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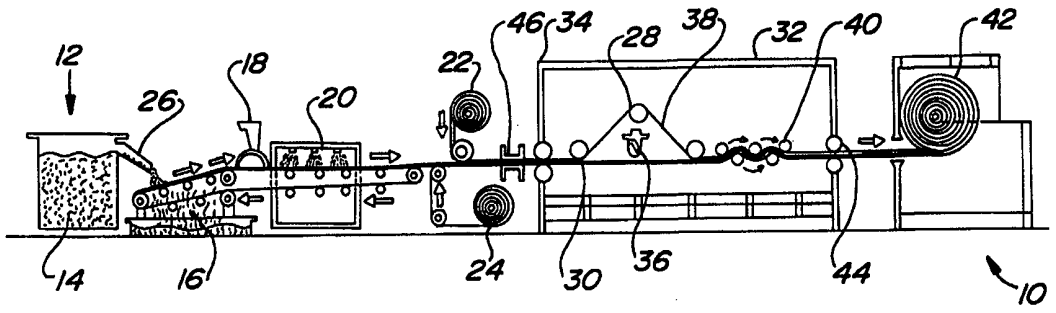

(57) Abstract

The present invention provides an apparatus (10) for manufacturing sheet molding compound comprising a fiber processing unit (12) for forming a fiber web. The apparatus also includes a precompaction unit (34) for squeezing air out of the fiber web and a resin mixture paste dispenser (36) for applying paste to the fiber web. The apparatus functions to minimize entrapped air from the resin mixture paste and fiber web.

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SHEET MOLDING COMPOUND MANUFACTURING IMPROVEMENTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to an apparatus and method for manufacturing sheet molding compound, and, more particularly, to an apparatus for manufacturing sheet molding compound while minimizing entrapped air therein.

2. Discussion of the Related Art

Compression molding is a technique for forming parts wherein a charge is placed between upper and lower heated die members defining a mold cavity. The dies are then brought to a closed position where the dies compress the charge causing it to flow and fill the mold cavity. After the resin cures, the molds are opened and the finished part is removed.

Compression molding techniques have been used to make parts having a relatively flat surface, such as exterior automotive body panels. The charges used for making such parts generally consist of a thermosetting resin containing reinforcing fibers and various fillers. Quite often, the charges are formed into sheets known in the art as sheet molding compounds (SMC). It has been difficult, however, to mold fiberglass reinforced plastic (FRP) parts so that they have an extremely smooth surface. The molded parts sometimes have surfaces that are blistered, rough or porous that require post-molding processing to smooth the blemishes. It is commonly believed that such blemishes result primarily from air that is trapped in the charge during molding. In an effort to minimize trapped air, one practice is to use a relatively thick charge which covers a relatively small area of the molding surface so that the air in the charge is "squeezed" out when the dies are closed.

It has also been recognized that the use of a vacuum during the compression molding process is useful in reducing the number of blemishes in the surface of the part. See, e.g., U.S. Pat. Nos. 4,488,862; 4,612,149; 4,551,085; and 5,130,071, which are hereby incorporated by reference. These prior patents teach applying a vacuum to the sheet molding compound charge during the compression molding process. Air also becomes entrapped, however, within the reinforcing fibers themselves while the fibers are mixed with the resin mixture paste during the manufacturing of the sheet molding compound charge. This trapped air can lead to voids or micro-pits on the surface of a molded part, requiring additional labor-intensive

finishing procedures in order to produce a part with an acceptable surface thereby increasing manufacturing costs.

There thus exists a need in the art to provide an improved method and apparatus for removing or minimizing entrapped air from the resin mixture paste and fiber reinforcing material while the sheet molding compound is formed in order to further reduce the occurrence of surface blemishes on molded articles.

SUMMARY OF THE INVENTION

The present invention provides an apparatus for manufacturing sheet molding compound comprising a fiber processing unit for forming a fiber web. The apparatus also includes a precompaction unit for squeezing air out of the fiber web and a resin mixture paste dispenser for applying paste to the fiber web. The apparatus functions to minimize entrapped air from the resin mixture paste and fiber web.

The preferred embodiment of the present invention also provides an apparatus for manufacturing sheet molding compound comprising a fiber mixture water bath, a conveyor belt that receives the fiber mixture, and a soluble binder resin dispenser unit. The apparatus includes a dryer unit and at least two plastic film rolls that release a layer of plastic film onto the conveyor belt, wherein the fiber mixture is sandwiched between a first and second plastic layer to form a plastic layered fiber web. The apparatus also includes pinch rollers for squeezing air out of said fiber web, and a vacuum chamber with a resin mixture paste dispenser, and a first mechanism that separates the first plastic layer from the second plastic layer. The paste is applied to the fiber web when the plastic layers are separated. Then, the first layer is returned to cover the fiber web and paste mixture by way of a second mechanism. The apparatus further has an output unit, wherein the sheet molding compound is rolled or festooned in a box.

