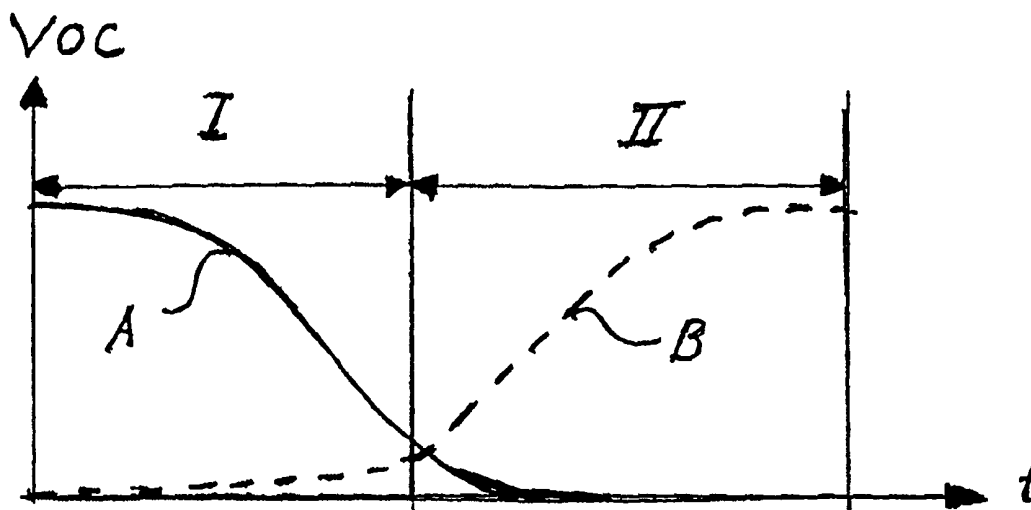




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : F26B 21/06, 23/02, B01D 53/86	A1	(11) International Publication Number: WO 99/09364 (43) International Publication Date: 25 February 1999 (25.02.99)
(21) International Application Number: PCT/SE98/01472 (22) International Filing Date: 14 August 1998 (14.08.98) (30) Priority Data: 9702938-3 14 August 1997 (14.08.97) SE (71) Applicant (for all designated States except US): SUNDS DEFIBRATOR INDUSTRIES AB [SE/SE]; Strandbergsgatan 61, S-112 51 Stockholm (SE). (72) Inventors; and (75) Inventors/Applicants (for US only): NILSSON, Lars [SE/SE]; Norregårdsvägen 7A, S-352 44 Växjö (SE). BACKA, Stefan [SE/SE]; Regementsgatan 5, S-723 45 Västerås (SE). PERSSON, Ulf [SE/SE]; Enköpingsvägen 31, S-740 82 Örsundsbro (SE). (74) Agents: ALDENBÄCK, Ulla et al.; Dr Ludwig Brann Patentbyrå AB, P.O. Box 1344, S-751 43 Uppsala (SE).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>In English translation (filed in Swedish).</i>

(54) Title: TWO STAGE PROCESS FOR DRYING OF RAW WOOD MATERIAL



(57) Abstract

Method for drying wood raw material (10) by means of hot gases (20) supplied to the drying process, in which VOC, apart from water, evaporate from the wood raw material into the gases. The drying process is divided and carried out in at least two sub-steps (I, II), from which process gas (22, 33) is removed separately, and the drying process is thus controlled that VOC evaporate during one of the sub-steps, and the VOC are concentrated to this sub-step. The temperature of the gas containing VOC is increased to a temperature exceeding 180 °C before VOC are oxidised catalytically at said elevated temperature, in order to reduce the discharge of VOC from the drying process.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakistan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

TWO STAGE PROCESS FOR DRYING OF RAW WOOD MATERIAL

FIELD OF THE INVENTION

The present invention relates to a method for drying wood. More precisely, the inventive method relates to a method for drying wood comprising steps to efficiently eliminate or reduce, from the drying gases, terpenes and other volatile organic compounds, which are forced out of the wood during the drying process.

