(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 059 166 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
13.12.2000 Bulletin 2000/50

(51) Int. Cl.[7]: **B41F 23/04**

(21) Application number: **00201866.1**

(22) Date of filing: **25.05.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **07.06.1999 NL 1012251**

(71) Applicant:
Roto Smeets de Boer N.V.
1216 GK Hilversum (NL)

(72) Inventor:
Van den Bosch, Petrus Wilhelmus Johannes Maria
4711 CJ Willebrord (NL)

(74) Representative:
Dokter, Hendrik Daniel
Octrooibureau Dokter
P.O. Box 657
7300 AR Apeldoorn (NL)

(54) Method and apparatus for drying printed materials

(57) Method for drying printed materials substantially immediately after the manufacture thereof, comprising the successive steps of

(i) feeding a quantity of printed material under conditions of room temperature and atmospheric pressure into a space closable and evacuable in vacuum-tight manner,
(ii) closing the space,
(iii) at least partially evacuating the space for a determined period and maintaining a predetermined low pressure in the space relative to the atmospheric pressure, and
(iv) removing the quantity of printed material from said space after the determined period,
and apparatus for performing this method, comprising
an autoclave which is adapted to temporarily store therein a quantity of printed materials substantially immediately after manufacture of said printed materials,
pumping means for evacuating the autoclave to a predetermined pressure, and
regeneration means for regenerating solvent from gases released during evacuation of the autoclave.

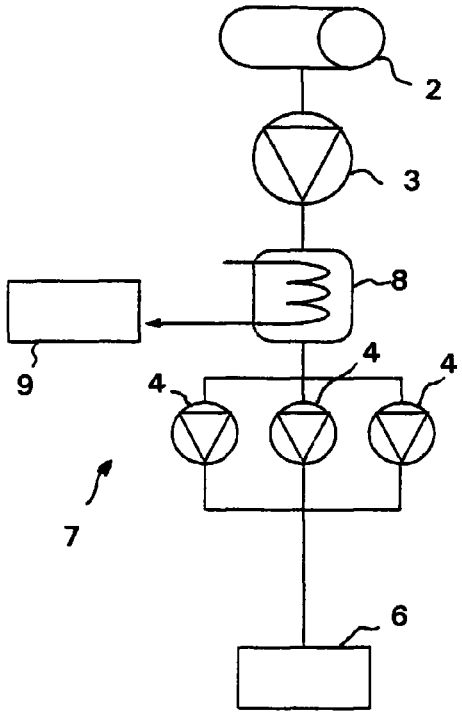

Fig. 5

EP 1 059 166 A1

Description

[0001] The invention relates to a method for drying printed materials substantially immediately after the manufacture thereof.

[0002] During a printing process solvent-rich ink is applied to an unprinted carrier, for instance of paper or cardboard. In a first phase of the printing process the molecules of the solvent can move virtually unobstructed and can be extracted in simple manner from an applied ink film, for instance by blowing a continuous flow of air over the ink film. The drying speed in this first phase is constant. In a second phase the ink surface of the ink film dries slowly, while the interior of the ink film still remains wet for some time. The drier the ink layer becomes, the more the escape of molecules from the solvent is obstructed. The drying speed in the second phase is determined by the diffusion in the ink film. In a third phase the printed material still contains only a small residual quantity of solvent, which residual quantity is designated with the term "retention". Both the surface and the interior of an applied ink film are dry in this third phase, so that molecules of a solvent are as it were captive in the ink film. The solvent is only released slowly.

[0003] The retention of solvent in finished printed materials increasingly represents a problem in cases where this solvent has toxic properties, such as for instance the solvent toluene commonly applied in intaglio techniques. Current norms for toluene retention in finished printed materials are realized according to per se known methods in the above described first and second phase of the printing process. In order to decrease the toluene retention still further, finished printed material has to be stored for a longer period according to the prior art, for instance a period of at least three weeks, so that the toluene can be released slowly from the printed material.

[0004] There are drawbacks to prolonged storage of finished printed material. Storage takes up much costly space and in some cases is not possible, for instance in the case of magazines where the period between printing and appearance is inherently very short.

[0005] The object of the invention is to provide a method for drying printed materials, according to which the retention of solvent in finished printed materials can be reduced considerably at acceptably low cost and within a very short period relative to the retention attainable by means of prior art methods.

[0006] A further object is to provide an apparatus for performing the proposed method.