The present invention is additionally directed to a method of manufacturing sheet molding compound comprising, in the preferred embodiment, the steps of forming a fiber web, compressing the fiber web between at least two layers of plastic film along a first moving mechanism, and squeezing air out of the fiber web by moving the web between two pinch rollers along the first moving conveyor. The fiber web is thus precompacted prior to the addition of a resin mixture paste.

A first plastic layer is then separated along a second moving mechanism from the fiber web within a vacuum chamber. The present method also includes applying the resin mixture paste onto the fiber web within the vacuum chamber, and returning

the first plastic layer to the fiber web. The compound thereafter exits the vacuum chamber along the first moving mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front perspective view of the preferred embodiment of the apparatus for manufacturing sheet molding compound of the present invention; and

FIG. 2 is a side perspective view of the apparatus of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring to FIGS. 1 and 2, a preferred embodiment of an apparatus for manufacturing sheet molding compound is illustrated and indicated generally by the numeral 10. The present invention apparatus functions to remove or minimize entrapped air from a fiber web by precompacting the web, and may further remove air from both the fiber web and a resin mixture paste by manufacturing the sheet molding compound with reinforcing fibers under a vacuum.

Generally speaking, apparatus 10 comprises a fiber processing unit 12 for forming a fiber web which includes a fiber mixture water bath 14, a moving mechanism or wire mesh conveyor belt 16, and a soluble binder resin dispenser unit 18. Water bath 14 also preferably includes a volume adjustable spillway 26 to regulate the amount of fiber mixture that is dispensed, as shown in FIGS. 1 and 2. The processing unit may also include a dryer unit 20.

The fiber mixture employed in the present invention may be formed into a continuous wet laid web by first suspending the fibers in a water bath to form a mixture, drawing out the fiber mixture onto conveyor belt 16, adding a binder from soluble binder resin dispenser unit 18, and removing the water and drying the fiber mixture in dryer unit 20. Conveyor belt 16 is preferably wire mesh to allow the water from the bath to drop through the mesh to a water runoff. A fiber web is formed as the binder dries, causing the fibers to stick together. The fiber web may alternatively be formed from chopped rovings of fiber particles. The fiber web is preferably comprised of glass fibers, but may also be, but is not limited to, cellulose, cotton, and carbon fibers. The fiber web may be made up of any material composition that may be formed into a web.

In the preferred embodiment, the present invention apparatus also comprises at least two plastic or polysheet film rolls, 22 and 24, respectively. The plastic film is preferably polyethylene, nylon, or a mixture of these, but may also be any standard

plastic film employed in the process of manufacturing sheet molding compound. Each of film rolls 22 and 24 release a layer of plastic film onto conveyor belt 16, which is also carrying the fiber web from the fiber processing unit as shown in FIGS. 1 and 2. As the conveyor belt continues along the length of the apparatus, the fiber web is sandwiched between a first plastic layer 28 and second plastic film layer 30 from rolls 22 and 24, forming a plastic layered fiber web.

The apparatus of the present invention may also include a vacuum chamber 32 surrounding a portion of conveyor belt 16 in order to remove or minimize any entrapped air from the fiber web and resin mixture paste. Vacuum chamber 32 houses a resin mixture paste dispenser 36 and a separating mechanism 38, preferably a second conveyor belt, that functions to separate first plastic layer 28 from second plastic layer 30.

The plastic layered fiber web preferably enters vacuum chamber 32 through a precompaction unit, such as pinch rollers 34 as shown in FIG. 1. The pinch rollers quickly and efficiently squeeze air out of the glass fibers layered in plastic prior to the addition of the resin mixture paste. In some applications, the precompacting of the fiber web with pinch rollers 34 prior to the addition of the resin mixture paste may be sufficient for removal of air from the web, and, therefore, the molding apparatus would not require a vacuum chamber.

Referring to FIG. 1, first plastic layer 28 is removed away from the plastic layered fiber web by travelling along second conveyor belt 38. A liquid sheet or ribbon of resin mixture paste is then applied to the fiber web as shown in FIG. 1. The paste dispenser is preferably located within the area or envelope created by separating the first plastic layer along the second conveyor belt from the fiber web. Paste dispenser 36 is also preferably variably pressurized and a vacuum of about 20 to about 29 inches of Hg is preferably maintained in the vacuum chamber.