PRIOR ART

Wood raw material such as bio-fuel, chips or fibres are dried before being used for energy production or for manufacturing wood based boards, such as particle boards or oriented strand boards. During the drying process, terpenes and other volatile organic compounds are forced out. Such organic compounds are often referred to as VOC - short for Volatile Organic Compounds - and they will be thus denoted in the following. VOC evaporate along with moisture for instance, into the gases which during the drying process flow through the drying device and the wood material, and leave the drying device along with said moisture containing waste gases from the process. Normally the temperature of the waste or process gases vented during the drying process is between 80°C - 150°C, depending on the residual moisture contents of the wood material. Depending on the drying conditions, and to some extent on the composition of the wood raw material, essentially all VOC evaporate during the initial stages of the drying process while, under other conditions or with other compositions, essentially all VOC evaporate during the final stages of the drying process. Since it is desired to reduce the discharged amount of VOC, the VOC present in the process gases are destroyed, normally using either catalytic or thermal oxidation. In order to secure an efficient destruction of the VOC present in the process gases, the exhaust gases are heated to a temperature of approximately 350°C for catalytic oxidation, and 850°C for thermal oxidation. A required gas tem-

perature for achieving sufficient oxidation is determined by the composition of the waste gases, which varies according to the composition, type and quality of the wood raw material. According to prior art, the waste gases are heated to the elevated temperature by means of a complicated and costly system, comprising heat exchangers of regenerating or recuperative type, where the heat of the waste gases, from which the VOC have been eliminated, is used for heating the gases still containing VOC, before they are delivered to the reactor. It is often, however, necessary to supply additional heat to the waste gases upstreams or in the reactor, in order to achieve the desired reduction of the VOC contents. According to prior art, the waste gases are vented from the drying device in only one place. This means that the whole amount of process gas leaving the drying device has to be pre-heated prior to oxidation in the reactor. This, together with the fact that the process gases often are heated to a higher temperature than necessary in order to secure an efficient reduction of the VOC discharge from the drying device, leads to increasing demands on, and size of, the heat exchange system arranged at the reactor, as well as an increased required energy for the destruction of VOC, and for the drying process as a whole.

AIM OF THE INVENTION

The primary aim of the invention is to provide a method for drying wood raw material, comprising a destruction of VOC evaporated during the drying with a more efficient use of energy, and lower investment needs. The inventive method is cost efficient, with low maintenance requirements and a low energy needs, which secures the oxidation of essentially all of the VOC which evaporate into the drying gases prior to venting the waste gases into the atmosphere.

Another aim of the invention is to provide a method for drying wood raw material which, irrespective of variations regarding the type, composition

and quality of the wood raw material, secures the oxidisation of all of the VOC evaporated into the drying gases before venting the drying gases into the atmosphere.

Further advantages of the present invention are apparent from the following description of the invention, and from the described preferred embodiments.

THE INVENTION

In order to achieve said results, the present invention suggests a method for drying wood raw material according to the preamble of claim 1, where said wood raw material is dried in at least two sub-steps, said drying being controlled so that essentially all VOC are removed during one sub-step, and so that said VOC from the wood raw material is concentrated in the process gas which is removed during said sub-step, said gas being separated from the remaining process gases. The gas containing VOC is heated before it is transferred to a reactor where it is oxidised catalytically, at a gas temperature which exceeds 180°C. A suitable gas temperature for the oxidisation of the VOC is from 200°C to 500°C. Preferably the VOC is oxidised within a temperature interval from 200°C to 350°C. The increase in gas temperature to a level which is necessary for catalytic oxidisation in the reactor is achieved by mixing the drying gases, with hot gases upstreams from the reactor, preferably combustion flue gases. By dividing the drying process into two or more sub-steps, while at the same time controlling the drying process so that the VOC is removed from the wood during one of the sub-steps, which leads to the concentration of essentially all of the VOC in the gases which are removed from said sub-step, the amount of gas to be treated is reduced significantly. At the same time, the VOC concentration in the amount of process gas to be treated is increased. Preferably the process gases, which no longer contain VOC, are returned to the drying process as

drying gas. Process gas which has been treated in the catalytic oxidation reactor is supplied to the drying process as drying gas, downstreams from the reactor, in a different sub-step in the drying process.

According to a preferred embodiment of the invention, the wood raw material is dried in an essentially continuous process, comprising at least two sub-steps. Sub-flows of process gas are removed from the different sub-steps and the drying process is controlled so that essentially all VOC evaporate from the wood raw material during one sub-step, thereby concentrating essentially all the VOC to the sub-flow from said sub-step. The gas temperature in said sub-flow is increased before the VOC are removed by catalytic oxidation at an elevated temperature in a reactor.