[0007] These objectives are achieved, and other advantages gained, with a method which according to the invention comprises of exposing a quantity of printed material for a determined period to a predetermined low pressure relative to the atmospheric pressure.

[0008] The method is for instance performed by subjecting finished printed material still in the printing press to a very low pressure immediately after the last printing run. The printing press is for instance provided for this purpose with a vacuum chamber closable by rollers, wherein finished printed material is fed into the vacuum chamber on a conveyor belt between a first pair of co-acting infeed rollers and is discharged from the vacuum chamber between a second pair of co-acting outfeed rollers.

[0009] In an advantageous embodiment the method according to the invention comprises the successive steps of:

(i) feeding a quantity of printed material under conditions of room temperature and atmospheric pressure into a space closable and evacuable in vacuum-tight manner,
(ii) closing the space,
(iii) at least partially evacuating the space for a determined period and maintaining a predetermined low pressure in the space relative to the atmospheric pressure, and
(iv) removing the quantity of printed material from said space after the determined period.

[0010] The method is particularly suitable for drying printed materials wherein at least one ink contains a solvent other than water, in particular an organic solvent, wherein according to the invention the predetermined low pressure is lower than the maximum vapour pressure of this solvent at room temperature. By evacuating the space to a pressure lower than the maximum vapour pressure a concentration gradient of the solvent in the applied ink film and the vicinity thereof can be maintained, which concentration gradient is necessary to sustain a diffusion in the gas phase (i.e. in the printed material, for instance paper, and in the vicinity thereof) of molecules of the solvent.

[0011] According to an advantageous embodiment of the method according to the invention the gases released during the evacuation according to step (iii) are guided to regeneration means for the solvent.

[0012] The determined period in step (iii) amounts for instance to a maximum of ten hours.

[0013] The determined period in step (iii) amounts for instance to at least one hour.

[0014] In a method according to the invention the predetermined pressure is preferably higher than 5 mbar (500 Pa). This preferred method is based on the consideration that the pump speed required at a pressure lower than 5 mbar is undesirably high from a cost viewpoint, and on the insight that at a pressure lower than 5 mbar the evaporation of water from printed materials is so high that, with a view to further processing of the printed materials, for instance in a binder, the moisture content becomes unacceptably low.

[0015] The quantity of printed materials to be fed in

step (i) is provided by way of example in the form of collected and bound finished printed materials, so-called *bundles*, but can also be provided for instance in the form of rolled-up folded sheets, so-called *printed rolls*, or in the form of flat folded sheets, so-called *piles*.

[0016] It has been found that close-packing of printed sheets of paper in a stack of finished printed material or in a pile under conditions of low pressure forms no obstacle to a rapid release of solvent.

[0017] The invention further relates to an apparatus for drying printed materials, comprising an autoclave and pumping means for evacuating the autoclave to a predetermined pressure, which autoclave is adapted to temporarily store therein a quantity of printed materials substantially immediately after manufacture of these printed materials.

[0018] An apparatus according to the invention preferably comprises regeneration means for regenerating solvent from gases released during evacuation of the autoclave. Regeneration of solvent generally affords a cost advantage, while in the case of harmful gases it is an obvious advantage that these gases not be released into the environment.

[0019] In an embodiment the regeneration means comprise an adsorber for adsorbing solvent thereon, and in normal operation of the apparatus the pumping means guide the released gases over the adsorber.

[0020] In a subsequent embodiment the regeneration means comprise a condenser, and in normal operation of the apparatus the pumping means guide the released gases over the condenser in order to separate the released gases into a low-solvent gas phase and a solvent-rich liquid phase.

[0021] In yet another embodiment the pumping means comprise a liquid ring-pump provided with a water buffer vessel, in a part of which buffer vessel a solvent-rich phase is created in normal operation of the apparatus, and the regeneration means are coupled to the solvent-rich phase of the buffer vessel.

[0022] In an advantageous embodiment the pumping means in an apparatus according to the invention comprise a cascade connection of at least one vacuum pump and at least one roots pump placed between this vacuum pump and the autoclave. The roots pump is applied in this embodiment to displace gases from the autoclave to the vacuum pump at a substantial compression ratio (for instance of a factor 10). The interposing of a roots pump results in a reduction of the required capacity of a vacuum pump to an extent such that a decrease in the total investment and operating costs of the apparatus is thereby achieved.