First plastic layer 28 is then returned to the fiber web via a mechanism for returning the layer, most preferably via second conveyor belt 38. In one embodiment, a heat sealing device commonly known in the art, such as a rotary band heat sealer, may also be located within the vacuum chamber. The heat sealer functions to seal the edges of the first and second plastic layers together after the first layer is returned to the fiber web.

The plastic layered fiber web may then be conveyed through kneading rollers 40 in order to mix the fiber web into the paste, forming a sheet molding compound. Thus, the present invention apparatus functions to minimize entrapped air from both

the resin mixture and fiber web while under a vacuum. Kneading rollers 40 may alternatively be located outside the vacuum chamber, and, therefore, the paste and fiber web are mixed together outside the chamber.

The present invention apparatus further includes an output unit 42 where the sheet molding compound with reinforcing fibers is conveyed, for example, through a second set of pinch rollers 44 and then rolled on a core or festooned in a box for further manufacturing.

Referring to FIG. 1, the present apparatus may also include an areal densitometer 46, which provides a detection reading of the plastic layered fiber web by a light source before the layer enters the vacuum chamber. The sheet molding compound also preferably maintains a constant areal weight when exiting vacuum chamber 32.

The invention has been described in detail with reference to preferred embodiments thereof. It should be understood, however, that variations and modifications can be made within the spirit and scope of the invention. For example, it is envisioned that polysheet film roll 22 may be located within the vacuum chamber, where the fiber web enters the vacuum chamber without first applying plastic layer 28 to the fiber web. A liquid sheet or ribbon of resin mixture paste may then be applied to the fiber web, and subsequently, plastic layer 28 is applied to the top of the fiber web. The plastic layered fiber web is then conveyed through kneading rollers 40 in order to mix the fiber web into the paste, forming a sheet molding compound before exiting the chamber.

Still further alternatives will become apparent to one skilled in the art after having the benefit of studying the foregoing specification and following claims.

WHAT IS CLAIMED IS:

1. An apparatus for manufacturing sheet molding compound comprising:

(a) a fiber processing unit for forming a fiber web;

(b) a precompaction unit for squeezing air out of said fiber web; and

(c) a resin mixture paste dispenser for applying paste to said fiber web;

wherein said apparatus minimizes entrapped air from said resin mixture paste and fiber web.

2. The apparatus according to claim 1 wherein said precompaction unit effects a reduction of about 50 to 70% in the thickness of said fiber web.

3. The apparatus according to claim 1 further comprising a vacuum chamber unit, wherein said resin mixture paste dispenser is enclosed within said vacuum chamber unit.

4. The apparatus according to claim 1 further comprising a binder resin dispensing unit, a drying unit, and an output unit.

5. The apparatus according to claim 1 which further comprises means for sandwiching said web between at least two plastic layers.

6. The apparatus according to claim 3 wherein said vacuum chamber unit further comprises a mechanism for separating a first plastic layer from said fiber web.

7. The apparatus according to claim 6 wherein said paste dispenser is located within an envelope created by the separation of said first plastic layer from said fiber web by said mechanism.

8. The apparatus according to claim 7 further comprising a second mechanism for returning said first plastic layer to said fiber web before said fiber web exits said vacuum chamber.

9. The apparatus according to claim 3 wherein said vacuum chamber further comprises kneading rollers.

10. The apparatus according to claim 3 wherein said vacuum chamber further includes a heat sealing device for sealing said first plastic layer to a second plastic layer.

11. An apparatus for manufacturing sheet molding compound comprising:

(a) a fiber mixture water bath;

(b) a conveyor belt that receives said fiber mixture;

(c) a soluble binder resin dispenser unit;

(d) a dryer unit;

(e) at least two plastic film rolls that release a layer of plastic film onto said conveyor belt, wherein said fiber mixture is sandwiched between a first and second plastic layer to form a plastic layered fiber web;

(f) a vacuum chamber having a resin mixture paste dispenser, a first mechanism that separates said first plastic layer from said second plastic layer, wherein said paste is applied to said fiber web when said first and second plastic layers are separated, and said vacuum chamber further including a second mechanism for returning said first layer to said fiber web, thereby forming sheet molding compound; and

(g) an output unit wherein said sheet molding compound is rolled or festooned in a box;

wherein said apparatus minimizes entrapped air from said sheet molding compound.

12. The apparatus according to claim 11 wherein said apparatus further includes pinch rollers for squeezing air out of said fiber web.

