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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

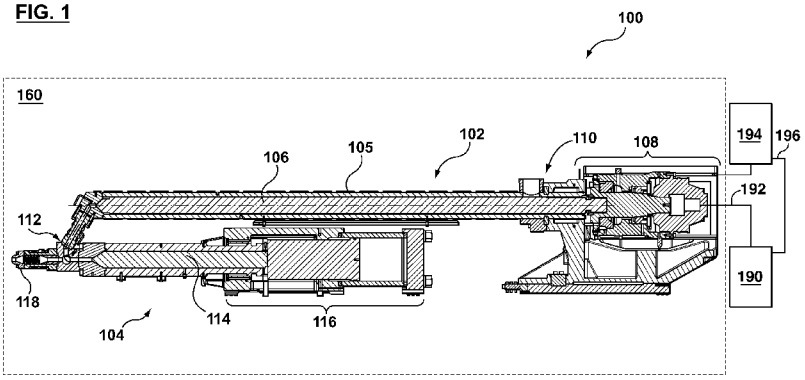
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(54) **Title**: AN INJECTION MOLDING MACHINE HAVING AN INTERNAL COMBUSTION ENGINE WITH A WASTE HEAT RECOVERY SUB-SYSTEM

FIG. 1



(57) **Abstract**: There is discloses an injection molding system (160) that comprises a drive (108) for actuating a component of the injection molding system; an internal combustion engine (190), the internal combustion engine (190) being directly mechanically coupled to the drive (108); a heat-driven component; a waste heat recovery sub-system (194) configured to recover waste heat from the internal combustion engine (190) and to re-use the so-recovered waste heat for operating the heat-driven component to perform at least one injection molding function.

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AN INJECTION MOLDING MACHINE HAVING AN INTERNAL COMBUSTION ENGINE WITH A WASTE HEAT RECOVERY SUB-SYSTEM

FIELD OF THE INVENTION

The present invention generally relates to, but is not limited to, a molding system, and more specifically the present invention relates to, but is not limited to, an injection molding machine having an internal combustion engine with a waste heat recovery sub-system.

BACKGROUND OF THE INVENTION

Molding is a process by virtue of which a molded article can be formed from molding material by using a molding system. Various molded articles can be formed by using the molding process, such as an injection molding process. One example of a molded article that can be formed, for example, from polyethylene terephthalate (PET) material is a preform that is capable of being subsequently blown into a beverage container, such as, a bottle and the like.

As an illustration, injection molding of molding material (such as, PET, for example) involves heating the PET material (or other suitable molding material for that matter) to a homogeneous molten state and injecting, under pressure, the so-melted PET material into a molding cavity defined, at least in part, by a female cavity piece and a male core piece mounted respectively on a cavity plate and a core plate of a mold. The cavity plate and the core plate are urged together and are held together by clamp force, the clamp force being sufficient to keep the cavity and the core pieces together against the pressure of the injected PET material.

The molding cavity has a shape that substantially corresponds to a final cold-state shape of the molded article to be molded. The so-injected PET material is then cooled to a temperature sufficient to enable ejection of the so-formed molded article from the molding cavity. When cooled, the molded article shrinks inside of the molding cavity and, as such, when the cavity and core plates are urged apart, the molded article tends to remain associated with the core piece. Accordingly, by urging the core plate away from the cavity plate, the molded article can be subsequently fully demolded by ejecting it off the core piece. Ejection structures are known to assist in removing the molded articles from the core halves. Examples of the ejection structures include stripper plates, stripper rings and neck rings, ejector pins, etc.

It is known in the art to use either hydraulic and/or electrically driven actuators to drive various components of an injection molding machine.

US patent 5,351,487 issued to Abdelmalek on October 4th, 1994 discloses a method for recovering and utilizing residual waste heat energy normally rejected into the atmosphere from a combined direct expansion refrigeration system driven by a natural gas or internal combustion engine, wherein the waste heat energy rejected from the condenser of the refrigeration system is combined with the heat energy rejected from the engine block cooling fluid and the exhaust gas stream and recovered by a refrigerant power fluid to drive a vapor power expander and co-generate auxiliary electric power.

SUMMARY OF THE INVENTION

According to a first broad aspect of the present invention, there is provided an injection molding system that comprises: a drive for actuating a component of the injection molding system; an internal combustion engine, the internal combustion engine being directly mechanically coupled to the drive; a heat-driven component; a waste heat recovery sub-system configured to recover waste heat from the internal combustion engine and to re-use the so-recovered waste heat for operating the heat-driven component to perform at least one injection molding function.