[0023] In a particularly advantageous embodiment the autoclave comprises at least three closable and separately evacuable compartments which are each provided with a closable entrance and a closable exit, wherein the exit of a first compartment forms the entrance of a second compartment and the exit of this second compartment forms the entrance of a third compartment.

[0024] In such an autoclave with three compartments it is possible to dry batches of finished printed materials in semi-continuous manner. The pressure in the second compartment is herein held continuously at the predetermined low value. A batch of printed materials, for instance loaded on pallets, is placed in the first compartment which is then closed and evacuated until the pressure in the first compartment becomes equal to the pressure in the second compartment. After opening of the exit of the first compartment the batch of printed materials is pushed along to the second compartment using a per se known transport system, and the exit of the first compartment is closed. The batch of printed materials is then held under the low pressure in the second compartment for a determined period, during which the first compartment can be loaded with a subsequent batch of finished printed materials and once again evacuated, and the third compartment can be discharged and evacuated once again. Once the determined period has elapsed, the exit of the second compartment is opened and the batch of printed materials is pushed along to the third compartment using a per se known transport system, whereafter the following batch of printed materials is subjected to the transporting and drying steps described here.

[0025] The invention will be elucidated hereinbelow on the basis of embodiments and with reference to the drawings.

[0026] In the drawings:

Fig. 1 shows a graphic representation of the drying speed of paper printed with a toluene-containing intaglio ink as a function of time,

Fig. 2 shows a graphic representation of the toluene reduction in batches of paper, each printed with a toluene-containing intaglio ink, as a function of the (low) external pressure applied for a determined period,

Fig. 3 is a graphic representation of the toluene reduction in batches of paper, each printed with a toluene-containing intaglio ink, at a (low) external pressure as a function of time,

Fig. 4 shows a first embodiment of an apparatus for drying printed materials according to the invention,

Fig. 5 shows a second embodiment of an apparatus for drying printed materials according to the invention,

Fig. 6 shows a third embodiment of an apparatus for drying printed materials according to the invention, and

Fig. 7 is a schematic view of a "pile" of finished printed material in a form in which it is suitable for loading onto a pallet and feeding into an autoclave of a drying apparatus according to the invention.

[0027] Corresponding components are designated in the drawings with the same reference numerals.

[0028] Fig. 1 is a graphic representation along linear scales in random units of the drying speed, s, of paper printed with a toluene-containing intaglio ink as a function of time, t, wherein the drying speed is defined as discharged mass per unit of time. During the printing process a toluene-containing ink is applied to a paper surface. The finished printed material may initially contain for instance about 6000 mg toluene per kg paper. In a first phase (I) the toluene molecules present are displaceable in virtually unobstructed manner and can be extracted in large quantities from the applied ink film, for instance by guiding heated air over the ink film at high speed. The greater part of the toluene is herein removed from the paper at a constant drying speed. In a second phase (II) the ink surface dries while the interior of the ink film still remains dry for a time. The printed materials can then contain for instance a quantity of toluene of between about 1500 mg/kg and about 6000 mg/kg. As the ink layer dries further, the escape of toluene is obstructed more strongly by the ink film. The decreasing drying speed is determined by the diffusion of the toluene in the ink film. In a third phase (III), when the printed materials leave the printer, the ink surface and the interior of the ink film are dried, as a result of which the toluene molecules are as it were captive in the ink film. In this phase the paper contains for instance less than about 1500 mg/kg toluene, which is only released slowly. It is during the second phase that the method according to the invention finds optimal application.

