

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
12 August 2010 (12.08.2010)

(10) International Publication Number
WO 2010/090992 A1

PCT

(51) International Patent Classification:

G02B 6/00 (2006.01) **B60Q 3/00** (2006.01)
F21V 8/00 (2006.01)

(21) International Application Number:

PCT/US2010/022831

(22) International Filing Date:

2 February 2010 (02.02.2010)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

61/150,964 9 February 2009 (09.02.2009) US

(71) Applicant (for all designated States except US): **JOHNSON CONTROLS TECHNOLOGY COMPANY** [US/US]; 915 E. 32nd Street, Holland, MI 49424 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **TINDALL, Rodney, J.** [US/US]; 11155 Summer Drive, Zeeland, MI 49464 (US).

(74) Agents: **SIMS, Norman, L.** et al.; Dobrusin & Thennisch Pc, 29 W. Lawrence Street, Suite 210, Pontiac, MI 48342 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: LIGHT GUIDE WITH IRREGULARITIES ON THE OUTER- OR SIDE-SURFACE TO IMPROVE LIGHT EMISSION

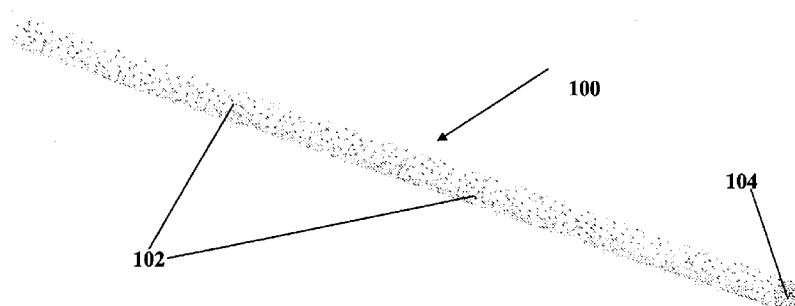


Fig. 1

(57) Abstract: This invention relates to a light guide (100) and methods of manufacturing a light guide (100). The surface is covered with numerous ideally randomly distributed nicks (102). The nicks (102) act as points at which light will be directed out of the light guide (100). The distribution of nicks (102) across the surface of the light guide (100) results in approximately omni-directional emission of light from the light guide (100) (i.e., light is emitted from the light guide (100), ideally, in generally equal amounts, in all directions along all treated surfaces. In various exemplary embodiments, the outer or side surface is treated with, for example, rollers, dies, lasers, chemical etching, sandpaper or abrasive material, sandblasting, bead blasting or abrasive blasting, to create an irregular surface with numerous nicks and/or facets.



WO 2010/090992 A1

Claim of Priority

[0001] The present application claims the benefit of the filing date of U.S. Provisional Application Serial No. 61/150,964 (filed February 9, 2009), and the entirety of the contents of this application being hereby expressly incorporated by reference.

Field of the Invention

[0002] This invention relates to a light guide and methods of manufacturing a light guide.

Related Art

[0003] It is known to provide a variety of lights in a vehicle interior for a number of practical and aesthetic purposes. Examples include lights for various indicators and controls on the dashboard, lights to illuminate all or part of the passenger compartment or trunk, and/or ambient or decorative lights. Light may be directed to a point or across an area. For example, light may be emitted across an area of an instrument panel or into a control knob.

[0004] Light guides function in a way that is analogous to a pipe. A light guide is typically a solid strand of material. Light guides are typically made of transparent polymers, such as acrylic and polyurethane. Light guides are commonly made using a variety of processes, including casting, molding, and extrusion. Light that enters one end surface of a light guide is transmitted down the light guide by repeatedly striking the outer or side surface of the light guide and reflecting back into the light guide until it reaches the end surface. If the outer or side surface of a cylindrical light guide were perfectly smooth, at least nearly all light would pass down the light guide to the end surface without any side surface emissions. However, in many applications, emission of light out the outer or side surface of a light guide is desirable or necessary along all or a part of its length.

SUMMARY

[0005] This invention relates to a light guide comprising a light conductor with an outer or side surface having multiple facets, depressions, indentations, notches, disruptions, irregularities, surface irregularities, textures and/or nicks, whereas, in the subsequent document, "facets" and/or "nicks" are used as a synonym for one or all of them. In various exemplary embodiments, the facets and/or nicks are randomly distributed across at least a portion of the outer or side light guide surface.

[0006] This invention also relates to a method of producing a light guide comprising treating the outer or side surface of a light guide to create an irregular outer or side surface. In various exemplary embodiments, the outer or side surface is treated with, for example, rollers, dies, lasers, chemical etching, sandpaper or abrasive material, sandblasting, bead blasting, or abrasive blasting, to create an irregular surface with numerous nicks and/or facets.