As was described above, the process gas containing VOC is heated before oxidation, preferably by mixing it with hot gases upstreams from the reactor. According to a preferred embodiment of the invention, hot drying gases are used for increasing the temperature to a required level before oxidation of VOC in the reactor. After oxidation in the reactor, the process gas, now relieved from its VOC contents, is transferred to a further process step. Normally, the hot drying gases are generated by combustion of a suitable fuel, such as oil, gas or wood or other suitable bio-fuel. It may be suitable to use waste material from the on-site production facility in this fuel. As an alternative or complement to the combustion gases, it is of course possible to use other heat sources, such as gas heaters based on electrical resistance elements, heat exchangers for extracting excess heat from the drying process or, even better, from another process with waste gases with a high heat content.

It has, during application of the inventive process, turned out that in order to achieve an efficient decrease of the VOC contents in the process gas, the gas temperature should exceed 180°C. It is advantageous to heat the proc-

ess gas, before the oxidation, to a gas temperature in the interval between 200° and 500°C. Preferably a gas temperature in the interval between 200°C and 350°C is chosen, in order to secure the destruction of essentially all the VOC, without unnecessarily influencing the energy efficiency in a negative way.

DRAWINGS

The invention will in the following be explained in closer detail, and be exemplified with preferred embodiments, with reference to the appended drawings.

Fig. 1 illustrates, schematically, a two step method for drying wood raw material according to a preferred embodiment of the invention.

Fig. 2 illustrates, schematically, a two step method for drying wood raw material according to an alternative embodiment of the invention.

Fig. 3 illustrates, schematically, evaporated VOC over time, in the embodiments shown in fig.1 and fig. 2.

DETAILED DESCRIPTION OF THE INVENTION

According to the preferred embodiment of the invention, shown in fig. 1, the wood raw material is dried by means of a two step method. Wet wood raw material 10 is supplied to the process in step 1, I, in which it is processed, whereupon the wood material 10 is transferred to step 2, II, in which it is processed further, before it leaves the process as dried wood raw material 19. In fig. 1, this two step method is shown as a continuous or semi-

continuous process where the wood material 10 passes through two drying devices or drying chambers 11, 12, e.g. drying ovens or autoclaves – the flow of the wood raw material 10 is denoted by filled bold face arrows. Drying gas 20, in the form of hot gases, is generated in some kind of gas generator 13 as described above, e.g. by combustion of a fuel such as wood waste material 14, in the presence of combustion air 15. Part of said hot drying gas 21 is provided to the drying oven 11 where the wood material 10 is processed during step 1, I, by allowing the drying gas 21 to pass through or over the wood material 10, making VOC and water evaporate from the wood material. The conditions inside oven 11 are controlled such, that VOC evaporated from the wood material are concentrated to step 1, I. Process gas 22 is vented from step 1, I, and mixed with hot drying gas 20 so that the temperature of the process gas is increased. The heated process gas 23 is introduced into a reactor 16 in which the VOC are oxidised. Then the process gas 24 coming from the reactor 16, which has been relieved from its VOC contents, is introduced into an oven 12 provided for step 2, II, of drying process. Process gas 25 is removed from step 2, II, and is preferably transferred to a conventional device for purifying exhaust gases, e.g. dust separation, not shown in the figures. In fig. 1 a parallel flow is shown during step 1, I, and cross-flow is shown during step 2, II, only for the purpose of illustrating the process in a clear schematic way. Thus, the type of relation between the respective flows of the wood raw material and the drying gas through the drying facilities, essentially counter flow, cross-flow or parallel flow, may be chosen freely according to what is deemed suitable.

As an alternative to the continuous or semi-continuous process in which the wood raw material is processed in two drying devices 11, 12, the two step method according to this embodiment may be performed in batches, said wood raw material being introduced into a drying oven or an autoclave, processed with drying gas in a first step 1. Then the step 1 process gas is mixed with more drying gas and heated to a temperature suitable for catalytic oxidation. The VOC contained in the process gas is now oxidised before

the process gas, now relieved from its VOC contents, is returned to the drying oven or autoclave, as drying gas for step 2.