13. The apparatus according to claim 12 wherein said pinch rollers effect a reduction of about 50 to 70% in the thickness of said fiber web.

14. The apparatus according to claim 11 wherein said vacuum chamber further includes kneading rollers.

15. The apparatus according to claim 11 wherein said vacuum chamber further includes a heat sealing device for sealing said first and second plastic layers together.

16. The apparatus according to claim 11 wherein said paste dispenser is located within the envelope created by separating said first plastic layer from said fiber web.

17. The apparatus according to claim 11 wherein said plastic film is selected from the group consisting of polyethylene, nylon, and mixtures thereof.

18. A method of manufacturing sheet molding compound comprising the steps of:

(a) forming a fiber web;

(b) sandwiching said fiber web between at least two plastic layers along a first moving conveyor;

(c) separating a first plastic layer from said fiber web within a vacuum chamber;

(d) applying said resin mixture paste onto said fiber web within said vacuum chamber;

(e) returning said first plastic layer to said fiber web, wherein entrapped air is minimized from said resin mixture paste and fiber web; and

(f) further conveying said compound so that it exits said vacuum chamber.

19. The method according to claim 18 further comprising the step of squeezing air out of said fiber web by moving said web between two pinch rollers along said first moving conveyor, wherein said fiber web is precompacted prior to the addition of a resin mixture paste.

20. The method according to claim 19 wherein said fiber web is precompacted to effect a reduction of about 50 to 70% in the thickness of said fiber web.

21. The method according to claim 19 further comprising the step of kneading said paste and fiber to mix said fiber web into said paste.

22. The method according to claim 19 further comprising the step of heat sealing said first and second plastic layers together in said vacuum chamber prior to exiting said chamber.

