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(71) Applicant: **HAUZER TECHNO COATING EUROPE BV**
NL-5916 PB Venlo (NL)

(72) Inventors:
- **Visser, Jan**
  NL-6006 RT Weerd (NL)
- **Engel, Klaus-Georg**
  D-47447 Moers (DE)

(74) Representative:
Smulders, Theodorus A.H.J., Ir. et al
Vereenigde Octrooibureaux
Nieuwe Parklaan 97
2587 BN 's-Gravenhage (NL)

(54) Regeneration of cryocondensation pump panels in a vacuum chamber

(57) A method of regenerating cryocondensation pump panels disposed in a vacuum chamber, which cryocondensation pump panels, before being heated for the regeneration, are screened from the vacuum chamber by screening panels, a reduced pressure relative to the vacuum chamber being created in the screened space in which the cryocondensation pump panels are situated, and a non-condensing gas being carried into the vacuum chamber so that non-condensing gas flows from the vacuum chamber via narrow gaps between the screening panels relative to each other and/or the vacuum chamber walls into the screened space.

The invention also relates to a vacuum chamber provided with screening panels for carrying out the method and to an apparatus provided with such a vacuum chamber.

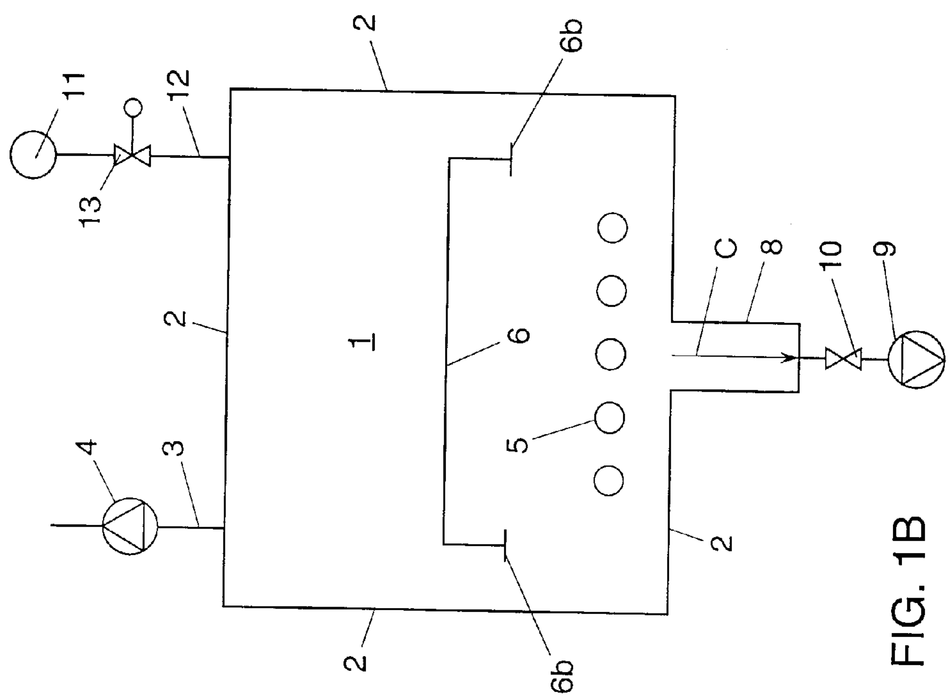

FIG. 1B

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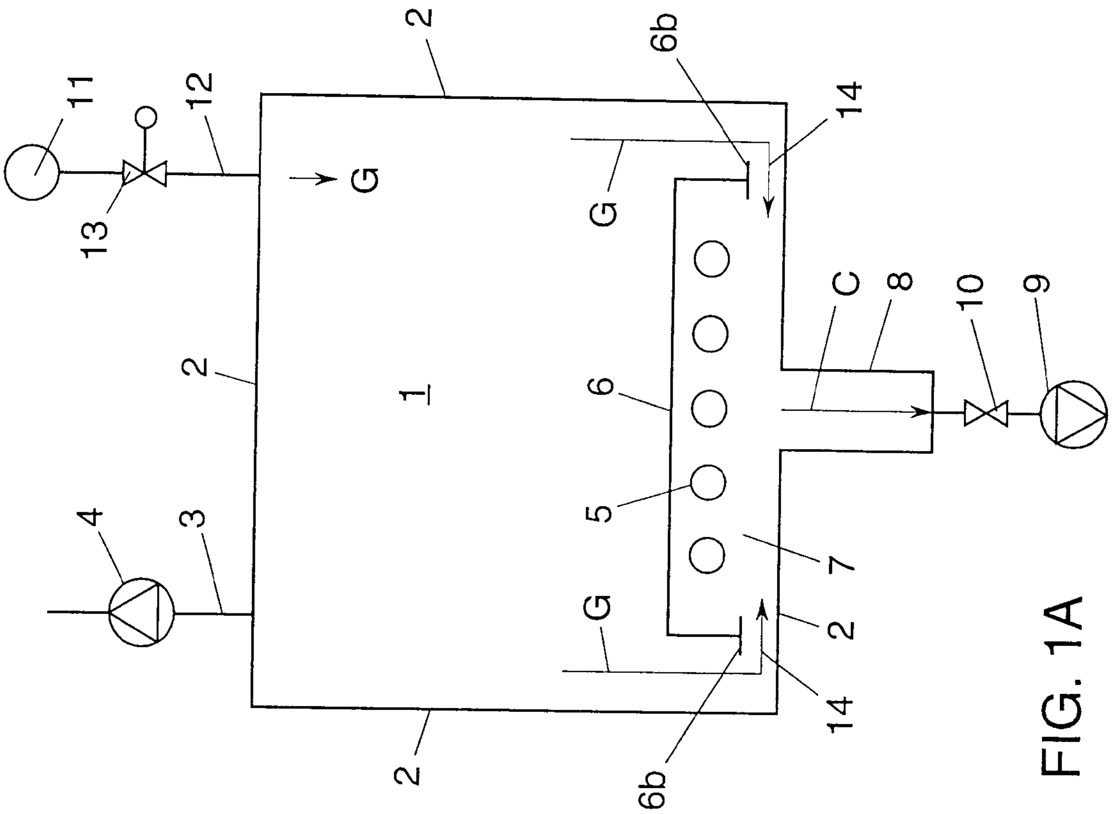


FIG. 1A

Description

This invention relates to a method according to the preamble of claim 1.

The cryopumping technique is a pumping technique largely used in vacuum technology. A detailed description of this pumping technique is to be found in different handbooks such as "KRYO-VAKUUMTECHNIK" written by R.A. Haefer and published by Springer-Verlag Berlin. The cryopumping technique is a clean pumping technique, i.e. in contrast with many other pumping techniques the pump does not contribute to the level of contamination of the vacuum. It is another advantage of the cryopumping technique that very high pumping speeds are possible, provided sufficiently large panels can be placed in the vacuum.

A drawback of a cryopump is that the pumping action is finite. It is a fact that the gas removed from a vacuum chamber condenses on a cryocondensation pump panel with the result that a temperature gradient is formed over the layer growing on the cryocondensation pump panel. After some time the temperature gradient increases so much that the pumping action decreases and finally ceases to exist. For this reason the cryocondensation pump panels must be regenerated from time to time.

In a known regeneration process the cryocondensation pump panels are heated so that the pumped gas is released. The released gas is then removed from the vacuum system. If the pressure remains lower than the atmospheric pressure, then the amount of gas will have to be discharged with an auxiliary pump or a pump group capable of transporting the gas to atmospheric pressure. In the regeneration process the pressure sometimes exceeds the atmospheric pressure so that the major part of the gas from the regeneration can be allowed to discharge into the outside air.

The relatively high pressure of condensable gases during the regeneration process promotes adsorption of condensable gases on walls that do not form part of the cryocondensation pump panels and have not been brought to a sufficiently high temperature. The walls of a vacuum chamber which are, e.g., at room temperature, when being exposed to a high water vapour pressure, will be highly contaminated with water with the result that the pumping process will be impeded at a later stage.

A solution to this problem known from practice is to dispose a vacuum valve between the vacuum chamber and the cryopump which in closed condition prevents contamination of the vacuum chamber during heating of the cryopanels. Since in this solution the cryopanels are outside the vacuum chamber, the pumping speed cannot exceed the maximum volumetric gas flow capable of passing the pump opening, as determined by the kinetic gas theory. In practice, the pumping speed of such an external cryopump, i.e. mounted on the vacuum chamber, hardly exceeds that of another type of pump with the same pump opening.