[0029] Fig. 2 is a graphic representation of the toluene reduction, red. (%), of paper printed with a toluene-containing intaglio ink and dried in accordance with the invented method, as a function of the (low) external pressure, p (mbar), applied for a determined period, for three different process parameters obtained by measuring the toluene reduction of a large number of batches at a determined pressure p and a residence time t. Curve A (unbroken line) shows the toluene reduction of paper printed with a standard toluene-containing intaglio ink and dried in an autoclave for 1.5 hours under conditions of low pressure p. Curve A shows that when the pressure is reduced from about 20 mbar to about 12 mbar the toluene reduction increases until a maximum value of about 50% is obtained, whereafter a further decrease in the pressure no longer results in a further toluene reduction. Curve B (dashed line) shows the toluene reduction of the same printed material as in curve A when it has been dried in the autoclave for 3 hours under conditions of low pressure p. Curve B shows that when the pressure is reduced from about 20 mbar to about 12 mbar the toluene reduction increases until a maximum value of about 63% is obtained, whereafter, as in curve A, a further decrease in the pressure no longer results in a further toluene reduction. The finding that below a sufficiently low pressure, in this case a "critical pressure" of 12 mbar, a further pressure decrease does not result in a further toluene reduction, is in line with the assumption that the decreasing drying speed is determined by the diffusion of the toluene in the ink film, on which the external pressure has no effect. The existence of a "critical pressure" for drying printed materials under low pressure is of great practical importance because a decrease in the pressure below this critical value is not only pointless, as shown above, but also results in an increase in the required pump capacity, and therewith in a (needless) increase in the cost of the pump installation. A further decrease in the pressure moreover leads to a stronger evaporation of water from paper, which is likewise disadvantageous for the required pump capacity and furthermore results in adverse consequences for the paper properties. Curve C (broken line) shows the toluene reduction of paper printed with a toluene-containing, so-called LR intaglio ink which is dried in an autoclave for 1.5 hours under conditions of low pressure p. An LR ink is an ink with an open structure from which the toluene can escape more easily than from the closed structure of the conventional intaglio inks. Because toluene evaporates more quickly from an LR ink than from a conventional ink, the diffusion of toluene in paper printed with an LR ink must be more rapid than in paper printed with a conventional ink, so that a lower pressure must also be applied to sustain this diffusion. Curve C shows that when the pressure is reduced from about 20 mbar to a "critical pressure" of about 10 mbar the toluene reduction increases until a maximum value of about 65% is obtained, whereafter a further decrease in the pressure no longer results in a further toluene reduction. The "critical pressure" for the LR ink used here is therefore, as expected, lower than that for a conventional intaglio ink, while the realized ink reduction is significantly higher.

[0030] Fig. 3 is a graphic representation of the toluene reduction in batches of paper, each printed with a toluene-containing intaglio ink, at a (low) external pressure as a function of time. Curve AB (unbroken line) shows the toluene reduction of the same printed material as in curves A and B of fig. 2 when this printed material has been dried in the autoclave under a pressure of 5 mbar. Curve AB shows that in a first phase (i) of about 1 hour, in which low pressure is applied around the printed material and this low pressure penetrates slowly into the printed material, the toluene reduction increases comparatively quickly until a value of about 40% is obtained. In a second phase (ii), in which a constant toluene concentration is adjusted on the surface of the ink film on the printed material, a further toluene reduction is then achieved to a value of about 80%. The toluene evaporation in this phase (ii) is determined by the diffusion in the ink film, and hereby by the concentration gradient of the toluene in the ink film. In a third phase (iii), after a total time period of about 10 hours, the toluene evaporation proceeds ever more slowly as a result of a decreasing toluene concentration on the surface of the ink film. Curve C (broken line) shows the toluene reduction of the same printed material as in curve

C of fig. 2 (with an LR ink) when this printed material has been dried in the autoclave under a pressure of 5 mbar. Curve C shows, just as curve AB, a progression in which three phases (i, ii, iii) can be distinguished. This shows that the second phase (ii) and third phase (iii) occur sooner in paper printed with LR ink (curve C) than in corresponding paper printed with conventional intaglio ink (curve AB).

[0031] Fig. 4 shows a highly simplified diagram of an apparatus 1 for drying toluene-containing printed material according to the invention, with an autoclave 2 which is connected to the inlet of a roots pump 3, the outlet of which is connected to the respective inlets of three backing pumps 4 placed in parallel, the respective outlets of which are connected to a toluene recovery installation (TRI) 5, an air outlet of which is connected to the space 6 in which is arranged the press for the printed materials for drying. In this embodiment autoclave 2 is a cylinder with a length of about 15 m and a diameter of about 3.5 m, in which about 20 pallets of finished printed materials can be stored. The operation of the apparatus is as follows. Using backing pumps 4 air is extracted from the filled autoclave 2 until a pressure of about 10 mbar is obtained. At this low pressure toluene evaporates and escapes as gas from the printed material, and the roots pump provides a volume displacement at a compression factor having a value of about 10. Air from the autoclave is guided by pumps 3, 4 directly to an adsorber (not shown) of the TRI 5, where condensation water is drawn off and guided to a water/toluene separator, where toluene is recovered which can be re-used in the printing process. Air from the TRI 5, which in principle is free of toluene, is fed back in the apparatus of this embodiment to space 6 in which the relevant printing press is arranged.