According to a second broad aspect of the present invention, there is provided an injection molding system that comprises: a drive for actuating a component of the injection molding system; a stand-alone power source, the stand-alone power source being directly mechanically coupled to the drive; a heat-driven component; a waste heat recovery sub-system configured to recover waste heat from the internal combustion engine and to re-use the so-recovered waste heat for operating the heat-driven component to perform at least one injection molding function.

These and other aspects and features of non-limiting embodiments of the present invention will now become apparent to those skilled in the art upon review of the following description of specific non-limiting embodiments of the invention in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

A better understanding of the non-limiting embodiments of the present invention (including alternatives and/or variations thereof) may be obtained with reference to the detailed description of the non-limiting embodiments along with the following drawings, in which:

Figure 1 is a cross-section view of a portion of an injection unit implemented in accordance with a non-limiting embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

With reference to Figure 1, there is depicted a non-limiting embodiment of an injection unit 100 that can be configured to implement non-limiting embodiments of the present invention. The injection unit 100 can be part of an injection molding machine 160, which is only conceptually depicted in Figure 1, but is well known to those skilled in the art. The injection molding system 160 can be configured for manufacturing of various molded articles. Purely as means of an example for illustrating embodiments of the present invention, it shall be assumed that the injection unit 100 is part of the injection molding system 160 configured for manufacturing of preforms which are suitable for subsequent blow-molding into beverage containers. However, it should be expressly understood that embodiments of the present invention are not so limited and can be equally implemented within context of other type of injection equipment.

To that extent, the injection molding system 160 can include a number of known components, such as a clamp, a mold mounted onto the clamp, chillers, heaters, de-humidifiers and other equipment.

Within this non-limiting illustration of embodiments of the present invention, the injection unit 100 can be of a two-stage type and to that extent, the injection unit 100 comprises a barrel 102 and a shooting pot 104. Within the barrel 102, there is provided a screw 106 which is actuated by a screw actuator 108. Within these embodiments of the present invention, the screw actuator 108 imparts rotational movement to the screw 106. The barrel 102 is associated with a plurality of barrel heaters 105. Combination of the rotation of the screw 106 and heat emitted by the plurality of barrel heaters 105 causes molding raw material (such as, for example, PET) fed through an inlet 110 to melt until a desired amount of material at a desired molten state has

been produced and accumulated in front of the screw 106. To facilitate feeding of the molding raw material through the inlet 110, the inlet 110 can be provided with a hopper (not depicted) or other suitable flow directing means, which are known to those of skilled in the art.

In the specific embodiment depicted in Figure 1, the material plasticized by the screw 106 is continuously transferred to into the shooting pot 104 via a transfer portion 112, the shooting pot 104 in this case being implemented as a dual shooting pot. Suitable configurations of the transfer portion 112 are well known to those of skill in the art and, as such, need not be described here at any length.

In alternative embodiments, accumulation of the desired amount of material in front of the screw 106 causes the screw 106 to translate backwardly (i.e. in the right-bound direction if viewed in Figure 1). In this case, the accumulated melt can be transferred to the shooting pot 104 by means of reciprocal movement of the screw 106. In those embodiments of the present invention, the screw actuator 108 imparts rotational and reciprocal movements to the screw 106.

The shooting pot 104 includes a plunger 114 which is actuated by a plunger actuator 116. The plunger actuator 116 imparts a lateral movement (or, in other words, forward translation) to the plunger 114, which causes the accumulated desired amount of material to be transferred into a mold (not depicted) via a nozzle 118.

In alternative non-limiting embodiments of the present invention, the injection unit 100 can be of a single stage type or, put another way, of a type known as reciprocating screw injection unit (not depicted). Within those embodiments of the present invention, the injection unit 100 comprises a plasticizing and injecting screw (not depicted), which serves several functions, including plasticizing and injection. Within those embodiments of the present invention, the plasticizing and injecting screw combines functions of the screw 106 and the plunger 114. For the purposes of the description of the present invention, the term “plunger” also includes functionality and structure of the plasticizing and injection screw (not depicted) of the reciprocating screw injection unit (not depicted) to the extent it performs injection function. Within these embodiments of the present invention, the term “plunger actuator” also includes an actuator (not depicted) of the plasticizing and injecting screw (not depicted).

