluate valve 3, an industrial circulating fluidised bed system for iron ore pre-reduction was fitted with the valve 3. The valve 3 comprised a 200mm ID pipe with a 6m deep downflow leg 5 and a 6m long 150mm ID upflow leg 7. Aeration gas was added as shown in Figure 1. The pressure differential across the valve 3 was 5-10 kPa, with the solids inlet 13 to the valve 3 being at the higher pressure. Aeration rates were adjusted such that gas velocities in each of the two legs 5, 7 were in the range 0.1 to 0.5 m/s. Iron ore with an average particle size of 50 microns was used successfully in the valve 3.

Many modifications may be made to the preferred embodiment of the valve shown in the figures without departing from the spirit and scope of the present invention.

CLAIMS:

1. A non-mechanical valve for controlling the flow of fluidisable solids, the valve comprising:

(i) a pipe having an inlet for solids at one end and an outlet for solids at the other end, the pipe comprising two upstanding legs and a base section connecting together lower ends of the legs;

(ii) a means for introducing aeration gas into each of the legs to maintain fluidised flow of solids through the valve;

(iii) a means for adjusting the flow of aeration gas to the legs to control the flow of solids through the valve.

2. The valve defined in claim 1 wherein the aeration gas introduction means comprises at least one aeration gas inlet in each leg.

3. The valve defined in claim 2 wherein the aeration gas introduction means comprises a means for delivering aeration gas to each aeration gas inlet.

4. The valve defined in claim 3 wherein the aeration gas introduction means comprises at least one aeration gas inlet in the base section.

5. The valve defined in claim 4 wherein the aeration gas delivery means be adapted to deliver aeration gas to the or each inlet in the base section.

6. The valve defined in any one of the preceding claims wherein the base section is horizontal or

angled.

7. A method of flow control of fluidisable solids by means of a non-mechanical valve comprising a pipe having a solids inlet and a solids outlet, the pipe comprising two upstanding legs and a base section connecting together lower ends of the legs, the method comprising:

(i) maintaining the valve flooded with solids;

(ii) injecting aeration gas into each leg to maintain solids flowing in the valve from the inlet to the outlet in a fluidised state; and

(iii) controlling aeration gas injection into the legs to control the flow of solids through the valve.

8. The method defined in claim 7 wherein step (iii) comprises increasing or decreasing the flow of aeration gas into one leg compared with the other leg to control the flow of solids through the valve.

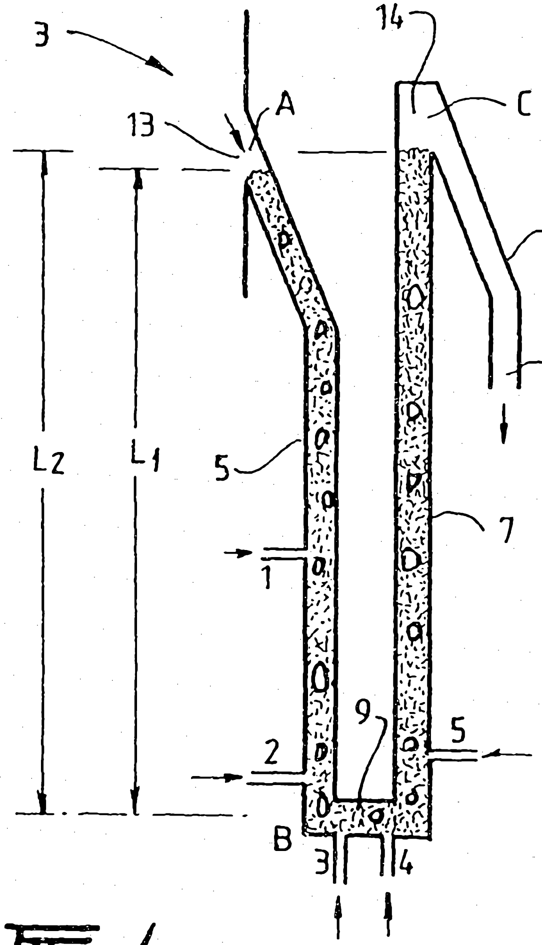


FIG. 1.

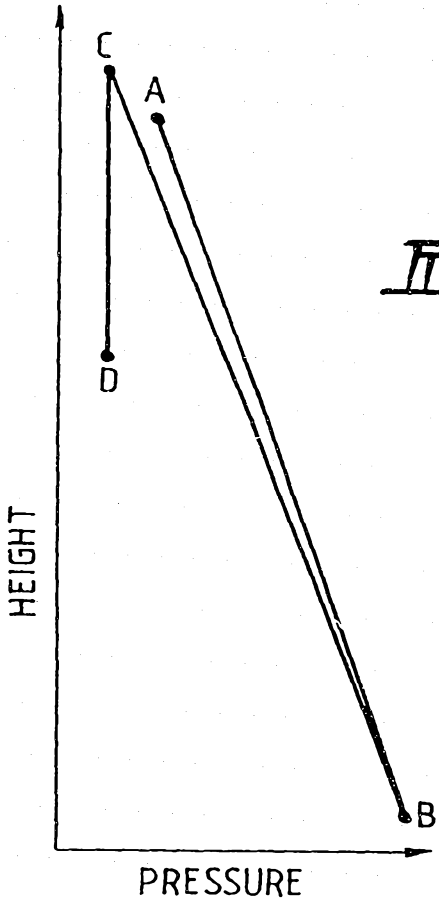


FIG. 2.