According to the alternative inventive two step method for drying wood raw material which is shown in fig. 2, wet wood raw material is, in the above described way introduced into an oven or an autoclave 11, in which the wood material is processed in step 1, I. The wood material is transferred to a new autoclave 12, where it is processed further in step 2, II, before it leaves the process as dried wood raw material 19. Also according to this alternative embodiment, hot gases are used as drying gas 20, a part of said hot drying gas 32 being supplied to the drying process during step 2, in which it passes through or over the wood raw material, the conditions in the drying device 12 during step 2, II, being so controlled, that essentially all VOC is evaporated from the wood material during step 2. Process gas 33 is removed from the drying facility 12 for step 2, II, and is mixed with hot drying gas 31 in order to increase the temperature of the process gas. The heated process gas 34 is, after being heated, introduced into a reactor 16 in which the VOC are oxidised, after which the process gas 35 relieved from its VOC contents, downstreams of the reactor 16 is supplied as drying gas into a drying oven or autoclave 11 provided for step 1 of the drying process, where it passes through or over the wood raw material. Process gas 36 is removed from step 1, I, and is advantageously transferred to a conventional device for purification of process gases from a drying facility, not shown. In fig. 2, cross-flow is shown in step 1, I, and counter-flow is shown in step 2, II, solely for the purpose of achieving a clear schematic illustration of the process. Thus, the type of relation between the flow of the wood raw material and the drying gases through the drying facility, essentially counter-flow, cross-flow or parallel flow, may also in this case be chosen freely according to what is deemed appropriate. In the application of said alternative drying process for drying batches of wood raw material, two batch processes should be run in parallel, so that process gas removed from step 2, II, in the one process can, after

VOC oxidation, be provided to step 1, I, of the other process, in order to maintain an efficient use of energy.

The evaporation of VOC from the wood raw material over time, in carrying out the above described two step methods according to the present invention is shown in fig. 3. The solid curve A shows that in carrying out the process according to fig. 1, such conditions are upheld during step 1, I, that the evaporation of VOC from the wood raw material is essentially completed during said step 1, I, and that only a negligible amount of residual VOC evaporates during step 2, II. As can be seen from the dotted curve B, such conditions are upheld during step 1, I, that essentially no, or only negligible amounts of VOC evaporate, while such conditions are upheld during step 2, II, that VOC evaporation from the wood raw material essentially takes place during step 2, II. In order to achieve the desired VOC evaporation during the process, the process is controlled regarding process variables such as temperature, pressure, dew point, velocity of the drying gas flow, flow distribution in the oven, et c. The choice between a process with VOC evaporation according to curve A and a process with VOC evaporation according to curve B is made based on conditions such as the structure of the drying facility, type and composition of the wood raw material, and demands on the dried wood material in a subsequent process or use.

CLAIMS

1. Two step method for drying wood raw material, in which hot gases are provided to the drying process, and in which, apart from water, also VOC evaporate into the gases, and in which VOC evaporated into the process gases are oxidised catalytically at an elevated temperature in order to reduce the discharge of VOC from the drying process, **characterised in** that wet wood raw material (10) is supplied to step 1, in which it is processed, after which the wood raw material is transferred to step 2 where it is processed further, before leaving the process as dried wood raw material (19), that drying gas (20) is generated in the form of hot gases, that part of said hot drying gas is supplied to the process during step 1 in which it passes through or over the wood raw material, that the conditions during step 1 are thus controlled, that essentially all VOC evaporate from the wood raw material during step 1, that process gas (22) is removed from step 1 and mixed with hot gases in order to increase the temperature of the process gas, that the heated process gas (23) is introduced into a reactor (16) in which VOC is oxidised, and in that, downstreams of the reactor, the hot process gas (24) now relieved from its VOC contents is supplied to the drying process in step 2, in which it passes through or over the wood raw material.

2. Method according to claim 1, **characterised in** that the temperature of the process gas (23) containing VOC is increased to a temperature in the interval between 200°C and 500°C.

3. Method according to claim 2, **characterised in** that the temperature of the process gas (23) containing VOC is increased to a temperature in the interval between 200°C and 350°C.

4. Method according to any of the above claims, **characterised in** that hot gases to be used as drying gas (20, 21) and for heating process gas (20) prior to VOC oxidation are generated by combustion of a fuel.

1/2

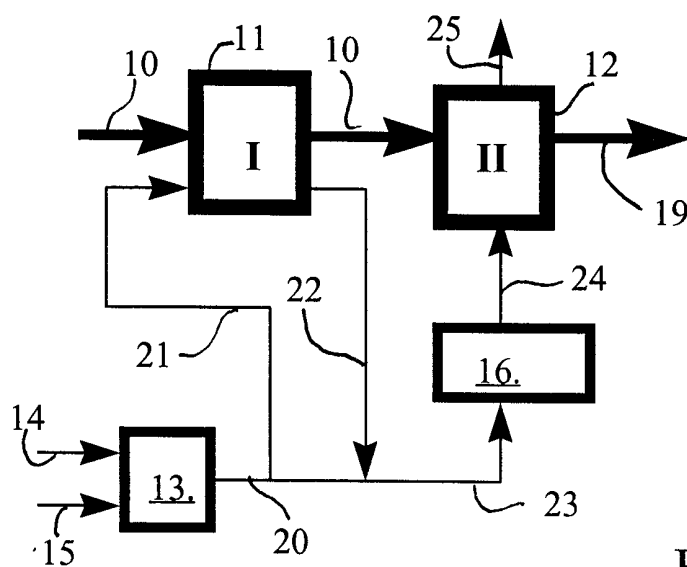


Fig 1.