Extremely high pumping speeds can be obtained only if the vacuum chamber is provided with cryopanels having a surface much larger in its totality than the pump opening of an external pump. However, especially when the vacuum chamber cannot be heated, the desired effect contemplated with the higher pumping speed for condensable gases of this internal pump, namely an improvement of the vacuum conditions, is often not or only partly obtained because the desorption of the vacuum chamber is brought to a higher level by the regeneration process. The heating of the vacuum chamber to a temperature at which the adsorption of gas released during the regeneration process, on the chamber walls is negligible is often impossible or undesirable in practice. The reasons therefor are, e.g., that owing to a rapid succession of pumping processes from atmospheric pressure to low pressure the regeneration time is too short to sufficiently heat the vacuum chamber and its components or that the heating causes too high a temperature load on the sealing materials of the vacuum chamber or too high a consumption of energy.

The object of the invention is to provide a method of regenerating cryocondensation pump panels in which the gases released during heating of a cryocondensation pump panel do not increase the level of desorption of the vacuum chamber walls, i.e. do not precipitate on the vacuum chamber walls or vacuum chamber components. To this end, the method is characterized by the steps according to claim 1.

The proposed method is based on the use of a laminar gas flow forming a flow resistance to gas moving in a direction opposite to the direction of the laminar gas flow. A barrier against the transport of the gas released from a cryocondensation pump panel to the vacuum chamber walls is created by directing a laminar gas flow from the vacuum chamber towards the cryocondensation pump panel and discharging it there by pumping or, if the pressure in the screened space exceeds the atmospheric pressure, allowing it to discharge into the atmosphere.

The degree of separation that can be realized by means of a laminar gas flow depends on the gas flow, the pressure and the dimensions of the flow channel. The pressure ratio of the gas diffusing against the laminar gas flow follows from:

$$\frac{p(high)}{p(low)} = eexp(\frac{Q.1}{p.A.D_i})$$

in which Q is the pressure•volume rate of the laminar gas flow

1 is the length of the flow channel = gap width
A is the passage of the flow channel = gap height x gap length
D_i is the diffusion coefficient.

The creation of a large pressure ratio by means of a large pressure•volume rate has a number of drawbacks. Since the laminar gas flow must be clean, the use a high gas flow is expensive. In addition, there are the costs of a pump having a high pumping speed, required to discharge the laminar gas flow. A high flow rate in a vacuum chamber has the additional effect that the dust present in the vacuum chamber can move. Especially in vacuum processes used in the manufacture of semiconductors and the manufacture of optical and wear-resistant layers, movement of dust to the substrate to be processed in the vacuum is undesirable.

Consequently, the separation is preferably realized by means of the dimensions of the flow channel, i.e. by selecting a narrow or a wide flow channel.

The method according to the invention is particularly favourable because no vacuum-tight seal between the vacuum chamber and the cryopanel is necessary. Consequently, the screening panel forming the narrow gap can be of simple construction, and with a low flow rate in the vacuum chamber contamination of the vacuum chamber with gas released from the cryopanels can be prevented.

In a further development of the invention the method is characterized by the steps of claim 2. Thus, the cryocondensation pump panels are kept from contamination by atmospheric air flowing into the vacuum chamber during release of the vacuum.

In order to prevent the time required for regenerating the cryocondensation pump panels being at the expense of the production time of the vacuum chamber, the method is preferably characterized by the steps of claim 3.

In a further development of the invention the method is characterized by the steps of claim 4. When the vacuum is initially formed after cooling of the cryocondensation pump panels, these steps prevent direct contamination of these panels by an excessive increase of condensable gases still present in the vacuum chamber.

In order to ensure that the regeneration process proceeds very rapidly and, moreover, that the screening panels are not themselves covered during regeneration with the condensate of condensable gases, it is very favourable according to a further development of the invention when the vacuum chamber is characterized by the steps of claim 5.

The invention also relates to an apparatus characterized by the features of claim 6. With a thus constructed vacuum chamber the method according to the invention can be carried out in a very favourable and economic manner. The screening panels can be of relatively simple construction, which is therefore rather inexpensive, since with them it is not necessary to completely seal the screened space relative to the vacuum chamber. Since according to the method non-condensing gas is carried into the vacuum chamber, a laminar flow of the non-condensable gas towards the screened space is formed in the narrow gaps between the screening panels and the vacuum chamber and/or the screening panels relative to each other. Thus, the condensable gas released during the regeneration process can diffuse only in very small amounts from the screened space, against the laminar non-condensing gas flow, to the vacuum chamber.

The invention also relates to an apparatus for coating products provided with a vacuum chamber according to the invention. With a thus constructed apparatus a minimum of production time is lost because the regeneration process of the cryocondensation pump panels can be carried out while the treated products are replaced by products not yet treated. Moreover, the regeneration takes place in a qualitatively excellent and effective manner.

A number of practical embodiments of the vacuum chamber according to the invention are described in the subclaims and will be further explained with reference to the accompanying drawings, in which

Figs. 1A-8A show a vacuum chamber comprising cryocondensation pump panels which are regenerated;

Figs. 1B-8B show the vacuum chambers of the corresponding Figs. 1A-8A, which vacuum chambers are in the pumping or production situation.

The drawings are all of a very schematic nature and diagrammatically show a vacuum chamber 1 bounded by walls 2, at least one of which can be opened, because it is designed as a door or a hatch. The vacuum chamber is also provided with at least one connection 3 for a high-vacuum pump 4. The vacuum chamber further contains cryocondensation pump panels 5 which in the practical examples shown are of tubular construction, so that a liquid or gas can be passed therethrough to control the temperature of the cryocondensation pump panels 5. All the embodiments shown are further provided with screening panels 6, which in a first position put the cryocondensation pump panels 5 into free communication with the vacuum chamber and in a second position place the cryocondensation pump panels 5 in a space 7 screened from the vacuum chamber. The B figures show the screening panels 6 in a first position, i.e. the position in which the cryocondensation pump panels 5 can be active as pump and are therefore in free communication with the vacuum chamber 1, while the A figures show the screening panels 6 in the second position, i.e. in a position in which the cryocondensation pump panels 5 are regenerated. Connected to the screened space 7 is a pipe 8 which contains a vacuum pump 9 arranged to create a reduced pressure in the screened space 7 relative to the vacuum chamber 1. Moreover, the pipe 8 contains a valve 10 opened during regeneration of the cryocondensation pump panels 5 and closed when the vacuum chamber 1 is in use. Moreover, the vacuum chamber 1 is provided with means 11, 12, 13 for introducing a non-condensing gas into the vacuum chamber 1 when the cryocondensation pump panels 5 are regenerated. These means 11, 12, 13 can be, e.g., a line 12 provided with a valve 13, which line 12 is at one end connected to the vacuum chamber 1 and at the other end to a source 11 of a non-condensing gas, e.g. nitrogen. As soon as the regeneration process starts, the valve 13 is opened, so that the vacuum chamber 1 is filled with nitrogen, which nitrogen, as a result of the reduced pressure prevailing in the screened space 7, flows to the screened space 7 via the gaps 14 between the vacuum chamber walls 2 and the screening panels 6 and/or the screening panels 6 relative to each other. By the non-condensing gas flowing to the screened space 7 condensable gases released from the cryocondensation pump panels 5 as a result of the regeneration process are prevented from flowing to the vacuum chamber 1.

The practical examples shown in Figs. 1-8 are distinguished only by the design of the screening panels 6 and the related arrangement of the cryocondensation pump panels 5.

Figs. 1A and 1B show an embodiment in which the screening panel 6 is designed as a slidably mounted angled plate 6. At the edges which must connect to the vacuum chamber walls 2 the plate is provided with an enlarged edge 6B, thus increasing the width of the gap 14 via which the non-condensable gas G must pass, which has a favourable effect on the screening of the condensable gases C released in the screened space 7.

Figs. 2A and 2B show a screening panel 6 arranged before the cryocondensation pump panels 5 and hingedly connected at the ends with two closing pieces 6A which in a first position shown in Fig. 2B put the cryocondensation pump panels 5 into free communication with the vacuum chamber 1 and in a second position shown in Fig. 2A place the cryocondensation pump panels 5 in a screened space 7. Figs. 3A, 3B; 4A, 4B; 5A, 5B show constructional modifications of the structural variants shown in Figs. 1A, 1B; 2A, 2B and need no further explanation.