[0032] Fig. 5 shows a highly simplified diagram of an alternative embodiment of a drying apparatus 7 which differs from the apparatus 1 of fig. 4 in that between roots pump 3 and backing pumps 4 a condenser 8 is placed for guiding thereover air coming from autoclave 2 and causing condensation from this air of a water/toluene mixture which is guided to a water/toluene separator 9 where toluene is recovered which can be re-used in the printing process.

[0033] Fig. 6 shows a highly simplified diagram of a subsequent embodiment of a drying apparatus 7 which differs from the apparatus 1 of fig. 4 in that behind the first roots pump 3 is placed a second stage with a roots pump 11, wherein the first roots pump 3 functions in a pressure range of 10 to 30 mbar and the second roots pump 11 functions in a pressure range of 30 (the vapour pressure of water) to 100 mbar. A liquid ring-vacuum pump 12 is connected behind the second roots pump 11. When this pump 12 operates at a pressure of 30 mbar, there occurs in the liquid ring condensation of toluene which is discharged with the water to a cooling water buffer vessel 13, where a separation between pure water and a toluene-rich phase takes place. In this embodiment pure water from buffer vessel 13 is drained for re-use to a boiler-house 14, while the toluene-rich phase is guided to a water/toluene separator 9.

[0034] Fig. 7 shows a perspective view of a "pile" 15 of finished printed material in a form in which it is suitable for loading onto a pallet and feeding into an autoclave of a drying apparatus according to the invention. A pile 15 comprises a number of printed and vertically placed folded sheets 16 which are clamped between two vertical wooden partition plates 17 using a tightly fastened strapping strip 18. It has been found that under conditions of low pressure the closed structure of a pile forms no obstacle to a rapid release of toluene.

Claims

1. Method for drying printed materials substantially immediately after the manufacture thereof, comprising of exposing a quantity of printed material for a determined period to a predetermined low pressure relative to the atmospheric pressure.

2. Method as claimed in claim 1, comprising the successive steps of:

   (i) feeding a quantity of printed material under conditions of room temperature and atmospheric pressure into a space closable and evacuable in vacuum-tight manner,
   (ii) closing the space,
   (iii) at least partially evacuating the space for a determined period and maintaining a predetermined low pressure in the space relative to the atmospheric pressure, and
   (iv) removing the quantity of printed material from said space after the determined period.

3. Method as claimed in claim 1 or 2 for drying printed materials wherein at least one ink contains a solvent other than water, in particular an organic solvent, **characterized in that** the predetermined low pressure is lower than the maximum vapour pressure of said solvent at room temperature.

4. Method as claimed in claim 3, **characterized in that** the gases released during the evacuation according to step (iii) are guided to regeneration means for the solvent.

5. Method as claimed in claim 3 or 4, **characterized in that** the determined period in step (iii) amounts to a maximum of ten hours.

6. Method as claimed in any of the claims 3-5, **characterized in that** the determined period in step (iii) amounts to at least one hour.

7. Method as claimed in any of the foregoing claims,

characterized in that the predetermined pressure is higher than 5 mbar (500 Pa).

8. Method as claimed in any of the claims 2-7, **characterized in that** the quantity of printed materials to be fed in step (i) is provided in the form of *printed rolls*.

9. Method as claimed in any of the claims 2-7, **characterized in that** the quantity of printed materials (16) to be fed in step (i) is provided in the form of *piles* (15).

10. Apparatus (1, 7, 10) for drying printed materials according to a method as claimed in claim 2 or 3, comprising an autoclave (2) and pumping means (3, 4, 11, 12) for evacuating the autoclave (2) to a predetermined pressure, **characterized in that** the autoclave (2) is adapted to temporarily store therein a quantity of printed materials substantially immediately after manufacture of said printed materials.

11. Apparatus (1, 7, 10) as claimed in claim 10 for drying printed materials according to a method as claimed in claim 3, **characterized in that** this comprises regeneration means (5, 8, 9, 13) for regenerating solvent from gases released during evacuation of the autoclave (2).

12. Apparatus (1) as claimed in claim 11, **characterized in that** the regeneration means (5) comprise an adsorber for adsorbing solvent thereon, and in normal operation of the apparatus (1) the pumping means (3, 4) guide the released gases over the adsorber.

13. Apparatus (7) as claimed in claim 11, **characterized in that** the regeneration means comprise a condenser (8), and in normal operation of the apparatus (7) the pumping means (3, 4) guide the released gases over the condenser (8) in order to separate the released gases into a low-solvent gas phase and a solvent-rich liquid phase.