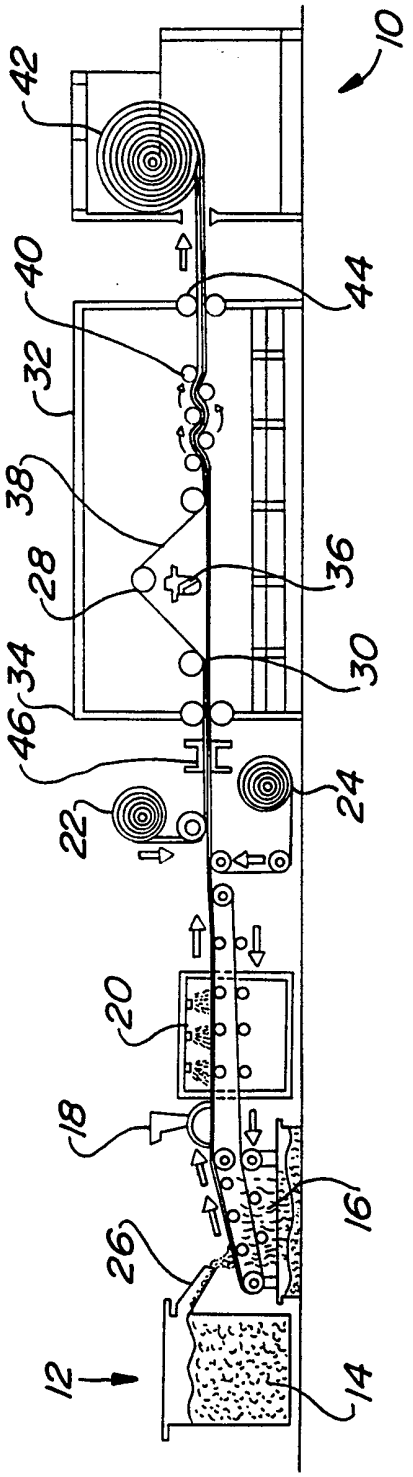

Fig-1

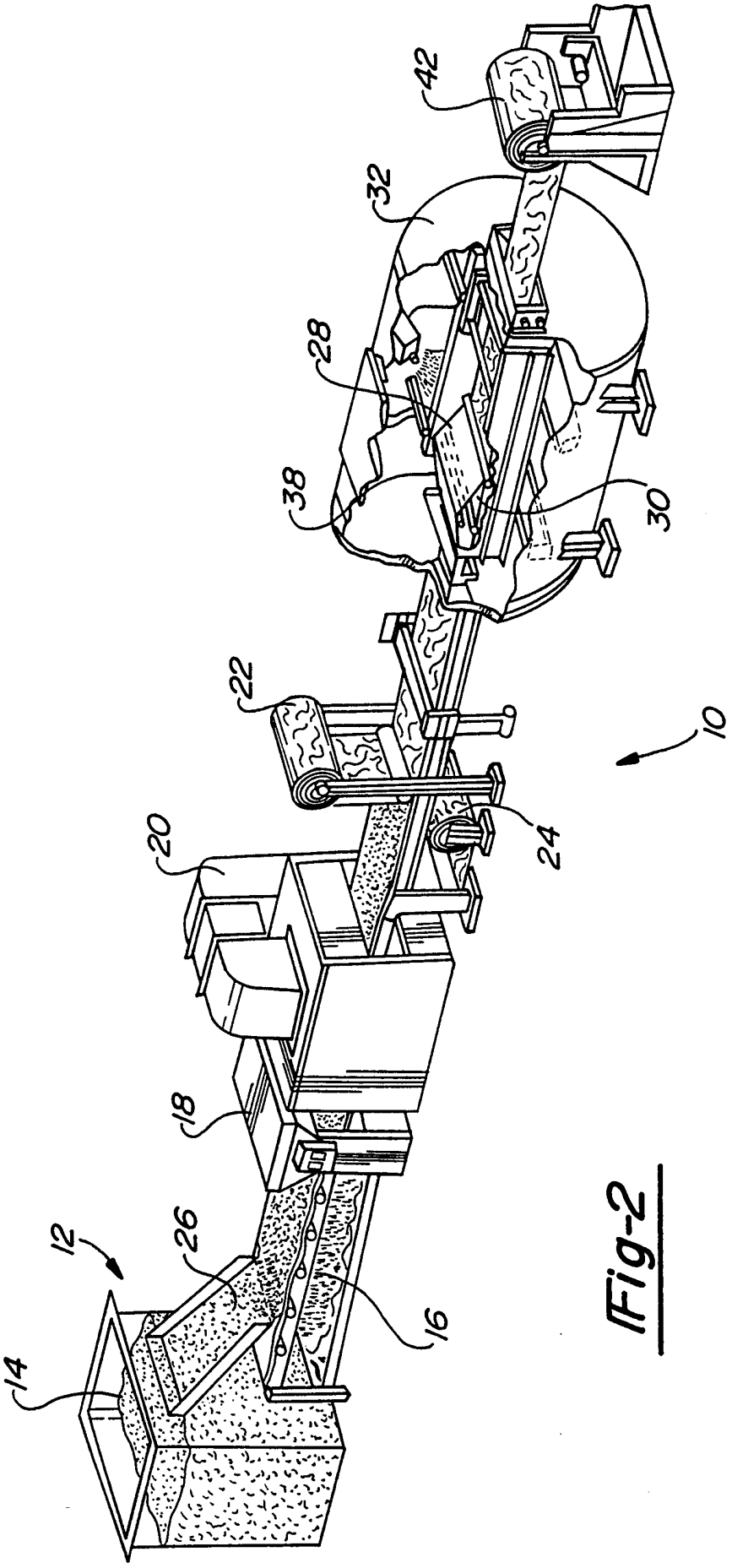

Fig-2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/07386

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B29C70/50

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 6 B29C

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 894 292 A (DIBUZ JENO J ET AL) 16 January 1990 (1990-01-16)	1,2
A	column 3, line 52 - line 66; figure ---	11,18
X	FR 2 704 477 A (HAINAUT SA FIBRES) 4 November 1994 (1994-11-04) page 9, line 10 - line 15; figure 1 ---	1,2
A	FR 2 266 595 A (PEUGEOT & RENAULT) 31 October 1975 (1975-10-31) page 2, line 36 - line 38; figure 6 ---	14,21
A	US 3 895 988 A (MILLER EVERETT R) 22 July 1975 (1975-07-22) column 4, line 22 - line 28 ---	15,22
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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8 July 1999	15/07/1999

Name and mailing address of the ISA	Authorized officer
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International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropnate, of the relevant passages	Relevant to claim No.
A	US 4 288 475 A (MEEKER BRIAN L) 8 September 1981 (1981-09-08) column 7, line 54 - column 8, line 64; figure 1	3,11,18
A	EP 0 103 954 A (GEN MOTORS CORP) 28 March 1984 (1984-03-28) page 5, line 10 - line 15; example 1	18

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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/07386

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4894292 A	16-01-1990	NONE	
FR 2704477 A	04-11-1994	NONE	
FR 2266595 A	31-10-1975	NONE	
US 3895988 A	22-07-1975	US 3752690 A	14-08-1973
US 4288475 A	08-09-1981	NONE	
EP 0103954 A	28-03-1984	US 4474845 A	02-10-1984
		CA 1202461 A	01-04-1986
		JP 2006616 B	13-02-1990
		JP 59064325 A	12-04-1984