[0007] This invention also relates to a method of producing a light guide comprising forming a light guide in a mold wherein at least a portion of the inner surface of the mold includes multiple facets.

[0008] These and other features and advantages of various embodiments of systems and methods according to this invention are described in, or are apparent from, the following detailed description of various exemplary embodiments of various devices, structures, and/or methods according to this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Various exemplary embodiments of the systems and methods according to the present disclosure will be described in detail, with reference to the following figures, wherein:

[0010] Fig. 1 is a partial perspective view of an exemplary embodiment of a light guide according to this invention; and

[0011] Fig. 2 is a graphical representation of the typical performance of a conventional light guide and an exemplary embodiment of a light guide according to this invention.

DETAILED DESCRIPTION

[0012] Light guides are commonly used to transport light from a source to another location. A light guide refers is typically a single, thin fiber or to a bundle of fibers. Light guides used for automotive applications are typically larger in diameter and are typically of a single, solid nominal cross section. They could be round or of a different cross section. For example, one might be a flat, thin strip that is much wider in cross section than it is thick. They may also be used to distribute light from a point source across a larger area such as, for example, along an elongated strip. In general, light guides transport most light to their end surface rather than emitting light along their outer or side surface(s). Thus, in applications where emission of light along the outer or side surface rather than at the end surface is desired or required, a significant portion of the light may be "lost" in that the "lost" light is not emitted where it is needed. The emission of light out of the light guide's outer or side surface may be increased by introducing surface irregularities along those outer or side surfaces. Light striking a non-smooth surface is more likely to exit the light guide than light striking a relatively smooth side-surface. However, conventional light guide manufacturing methods produce light guides with generally smooth outer or side surfaces. This invention addresses methods for producing light guides with at least some non-smooth outer or side surfaces.

[0013] In various exemplary embodiments, the light guide may be manufactured by conventional methods with generally smooth outer or side surfaces and further processed to change the characteristics of its outer or side surfaces. In various other exemplary embodiments, the light guide may be manufactured with a non-smooth outer or side surface that may or may not be further processed.

[0014] Fig. 1 shows a section of an exemplary light guide 100. The surface is covered with numerous ideally randomly distributed nicks 102. The nicks 102 act as points at which light will be directed out of the light guide 100. The distribution of nicks 102 across the surface of the light guide 100 results in approximately omni-directional emission of light from the light guide 100 (i.e., light is emitted from the light guide 100, ideally, in generally equal amounts, in all directions along all treated surfaces). In general, creating more facets and/or nicks in a given portion of the outer or side surface of the light guide 100 increases its light emission

or illuminance in that portion. In various exemplary embodiments, the distal end 104 of the light guide 100 furthest from the light source may be smooth or treated. Treating the distal end 104 of the light guide 100 will not appreciably affect the illuminance produced at the distal end 104 as virtually all light that reaches the distal end 104 will be emitted, but the distal end 104 may be treated to diffuse and/or scatter the light that is emitted at the distal end 104.

[0015] Fig. 2 compares the illuminance from a light guide that is smooth to the illuminance of a light guide according to this invention. In this test, a light source was placed at both ends of the light guides. Table 1 shows the data upon which Fig. 2 is based. The y-axis is illuminance and the x-axis is distance along the light guide from the light source. The outer or side surface of the light guide was treated by rolling the light guide over coarse (60 grit) sandpaper. Line 112 represents the smooth or untreated light guide's performance. Line 114 represents the treated light guide's performance. a light guide according to this invention will emit more light than a similarly illuminated and dimensioned conventional smooth and/or untreated light guide. It follows that a light guide 100 according to this invention can emit the same amount of light as a conventional light guide using a dimmer light source, reducing power demands for lighting.

Table 1

Distance (in)	Distance (mm)	<u>Illuminance</u>	
		Untreated	Treated
0	0	0.08	0.31
2	50.8	0.10	0.37
4	101.6	0.13	0.46
6	152.4	0.16	0.53
8	203.2	0.18	0.55
10	254.0	0.18	0.55
12	304.8	0.17	0.52
14	355.6	0.15	0.46
16	406.4	0.12	0.39
18	457.2	0.09	0.31
average		0.136	0.445

[0016] In various exemplary embodiments, the light guide 100 is treated by rolling or compressing the light guide 100 over or through one or more dies or rollers. The surface of the dies or rollers contain multiple, tiny projections and/or facets. After treatment, the surface of the light guide 100 will contain numerous nicks 102 and/or facets, creating numerous small facets in and/or on the outer or side

surface of the light guide 100. In various exemplary embodiments, the rollers or dies may be configured such that all of the light guide's outer or side surface is treated or such that only select portions of the outer or side surface are treated. In various exemplary embodiments, the light guide 100 may be passed through one or more sets of dies or rollers.