14. Apparatus (10) as claimed in claim 11, **characterized in that** the pumping means (12) comprise a liquid ring-pump (12) provided with a water buffer vessel (13), in a part of which buffer vessel (13) a solvent-rich phase is created in normal operation of the apparatus (10), and the regeneration means (9) are coupled to the solvent-rich phase of the buffer vessel (13).

15. Apparatus (1, 7, 10) as claimed in any of the claims 10-14, **characterized in that** the pumping means comprise a cascade connection of at least one vacuum pump (4, 12) and at least one roots pump (4, 11) placed between this vacuum pump (4, 12) and the autoclave (2).

16. Apparatus as claimed in any of the claims 10-15, **characterized in that** the autoclave comprises at least three closable and separately evacuable compartments which are each provided with a closable entrance and a closable exit, wherein the exit of a first compartment forms the entrance of a second compartment and the exit of this second compartment forms the entrance of a third compartment.

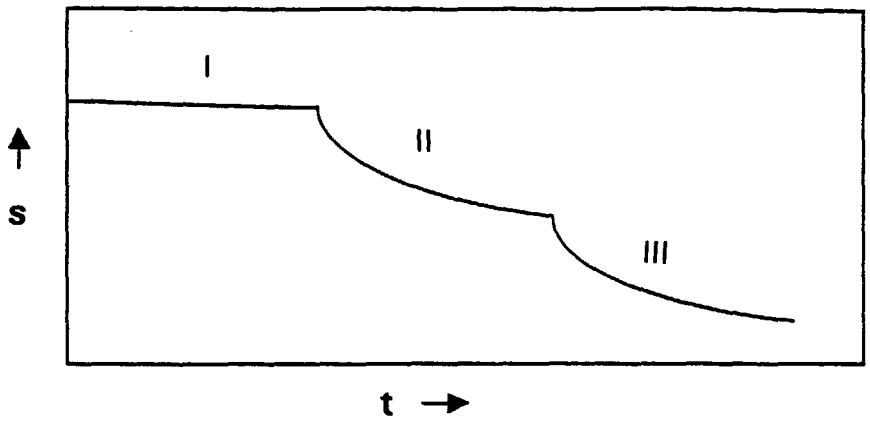

Fig. 1

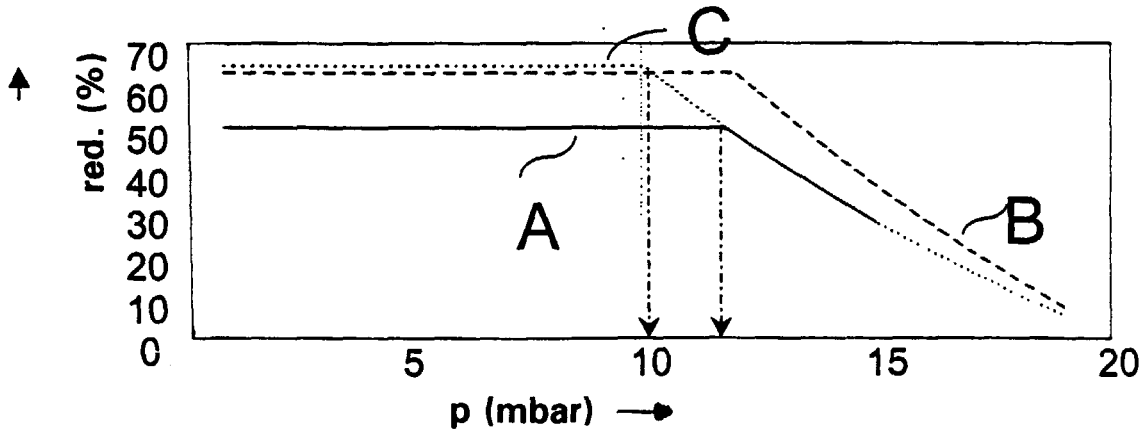

Fig. 2

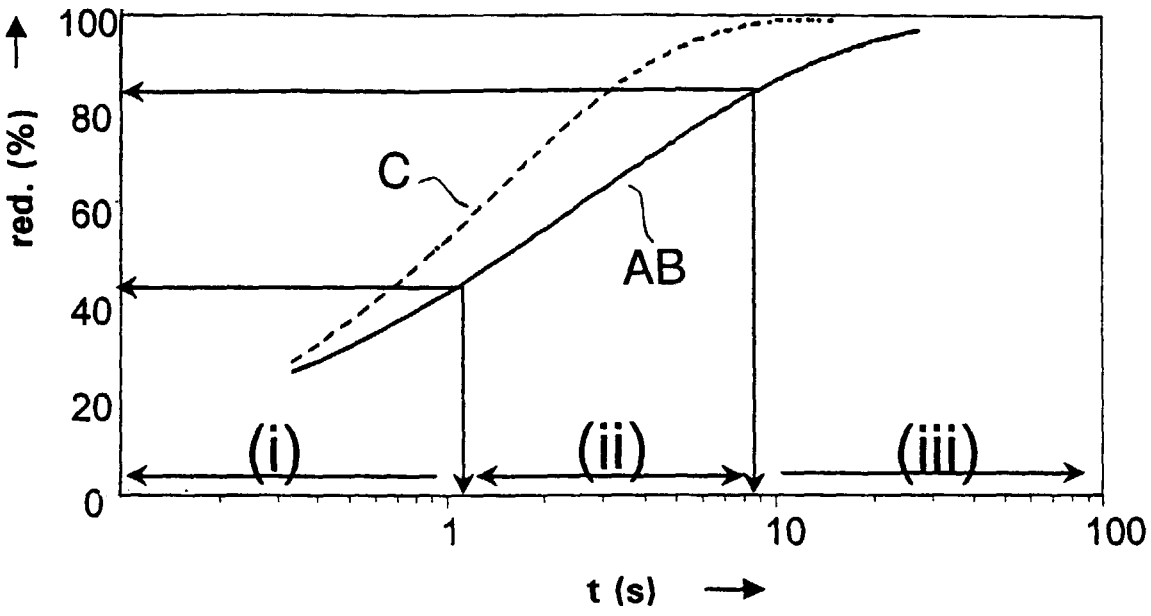

Fig. 3

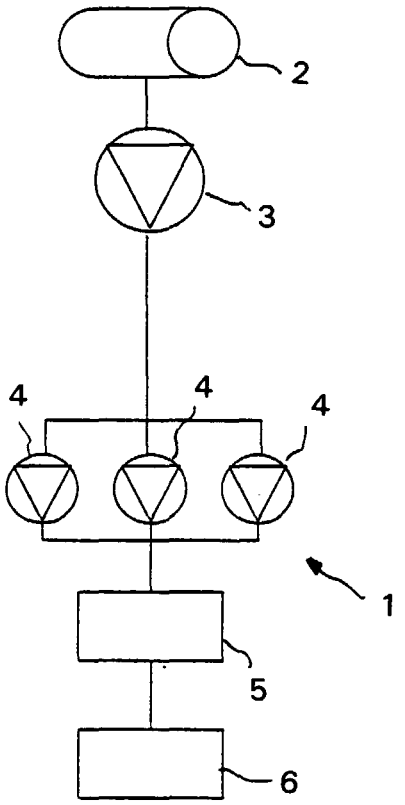

Fig. 4

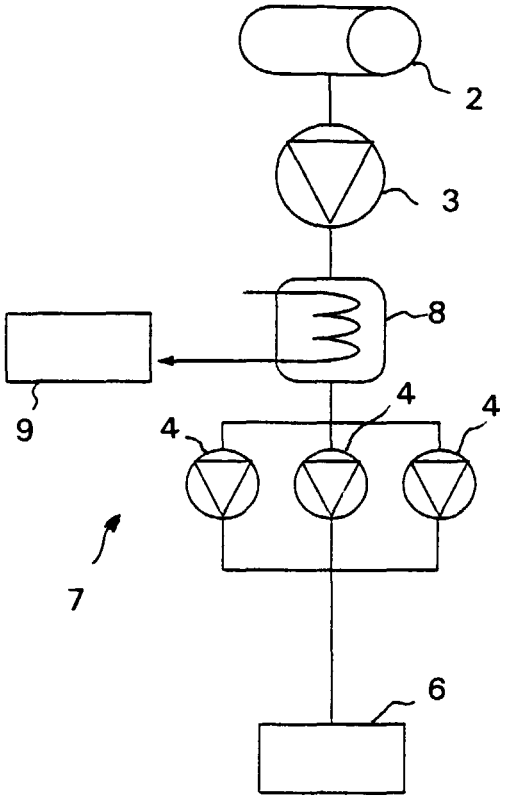

Fig. 5

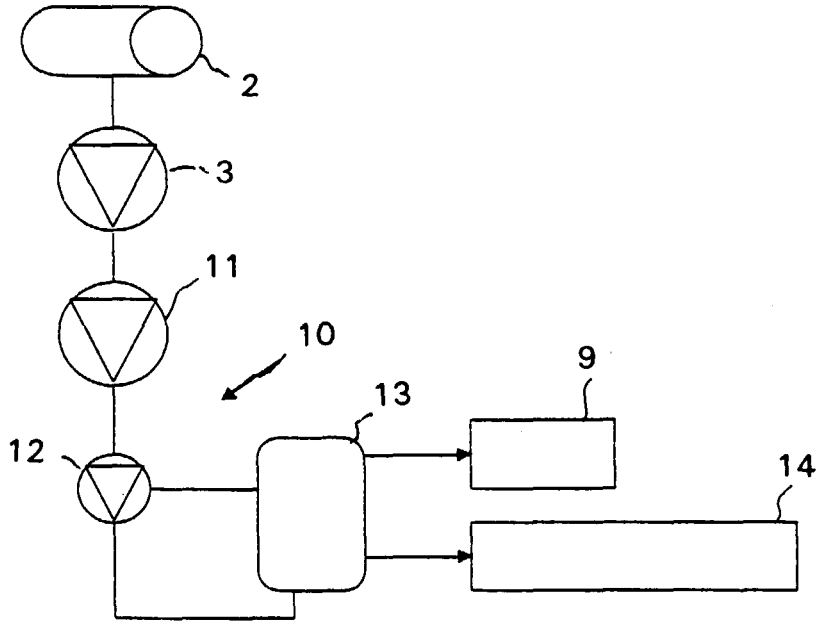

Fig. 6

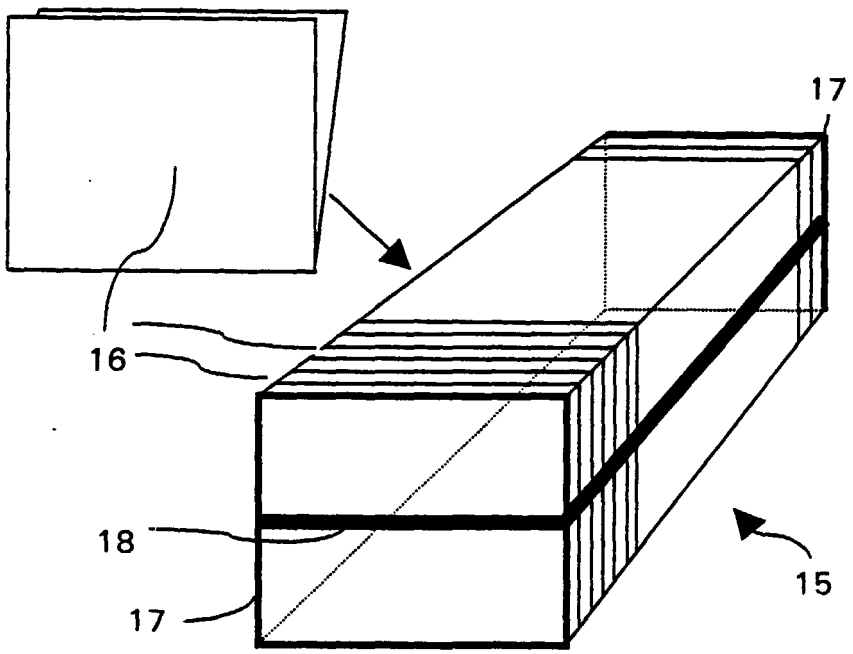

Fig. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 20 1866

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.7)
A	FR 1 144 031 A (SOCIÉTÉ DE SERVICES PUBLICS) 8 October 1957 (1957-10-08) * the whole document *	1	B41F23/04
A	FR 1 140 692 A (LAVORAZIONE AGGLOMERATI SUGHERO) 5 August 1957 (1957-08-05) * the whole document *	1	
A	US 3 259 992 A (WILLARD R. BONWIT) 12 July 1966 (1966-07-12) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

B41F
B41M
F26B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 September 2000	Loncke, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 20 1866

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18-09-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 1144031 A	08-10-1957	NONE	
FR 1140692 A	05-08-1957	NONE	
US 3259992 A	12-07-1966	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82