According to embodiments of the present invention, there is provided an internal combustion engine 190. In some embodiments of the present invention, the internal combustion engine 190 comprises natural gas fueled internal combustion engine. In alternative non-limiting embodiments, the internal combustion engine 190 comprises an alternative gas fuelled internal combustion engine. Within these embodiments of the present invention, the alternative gas can include but is not limited to a biogas, a landfill gas, liquid fossil fuel, a synthetic gas, municipal sewage gas and the like.

In accordance with the non-limiting embodiments of the present invention, the internal combustion engine is directly mechanically coupled to a drive of the injection unit 100. In an embodiment, the internal combustion engine 190 can be directly mechanically coupled to the screw actuator 108 by a direct mechanical coupling, schematically illustrated in Figure 1 at 192. More specifically, a spindle (not depicted) associated with the internal combustion engine 190 is directly mechanically coupled to a spindle (not numbered) associated with the screw actuator 108. In other words and generally speaking, the internal combustion engine 190 is directly mechanically coupled to a drive that is operable to actuate at least one component of the injection unit or the injection molding machine 160, jointly referred to as an "injection molding system".

For the avoidance of doubt, the term "directly mechanically coupled" is meant to denote a connection whereby actuation of one device mechanically drives actuation of another device. In other words and as a specific example only, a rotation of the spindle of the internal combustion engine 190 drives a rotation of the spindle of the screw actuator 108. It should however be noted that the term "directly mechanically coupled" and the direct mechanical coupling 192 are not necessarily limited to any specific mechanical embodiment of such coupling and various implementations are possible without departing from the teaching of the present invention. For example, the direct mechanical coupling 192 can be implemented as a clutch and the like. Put another way, the "driven components" can be directly mechanically coupled through a clutch to the "driving component".

A specific technical effect attributable at least partially to this direct mechanical coupling may include alleviating the need for generators typically present in a co-generation system. Another example of a technical effect attributable at least partially to the use of mechanical energy to drive a mechanical device, may include an implementation of the system that is comparatively

less costly (due to the avoidance of the generators) and may potentially result in less waste of energy due to fewer transformations of energy.

It should be expressly noted that even though in the illustrated embodiment the internal combustion engine 190 is directly mechanically coupled to the screw actuator 108, in alternative embodiments, the internal combustion engine 190 can be coupled to other drives associated with the injection unit 100, such as for examples but not limited to a hydraulic pump and the like.

Additionally, in accordance with embodiments of the present invention, there is provided a waste heat recovery sub-system 194. More specifically, according to embodiments of the present invention, the waste heat recovery sub-system 194 is configured to recover waste heat associated with the internal combustion engine 190. The waste heat can be recovered from one or both the exhaust and the engine jacket (both not depicted) associated with the internal combustion engine 190. The heat can be recovered through use of heat exchangers, as schematically depicted at 196 and as is known in the art.

The waste heat recovery sub-system 194 is further configured to re-use the so-recovered waste heat in other parts of the injection molding system 160 and, more specifically, to re-use the so-recovered waste heat in at least one heat-driven component of the injection molding system to perform at least one molding system function. For example, the so-recovered waste heat can be used or operating a waste power chillers, such as absorption or adsorption chillers, which in these examples, become embodiments of such heat-driven components with associated injection molding functions of cooling air. Additionally or alternatively, the so-recovered waste heat can be used in resin preparation devices, such as in pellet heaters, dryers, mold and machine heaters and the like.

In operation, an operator triggers the flow of fuel into the internal combustion engine 190 and initiates the turning of the engine, such as using a starter motor (not depicted) and the like. In some embodiments of the present invention, the start up of the internal combustion engine 190 can be a semi-automated or automated process. To that end, the starter motor and the internal combustion engine 190 can be interfaced through a computing apparatus, such as a dedicated processor or the general-purpose computer or the controller of the injection molding machine 160.

In alternative embodiments of the present invention, there can be provided a stand-alone power source for use with the injection molding system 100 or a component thereof. The stand-alone power source is directly mechanically coupled to a portion of the injection molding system 100 that is being driven/actuated by the stand-alone power source. The stand-alone power source is a dedicated source of power for the injection molding system in a sense that it is independent from a power distribution grid, such as an electric grid and the like. The stand-alone power source can be implemented as the above-described internal combustion engine 190. Alternatively, the stand-alone power source can be implemented as a fuel cell. Other implementations are, of course, possible.