Figs. 6A and 6B show an embodiment in which the cryocondensation pump panels 5 are of tubular construction and are preferably situated in a corner of the vacuum chamber 1. The screening panels 6 have a cross-section in the form of a circular segment, within the concave part of which the tubular cryocondensation pump panels 5 are situated. In the first position shown in Fig. 6B the screening panels 6 having the form of a circular segment are directed with the concave part towards the vacuum chamber 1, while in the second position shown in Fig. 6A the convex part of the screening panels 6 is directed towards the vacuum chamber 1. It is thus ensured that during the normal production process in the vacuum chamber 1 the access from the vacuum chamber 1 to the cryocondensation pump panel 5 is completely free. It is self-evident that the shape of the screening panel 6 and the manner of displacing the screening panel 6 may vary for each individual case. Thus the displacement of the screening panels 6 having the form of a circular segment may be effected, e.g., by rotation or by translation.

In Figs. 7A, 7B the space to be screened also contains stationary panels 15 disposed between the vacuum chamber walls 2 and the cryocondensation pump panels 5. The stationary panels 15 may be provided with heating elements designed for heating the stationary panels 15 during the regeneration process. In the embodiments shown in Figs. 7A and 7B the screening panel 6 is preferably also provided with heating elements designed for heating the screening panels 6 during the regeneration process. It is thus ensured that all the walls 6, 15 of the screened space 7 can be simply heated during regeneration. This has the advantage that the condensable gases released during the regeneration process will not precipitate on these walls 6, 15, so that after the regeneration process has been completed and the walls 6, 15 have been put again into free communication with the other parts of the vacuum chamber 1, no gases condensing thereon can find their way to the vacuum chamber 1.

Figs. 8A and 8B show an embodiment in which the screening panels 6 are designed in the form of venetian blinds.

It is evident that the invention is not limited to the practical examples shown, but that various modifications are possible within the scope of the invention. Thus, e.g., the stationary panels 15 provided with heating elements as shown in Figs. 7A, 7B may also be used in the other practical examples. Also the screening panels 6 provided with heating elements described with reference to Figs. 7A and 7B may be used in the other practical examples.

Claims

1. A method of regenerating cryocondensation pump panels (5) disposed in a vacuum chamber (1), the cryocondensation pump panels (5) being heated for the regeneration, characterized in that the cryocondensation pump panels (5), before being heated, are screened from the vacuum chamber (1) by screening panels (6), a reduced pressure relative to the vacuum chamber (1) being created in the screened space (7) containing the cryocondensation pump panels (5), and a non-condensing gas (G) being carried into the vacuum chamber (1) so that non-condensing gas (G) flows from the vacuum chamber (1) via narrow gaps (14) formed between the screening panels (6) and the vacuum chamber walls (2) and/oder the screening panels (6) relative to each other, into the screened space (7).

2. A method according to claim 1, characterized in that the screened space (7) is formed before non-condensing gas (G) is carried into the vacuum chamber

(1) and the vacuum in the vacuum chamber (1) is released.

3. A method according to claim 1 or 2, characterized in that the regeneration of the cryocondensation pump panels (5) is effected while the vacuum chamber (1) is opened for carrying out therein operations, such as, e.g., exchanging products treated in the vacuum chamber (1) for products to be treated in the vacuum chamber (1).

4. A method according to any of the preceding claims, characterized in that the cryocondensation pump panels (5) are put into an undisturbed free communication with the vacuum chamber (1) again only after closing again and substantially vacuum pumping the vacuum chamber (1).

5. A method according to any of the preceding claims, characterized in that the screening panels (6) are heated during the regeneration process.

6. A vacuum chamber, provided with at least one connection (3) for a hig-vacuum pump (4) and with cryocondensation pump panels (5) disposed in the vacuum chamber (1), characterized by screening panels (6) which in a first position put the cryocondensation pump panels (5) into free communication with the vacuum chamber (1) and in a second position place the cryocondensation pump panels (5) in a space (7) screened from the vacuum chamber (1), pumping means (9) being provided to creat in the screened space (7) a reduced pressure relative to the vacuum chamber (1), and means (11, 12, 13) being provided to carry a non-condensing gas into the vacuum chamber (1).

7. A vacuum chamber according to claim 6, characterized in that at the edges (6B) which in the second position screen the screened space (7) the screening panels (6) are carried out such that narrow gaps (14) formed between the screening panels (6) and the vacuum chamber walls (2) and/or between the screening panels (6) relative to each other have a small gap height and a large gap width so that little or no gas (C) released by the regeneration of the cryocondensation pump panels (5) can diffuse from the screened space (7) via the gap (14), against the direction of flow of non-condensable gas (G) flowing through the gap (14), to the vacuum chamber (1).

8. A vacuum chamber according to claim 6 or 7, characterized in that the cryocondensation pump panels (5) are of tubular construction, through which tubes a cooling medium can flow, the screening panels (6) having a cross-section in the form of a circular segment, within the concave part of which the tubular cryocondensation pump panels (5) are situated, the screening panels (6) having the form of a circular segment in the first position thereof being directed with the concave part towards the vacuum chamber (1) and in the second position with the convex part towards the vacuum chamber (1).

9. A vacuum chamber according to claim 6 or 7, characterized in that the screening panels (6) are hingedly or slidably arranged angled plates.

10. A vacuum chamber according to claim 6 or 7, characterized in that the screening panels (6) are in the form of venetian blinds.

11. A vacuum chamber according to any of claims 6-10, characterized in that the screening panels (6) are provided with heating elements designed for heating the screening panels (6) during the regeneration process.

12. A vacuum chamber according to any of claims 6-11, characterized in that, moreover, stationary panels (15) are disposed between the vacuum chamber walls (2) and the cryocondensation pump panels (5), which stationary panels (15) are provided with heating elements designed for heating the stationary panels (15) during the regeneration process.