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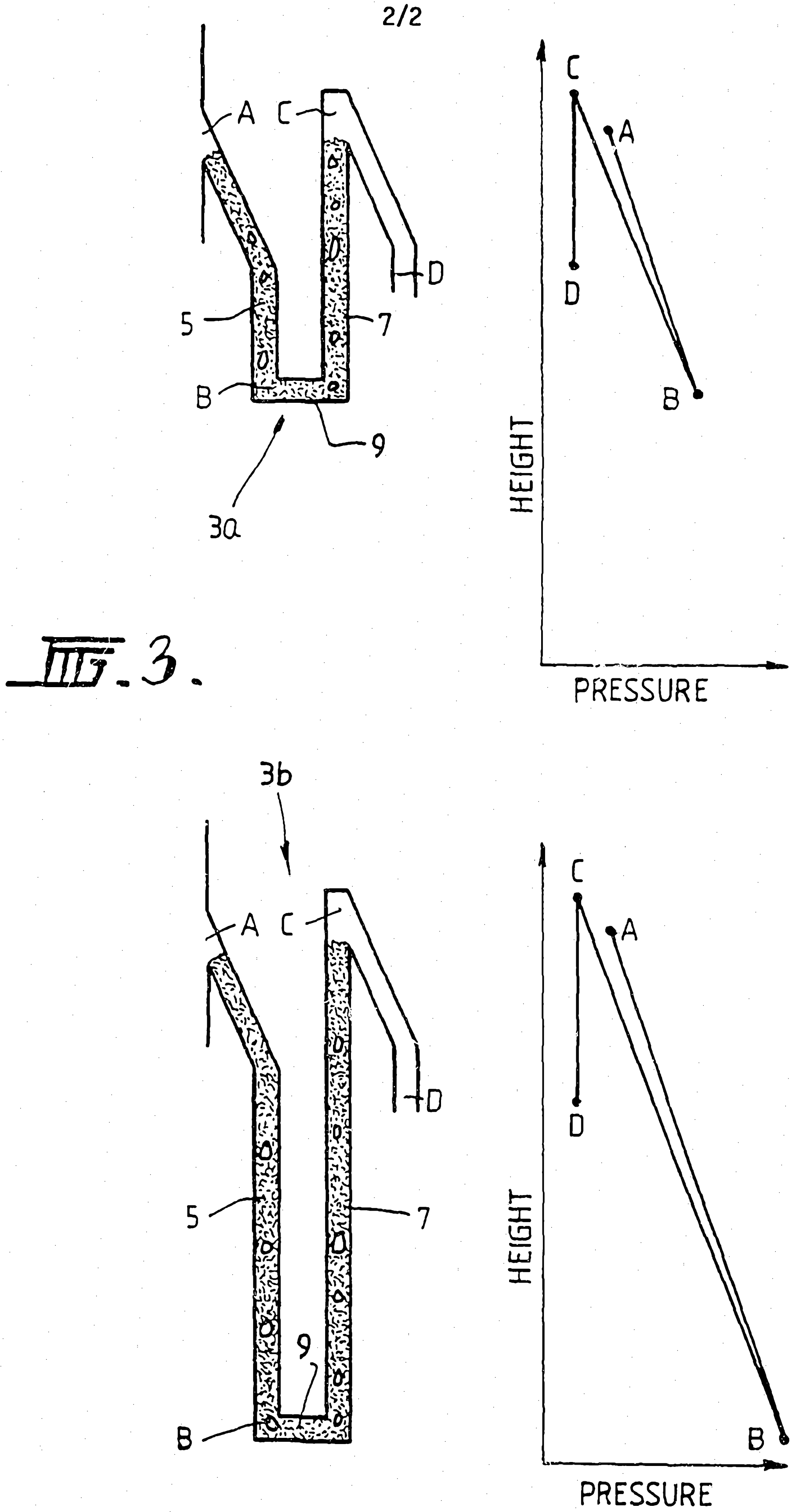
A
C
D
5
7
B
9
3a
C
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HEIGHT
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3b
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C
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B
HEIGHT
PRESSURE

FIG. 3.

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 96/00196

A.	**CLASSIFICATION OF SUBJECT MATTER**

Int Cl^6. B65G 53/16

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: B65G 53/16

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

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

C.	**DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2267965 A (GUYOT) 14 November 1975 See page 4, line 29 - page 5 line 6, figure 1	
A	US 4281946 A (KANICS) 4 August 1981 See entire document	
A	GB 2001862 A (HANDELSBOLAGET NORDISK FLUIDBADDFORGASNING) 14 February 1979 See entire document	

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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
"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
"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
26 June 1996	02 JUL 1996
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (06) 285 3929	Authorized officer **GREG POWELL** Telephone No.: (06) 283 2308

INTERNATIONAL SEARCH REPORT

.ernational Application No.
PCT/AU 96/00196

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 2286682 A (SOCIETE ANONYME DES ETABLISSEMENTS PH. BONVILLAIN ET E. RONCERAY) 30 April 1976 See entire document	
A	Patent Abstracts of Japan, M-1688, page 85, JP 6-191640 A (HITACHI PLANT ENG & CONTR CO LTD) 12 July 1994 Abstract	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.
PCT/AU 96/00196

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
FR	2267965						
US	4281946	BR	7708436	DE	2657677	FR	2374238
		GB	1594830	IT	1089643	JP	53096184
GB	2001862	DE	2828614	SE	7707545		
FR	2286682						

END OF ANNEX