[0017] In various exemplary embodiments, a light guide 100 is treated with an abrasive surface such as, for example, sandpaper. The treated outer or side surface of the light guide 100 will contain numerous randomly-located nicks that act as small, facets. In various exemplary embodiments, the light guide 100 may be treated on all, or only on a portion, of its outer or side surface, as desired for a particular application.

[0018] In various other exemplary embodiments, the light guide 100 is treated by sandblasting the light guide 100. The treated surfaces will contain numerous randomly-located nicks that act as small facets. In various exemplary embodiments, the light guide 100 may be treated on all, or only on a portion, of its outer or side surface, as desired for a particular application. In various exemplary embodiments, the light guide 100 may be treated using bead or abrasive blasting with the same effect as sandblasting.

[0019] In still other exemplary embodiments, the light guide 100 is treated with a laser to create small nicks and/or facets across at least a portion of the surface of the light guide 100. In various exemplary embodiments, different portions of the outer or side surface may receive more or less treatment to create more or fewer nicks and/or facets than other portions of the outer or side surface of the light guide 100. In various exemplary embodiments, the light guide 100 may be treated on all, or only on a portion, of its outer or side surface, as desired for a particular application.

[0020] In various other exemplary embodiments, the light guide 100 is treated by laser etching the light guide 100. The treated surfaces will contain numerous randomly-located nicks that act as small facets. In various exemplary embodiments, the light guide 100 may be treated on all, or only on a portion, of its outer or side surface, as desired for a particular application.

[0021] In yet other exemplary embodiments, the light guide 100 is molded in a mold, where the mold has an inner surface provided or formed with

numerous small projections and/or facets. The surface of the light guide 100 will mirror the surface of the mold and have numerous facets.

[0022] In various exemplary embodiments, the treatment may be varied at different points of the light guide 100. This may be done to alter the light guide's light emission profile. For example, light guides tend to become dimmer at distances further from the light source, because there is less light (fewer photons) available to be emitted the farther a particular portion of the light guide 100 is from the illuminated end of that light guide 100. Accordingly, the light guide 100 may be treated to create more nicks and/or facets in portions farther from the illuminated end, relative to portions nearer to the illuminated end. This tends to increase the amount of the available light emitted from such more distant portions. The light guide 100 may also be treated to create areas of greater or lesser illuminance independent of distance from the illuminated end of the light guide 100.

[0023] In various exemplary embodiments, the light guide 100 is treated on all surfaces. Such a light guide 100 may be installed without regard for how it is oriented (i.e., there is no designated show surface, as all surfaces may function as the show surface).