13. An apparatus for coating products, provided with a vacuum chamber according to any of claims 6-12.

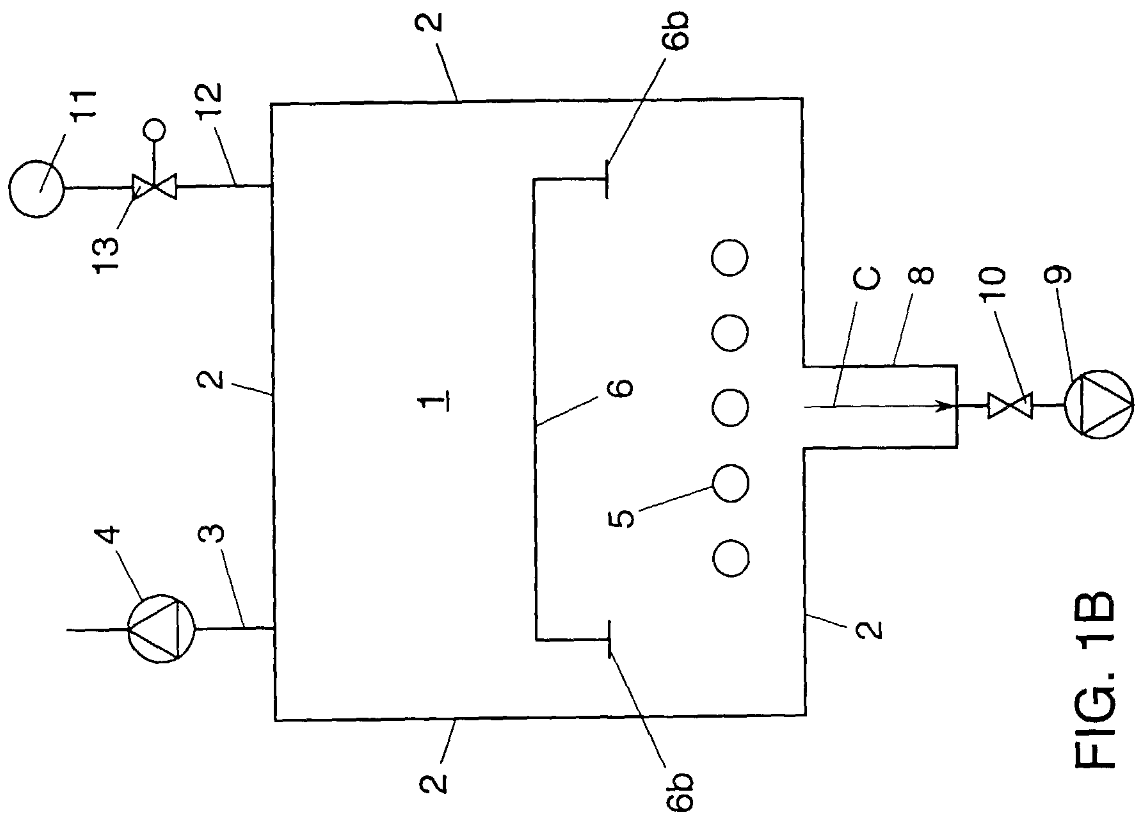
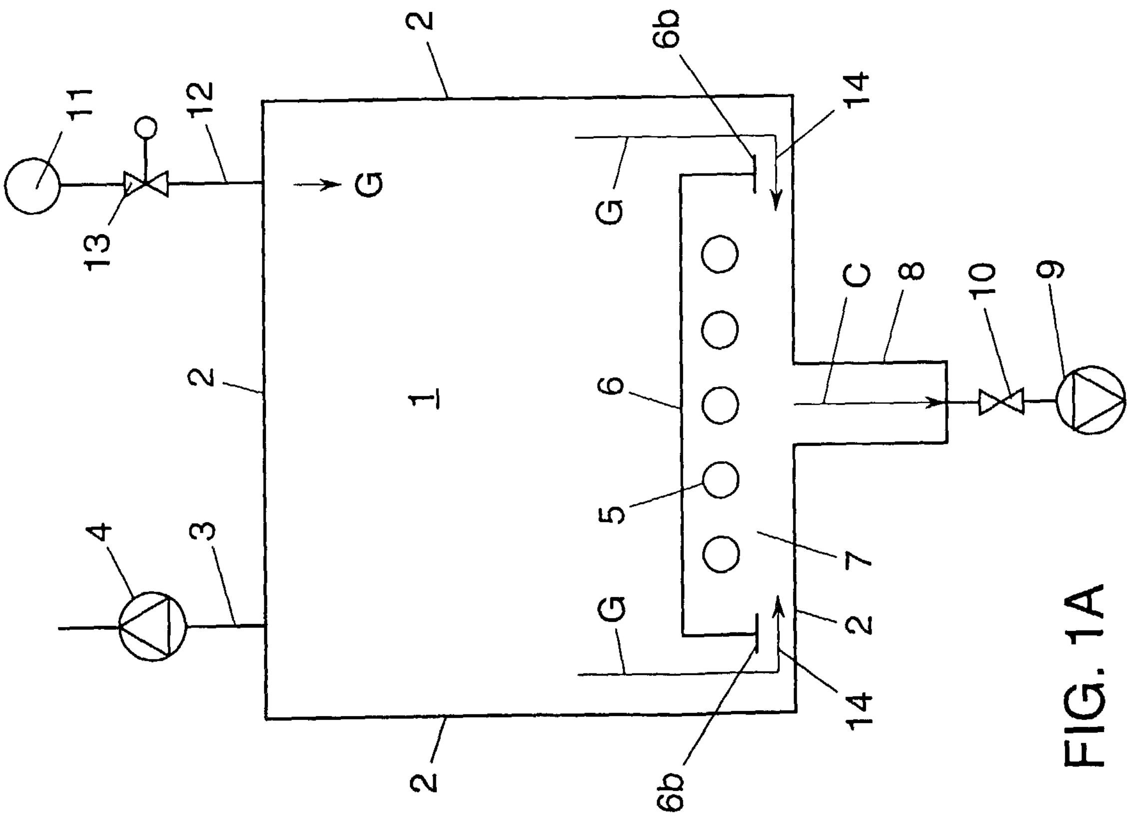

2
11
12
13
6b
4
3
2
1
6
5
C
8
10
9
2
6b

FIG. 1B


2
11
12
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G
6b
14
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6
5
7
C
8
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9
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14
2
6b