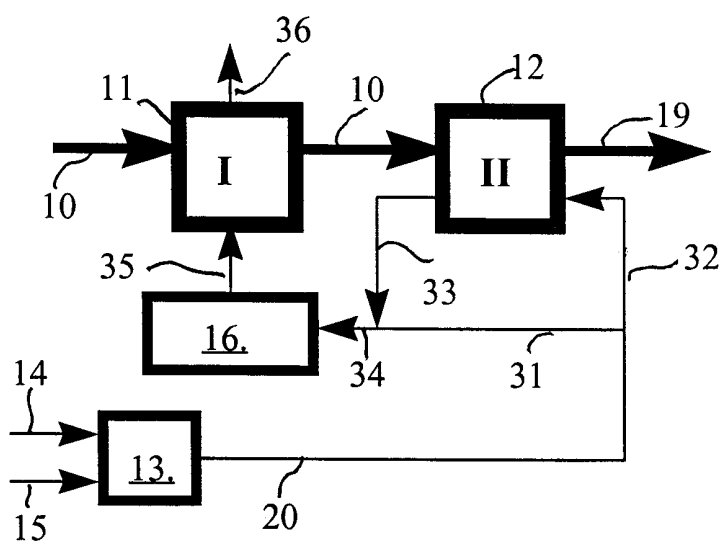
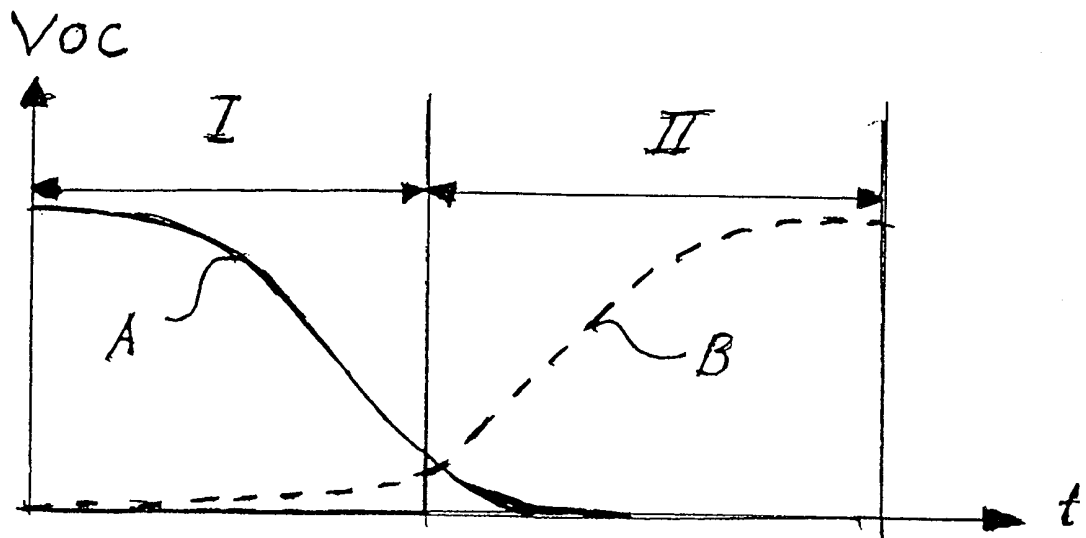


Fig 2.

2/2

Fig 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/01472

A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: F26B 21/06, F26B 23/02, B01D 53/86 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)		
IPC6: F26B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
WPI, EPODOC		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9425812 A1 (FRITZ EGGER GES. M.B.H.), 10 November 1994 (10.11.94), page 5, line 29 - page 6, line 34, figure 1, abstract	1-4
	--	
A	US 4213947 A (FREMONT ET AL), 22 July 1980 (22.07.80), column 2, line 58 - column 3, line 56, figure 1, abstract	1-4
	--	

☐ Further documents are listed in the continuation of Box C. ☒ 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
17 November 1998		24. 11 .1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86		Authorized officer Björn Salén Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/11/98

International application No.

PCT/SE 98/01472

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9425812 A1	10/11/94	DE 4313972 A	03/11/94
US 4213947 A	22/07/80	NONE	