Description of the non-limiting embodiments of the present inventions provides examples of the present invention, and these examples do not limit the scope of the present invention. It is to be expressly understood that the scope of the present invention is limited by the claims. The concepts described above may be adapted for specific conditions and/or functions, and may be further extended to a variety of other applications that are within the scope of the present invention. Having thus described the non-limiting embodiments of the present invention, it will be apparent that modifications and enhancements are possible without departing from the concepts as described. Therefore, what is to be protected by way of letters patent are limited only by the scope of the following claims:

What is claimed is:

1. An injection molding system (160) comprising:

a drive (108) for actuating a component of the injection molding system;

an internal combustion engine (190), the internal combustion engine (190) being directly mechanically coupled to the drive (108);

a heat-driven component;

a waste heat recovery sub-system (194) configured to recover waste heat from the internal combustion engine (190) and to re-use the so-recovered waste heat for operating the heat-driven component to perform at least one injection molding function.

2. The injection molding system of claim 1, wherein said internal combustion engine (190) comprises a natural gas fueled internal combustion engine.

3. The injection molding system of claim 1, wherein said internal combustion engine (190) comprises an alternative gas fuelled internal combustion engine.

4. The injection molding system of claim 3, wherein the alternative gas comprises at least one of biogas, a landfill gas, liquid fossil fuel, a synthetic gas and municipal sewage gas..

5. The injection molding system of claim 1, wherein the internal combustion engine (190) is coupled to the drive (108) via a direct mechanical coupling (192).

6. The injection molding system of claim 5, wherein the direct mechanical coupling (192) comprises a clutch.

7. The injection molding system of claim 6, wherein the internal combustion engine (190) comprises a first spindle and the drive (108) comprises a second spindle and wherein the direct mechanical coupling (192) directly mechanically couples said first spindle and said second spindle.

8. The injection molding system of claim 1, wherein the waste heat recovery sub-system (194) is configured to recover waste heat from at least one of an exhaust and an engine jacket associated with the internal combustion engine (190).

9. The injection molding system of claim 1, wherein the heat-driven component comprises a power chiller.

10. The injection molding system of claim 1, wherein the heat-driven component comprises a resin preparation device.

11. The injection molding system of claim 1, wherein said drive is a drive associated with a screw (106) of an injection unit (100).

12. The injection molding system of claim 1, wherein said drive is a drive associated with a hydraulic pump.

13. An injection molding system (160) comprising:

a drive (108) for actuating a component of the injection molding system;

a stand-alone power source, the stand-alone power source being directly mechanically coupled to the drive (108);

a heat-driven component;

a waste heat recovery sub-system (194) configured to recover waste heat from the internal combustion engine (190) and to re-use the so-recovered waste heat for operating the heat-driven component to perform at least one injection molding function.

14. The injection molding system of claim 13, wherein said stand-alone power source is implemented as an internal combustion engine (190).

15. The injection molding system of claim 13, wherein said stand-alone power source is implemented as a fuel cell.

16. The injection molding system of claim 13, wherein said stand-alone power source is a dedicated power source for the injection molding system.

17. The injection molding system of claim 13, wherein said stand-alone power source is independent from an power distribution grid.

18. The injection molding system of claim 13, wherein said drive is a drive associated with a screw (106) of an injection unit (100).

19. The injection molding system of claim 13, wherein said drive is a drive associated with a hydraulic pump.

20. The injection molding system of claim 13, wherein the internal combustion engine (190) is coupled to the drive (108) via a direct mechanical coupling (192).