FIG. 1A

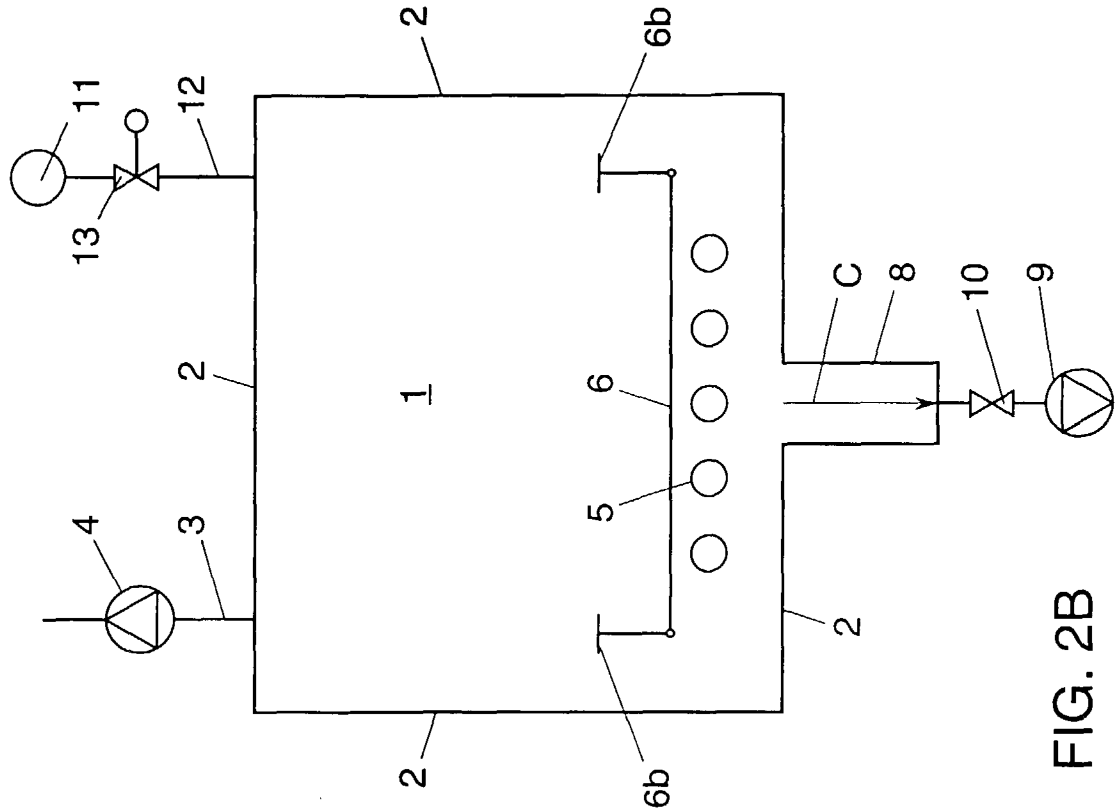


FIG. 2B

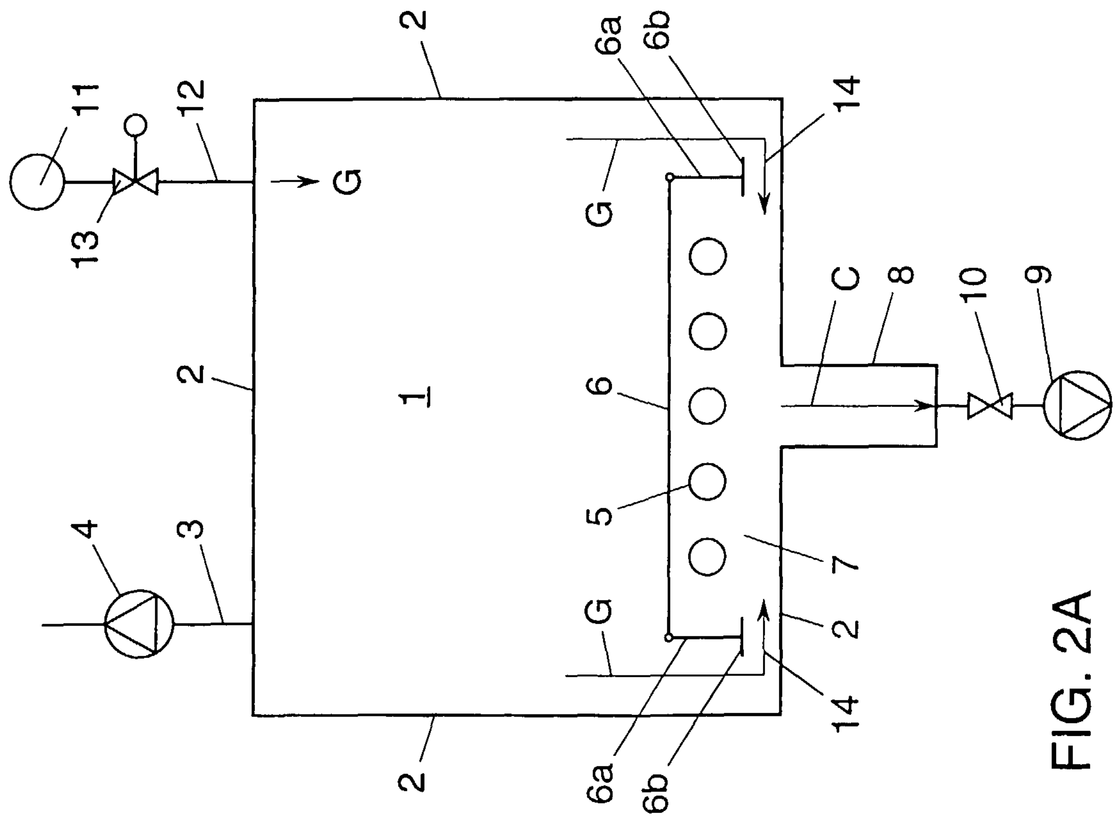
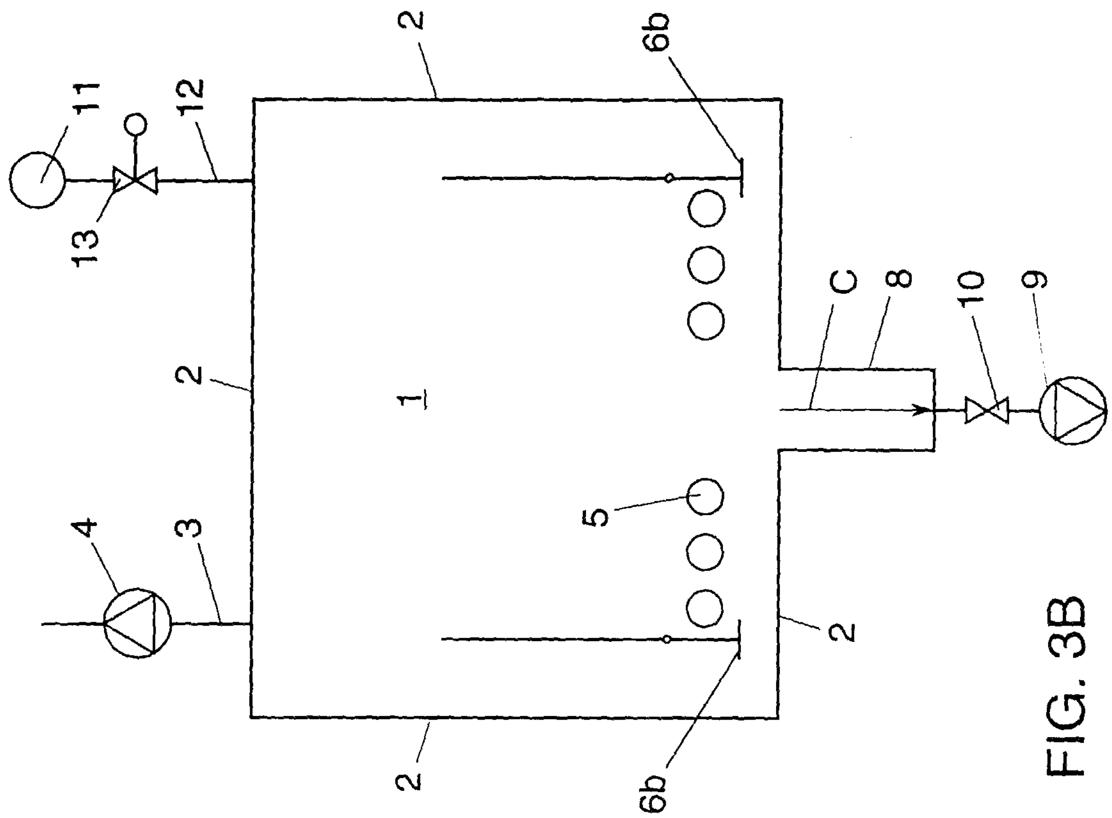


FIG. 2A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C
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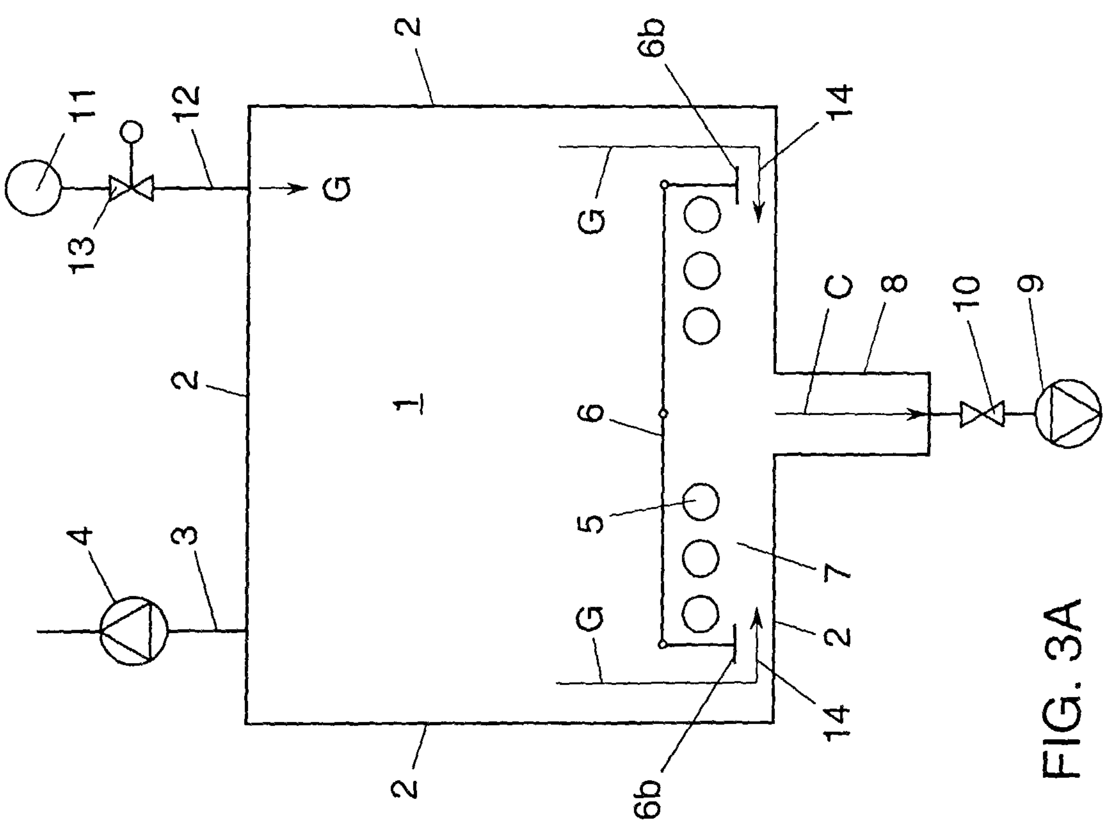
6b

FIG. 3B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G
14
13
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2
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C
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6
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4
3
7
G
2
14
2
6b

FIG. 3A

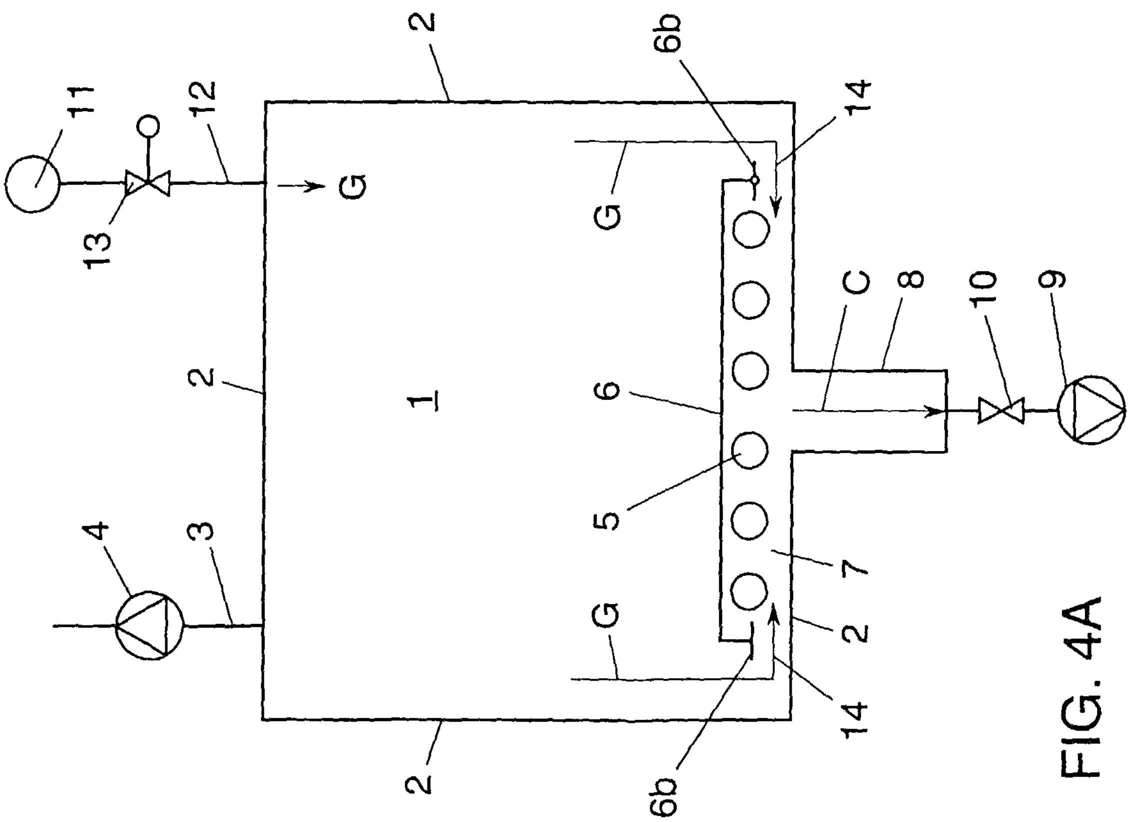


FIG. 4A

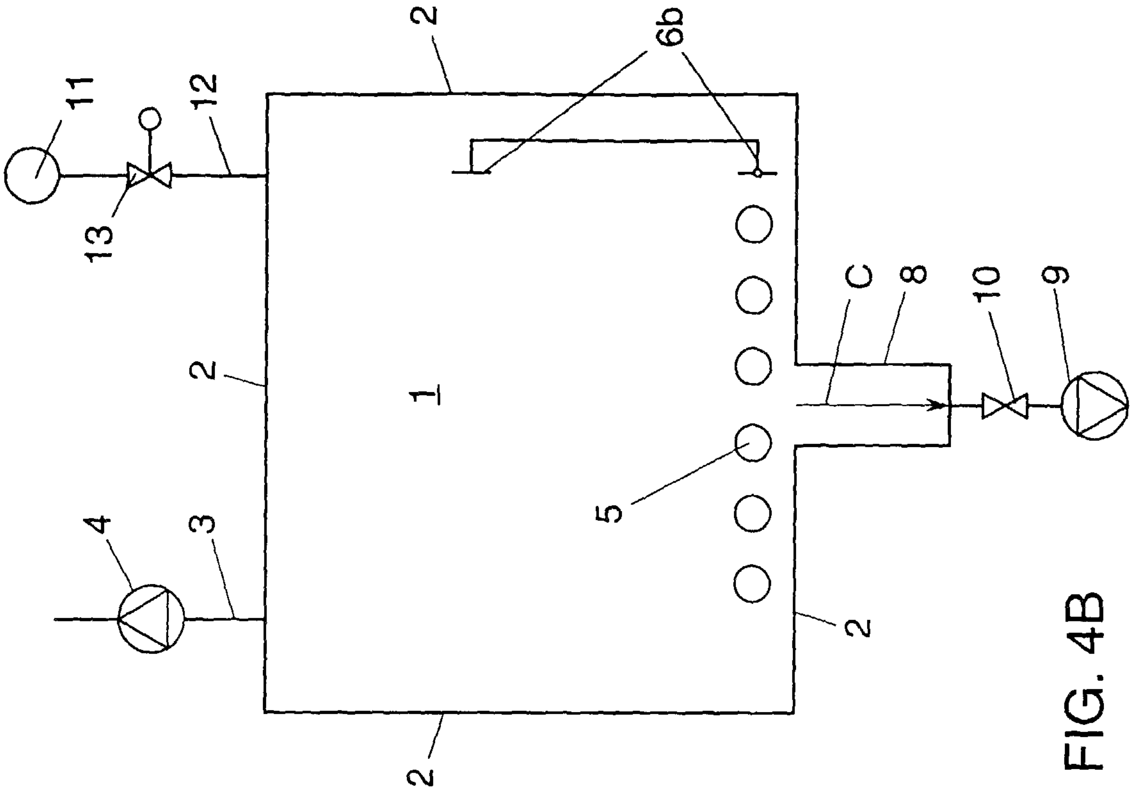
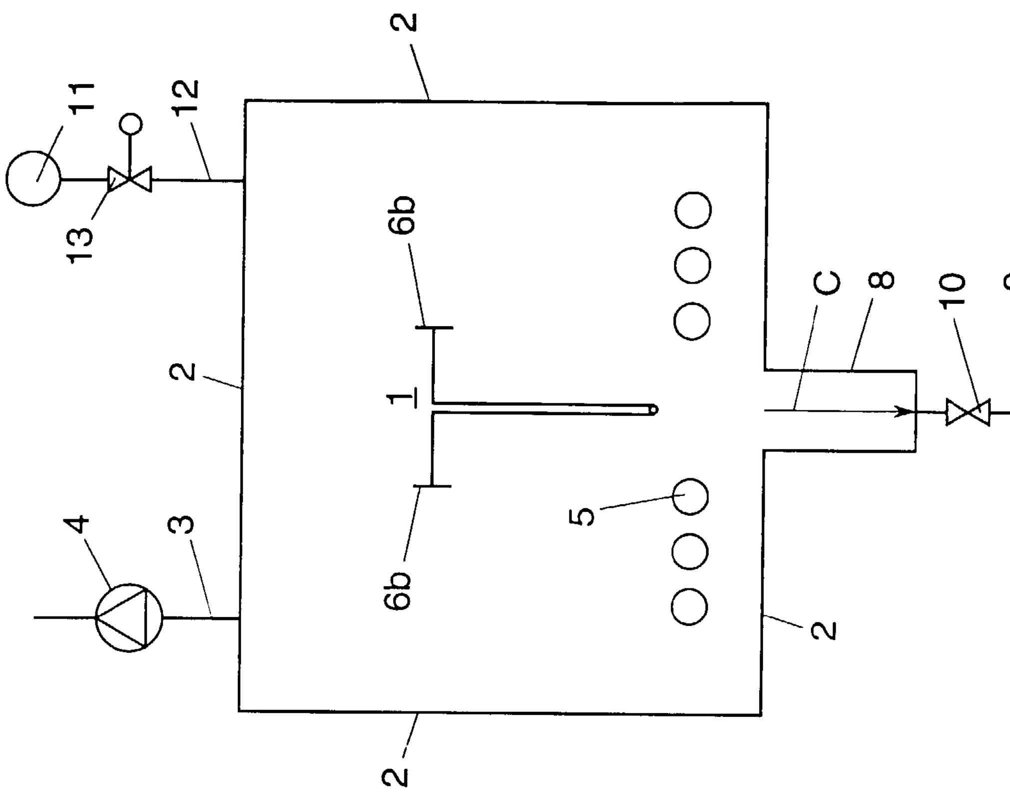


FIG. 4B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6b
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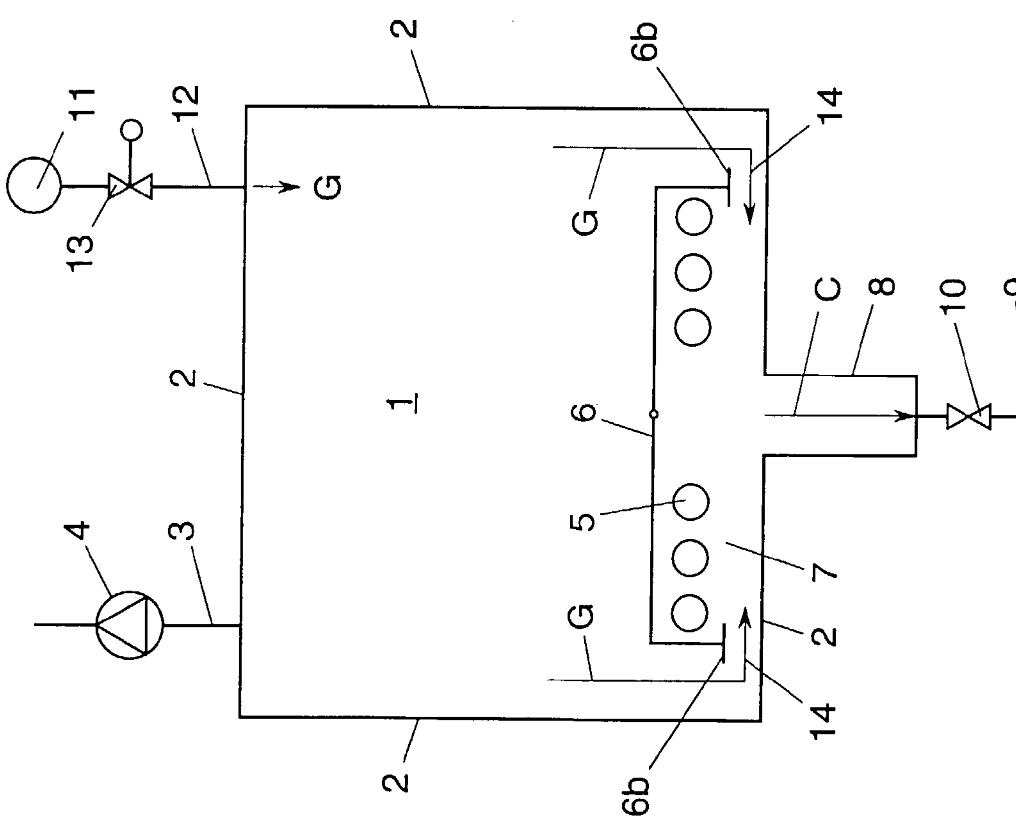
4
3
5
C
8
10
9
6b
2
2