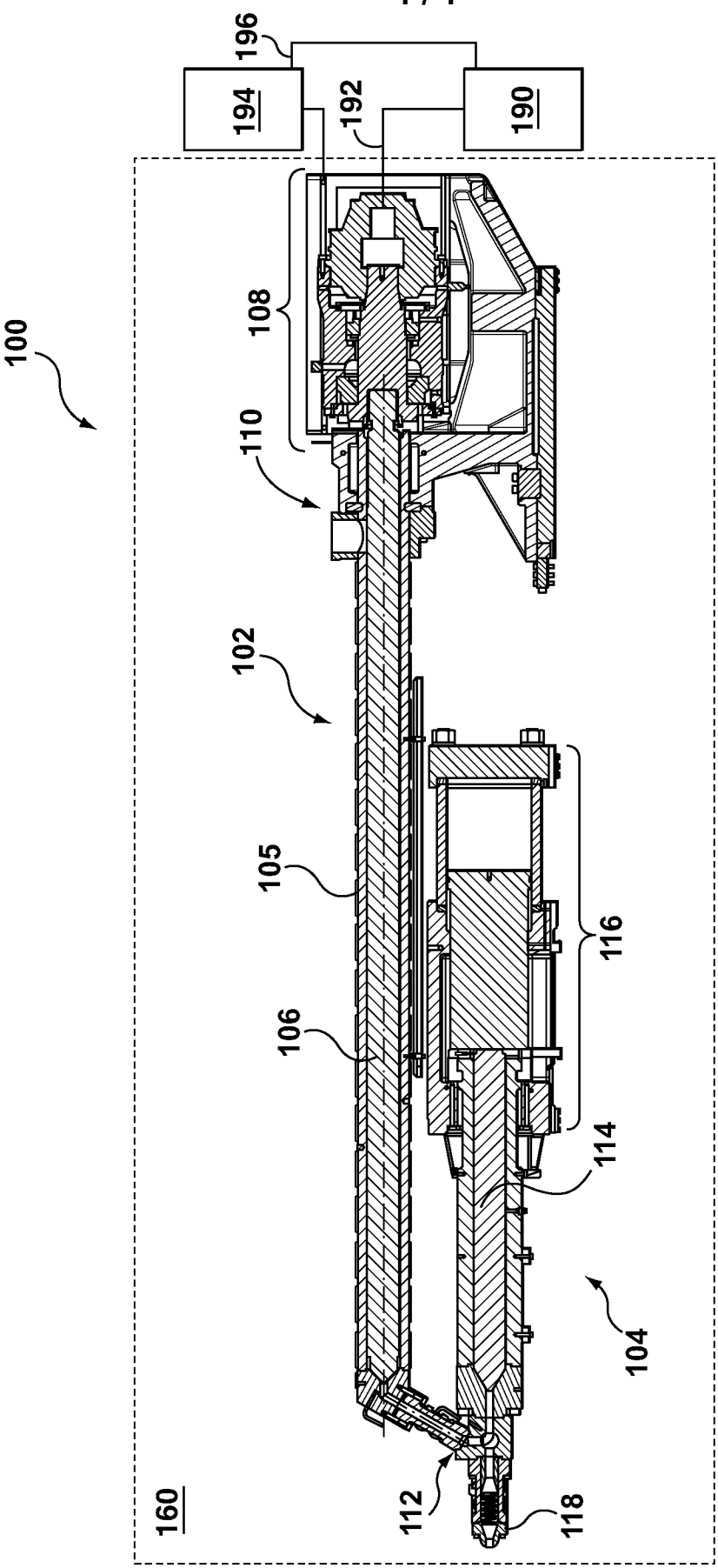


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2012/050262

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***B29C 45/17*** (2006.01) , ***B29C 45/72*** (2006.01) , ***B30B 11/22*** (2006.01) , ***B30B 15/34*** (2006.01) , ***F02B 43/00*** (2006.01) , ***F02G 5/00*** (2006.01), ***F02G 5/04*** (2006.01)

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: ***B29C 45/**** (2006.01), ***B30B*** (2006.01), ***F02B 43/00*** (2006.01) , ***F02G 5/**** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)

EPOQUE (EPODOC and X-FULL), CPD with key words, such as: molding/moulding machine, actuat*, driv*, combust* engine.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 19750379 A1 (FOSTER, F.) 04 February 1999 (04-02-1999) *abstract*	13, and 16-19
A	US 6409480 B1 (DIENO, K. et al.) 25 June 2002 (25-06-2002) *whole document*	1-20
A	US 5351487 A (ABDELMALEK, F. T.) 04 October 1994 (04-10-1994) *cited by applicant* *whole document*	1-20

[ ] 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 application or patent 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
11 June 2012 (11-06-2012)	18 June 2012 (18-06-2012)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Pengfei Zhang (819) 953-0654

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2012/050262

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
DE 19750379 A1	04 February 1999 (04-02-1999)	DE19750379A1	04 February 1999 (04-02-1999)
		DE19750379B4	13 December 2007 (13-12-2007)
		US6048179A	11 April 2000 (11-04-2000)
US 6409480 B1	25 June 2002 (25-06-2002)	AT291174T	15 April 2005 (15-04-2005)
		CN1274047A	22 November 2000 (22-11-2000)
		DE19922947A1	23 November 2000 (23-11-2000)
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		EP1052408A2	15 November 2000 (15-11-2000)
		EP1052408A3	21 March 2001 (21-03-2001)
		EP1052408B1	16 March 2005 (16-03-2005)
		JP2000326357A	28 November 2000 (28-11-2000)
US 5351487 A	04 October 1994 (04-10-1994)	US5327987A	12 July 1994 (12-07-1994)
		US5337560A	16 August 1994 (16-08-1994)