FIG. 5B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2
14
6b
2

FIG. 5A

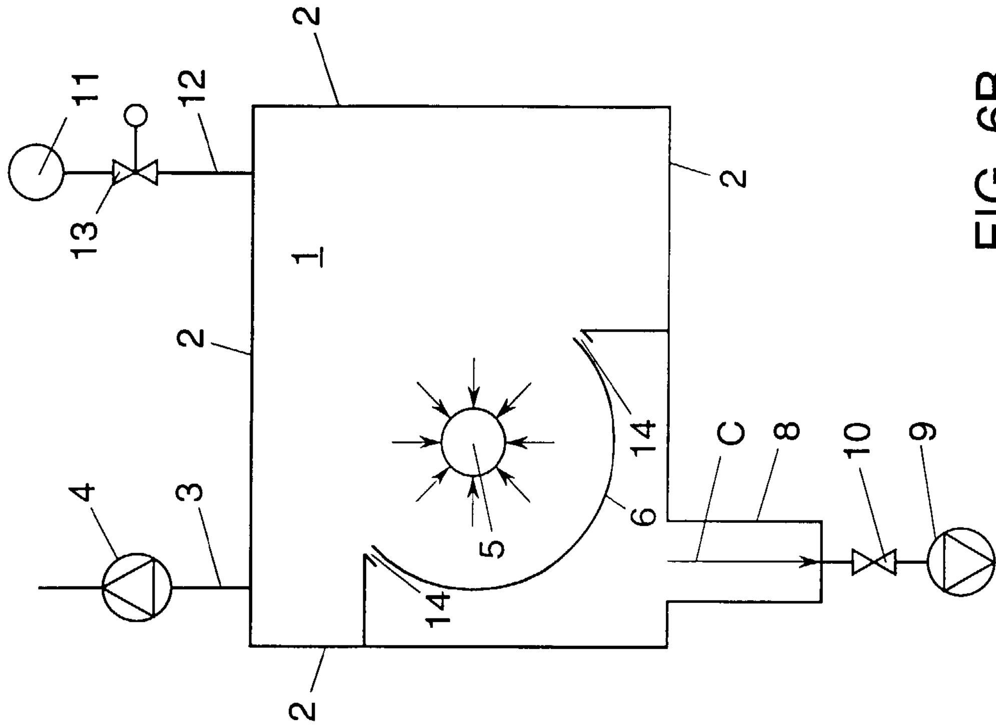

FIG. 6B

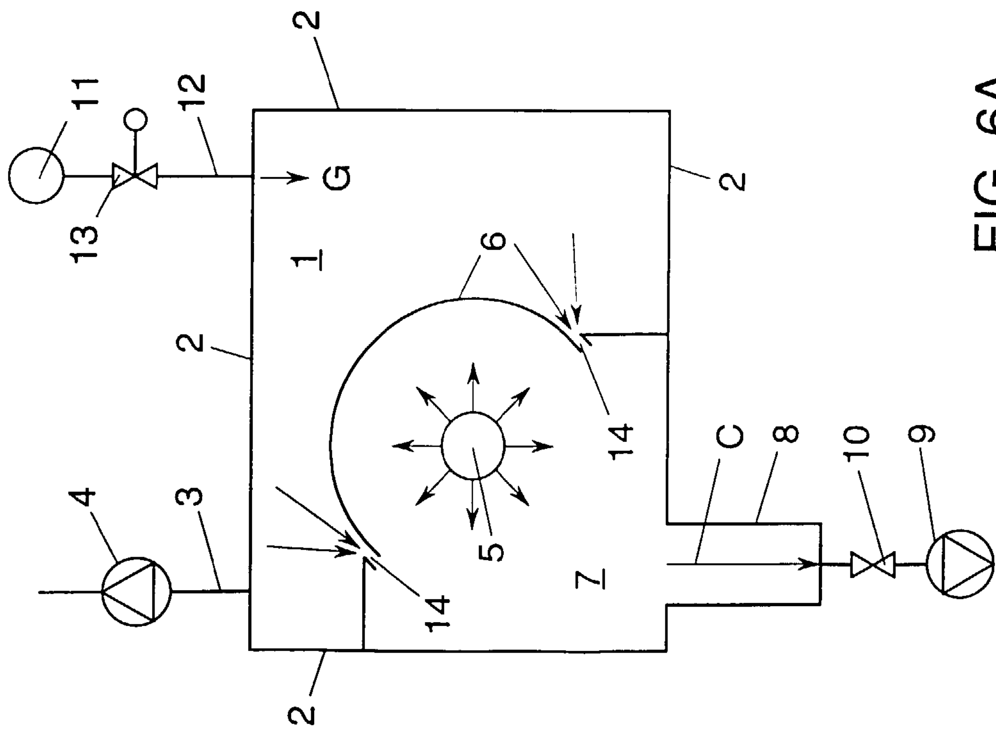

FIG. 6A

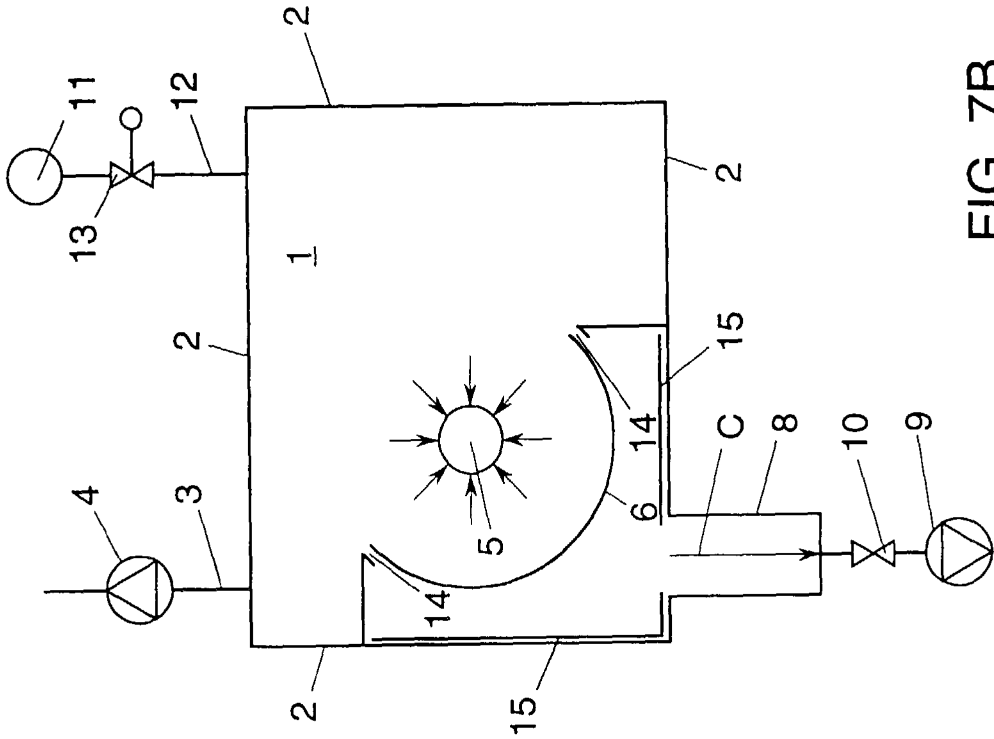

FIG. 7B

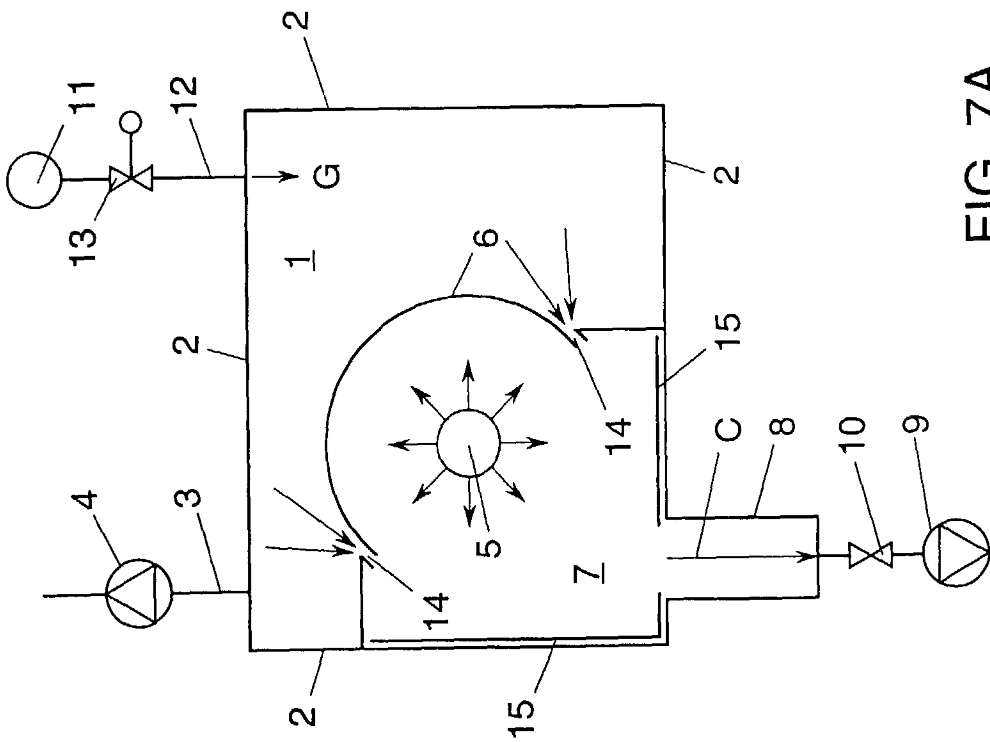

FIG. 7A

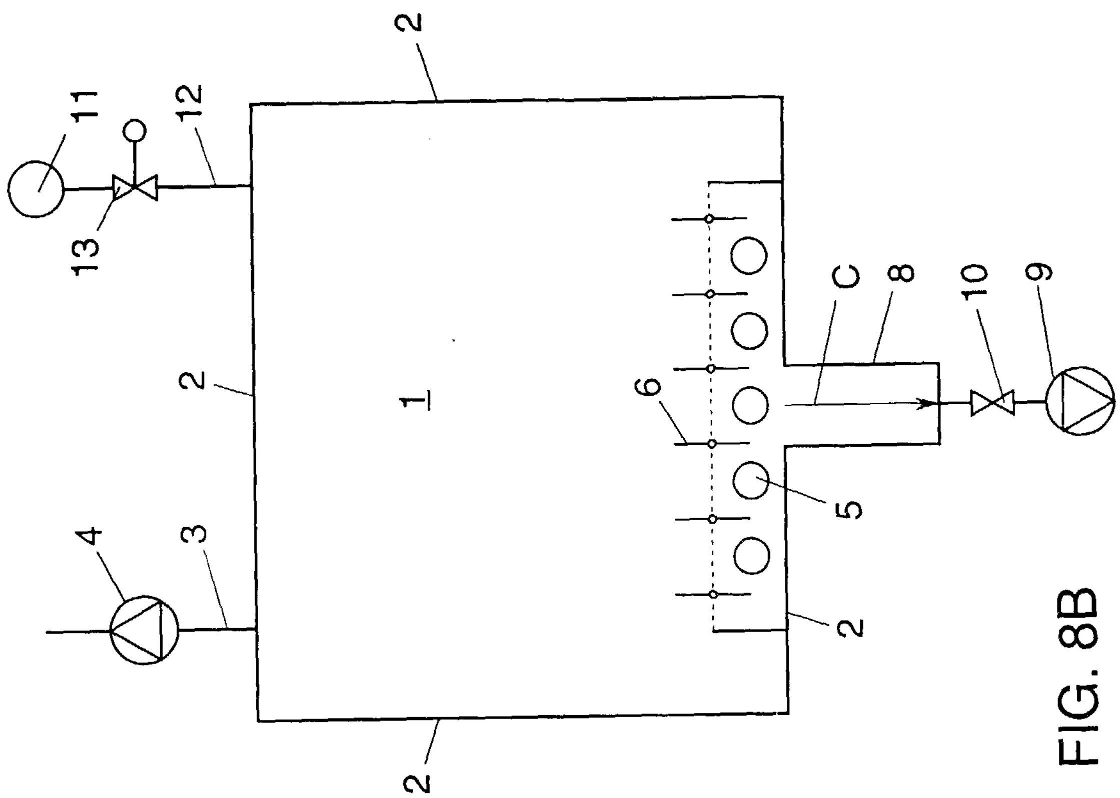

FIG. 8B

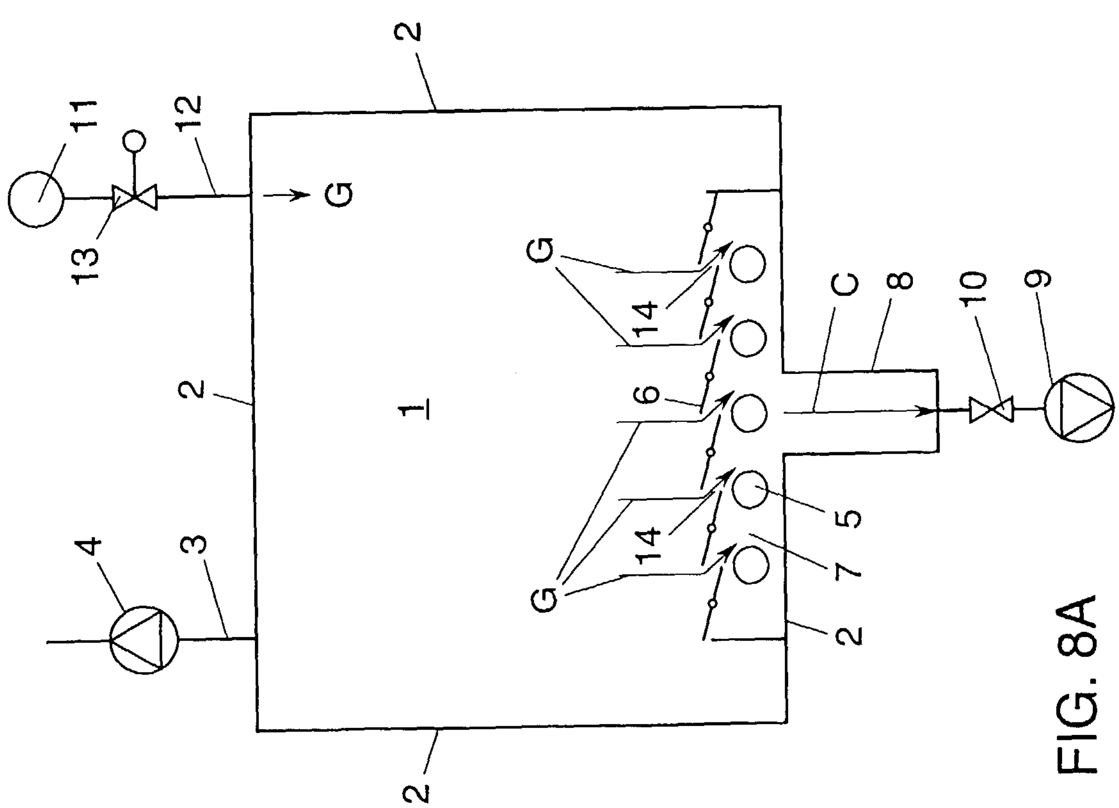

FIG. 8A

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 20 0260

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	FR-A-2 321 609 (L'AIR LIQUIDE) 18 March 1977 * the whole document * ---	1	F04B37/08
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 6 (M-445) [2063] , 11 January 1986 & JP-A-60 169686 (HITACHI SEISAKUSHO), 3 September 1985, * abstract * ---	1	
A	EP-A-0 102 787 (COMPTECH,INC) 14 March 1984 ---		
A	WO-A-89 11896 (GRUMMAN AEROSPACE CORP.) 14 December 1989 ---		
A	US-A-5 105 852 (WAGNER) 21 April 1992 -----		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 April 1996	Von Arx, H

CATEGORY OF CITED DOCUMENTS

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