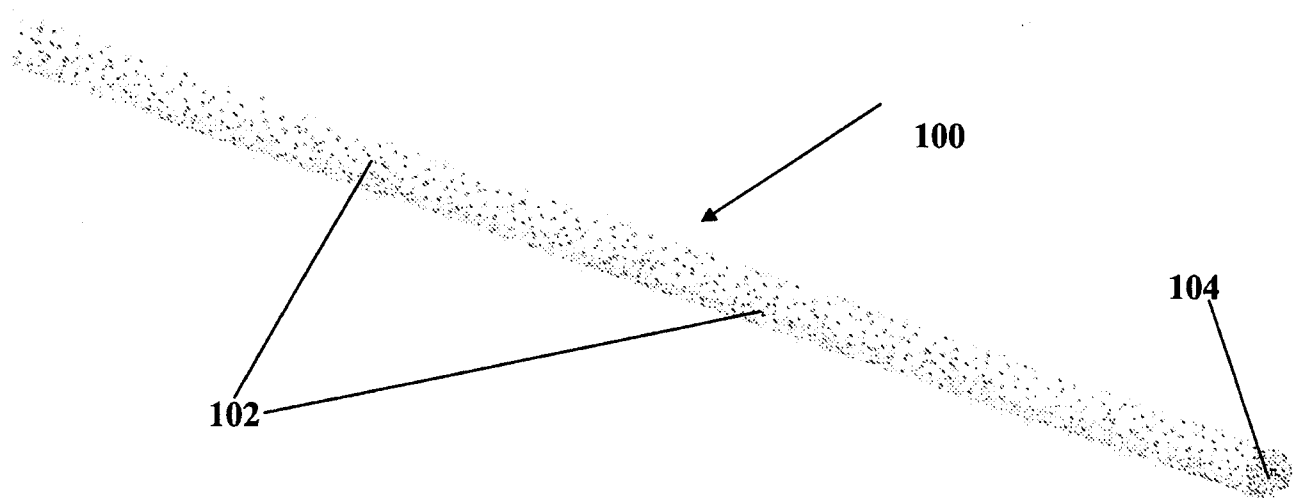
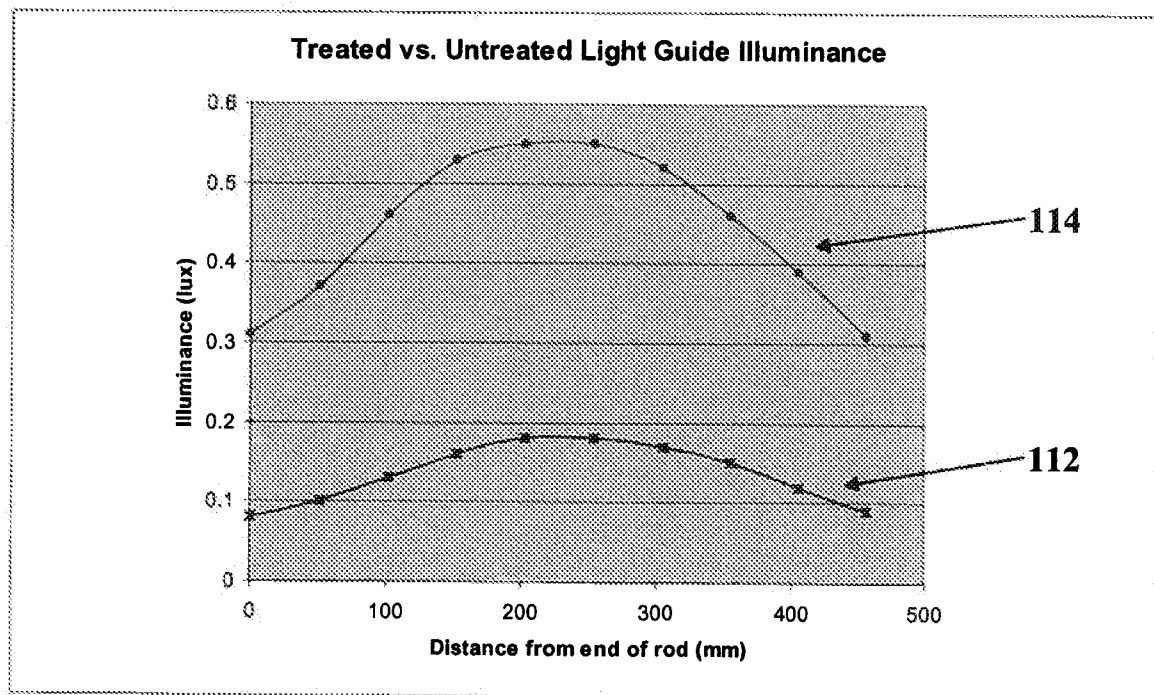
[0024] It should be understood that the drawings are not necessarily to scale. In certain instances, details that are not necessary to the understanding of the invention or render other details difficult to perceive may have been omitted. It should be understood, of course, that the invention is not necessarily limited to the particular embodiments illustrated herein.

[0025] It is also important to note that the construction and arrangement of the light guide, as shown in the various exemplary embodiments, is illustrative only. While the light guide, according to this invention, has been described in conjunction with the exemplary embodiments outlined above, various alternatives, modifications, variations, improvements, and/or substantial equivalents, whether known or that are or may be presently unforeseen, may become apparent. Accordingly, the exemplary embodiments of the light guide, according to this invention, as set forth above, are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the invention. Therefore, the description provided above is intended to embrace all known or later-developed alternatives, modifications variations, improvements, and/or substantial equivalents.

Claims:

1. Light guide to transport light from a source to another location, with an outer- or side-surface, characterized in, that it comprises, at least locally, surface irregularities on the outer- or side-surface to improve light emission along the outer- or side-surface.
2. Light guide according to claim 1, whereas the outer- or side-surface is at least locally irregular with numerous nicks and/or facets.
3. Light guide according to claim 1, whereas only a preselected area of the outer- or side-surface comprises irregularities.
4. Light guide according to claim 1, whereas the outer- or side-surface is roughened.
5. Method for producing a light guide, comprising at least partially treating the outer- or side-surface of a light guide to create an irregular outer or side surface.
6. Method according to claim 5, whereas the irregularities are inserted into originally smooth outer- or side-surface
7. Method according to claim 5, whereas the outer- or side-surface is treated with a roller, a die, sandpaper or abrasive material, a laser, by chemical etching, sandblasting, bead-blasting and/or abrasive blasting.
8. Method according to claim 5, whereas the light guide is molded and the mould has an inner surface provided with numerous small projections and/or facets.
9. Method according to claim 5, whereas certain portions of the outer- or side-surface are treated with two or more processes.

1/1

**Fig. 1****Fig. 2**

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2010/022831

A. CLASSIFICATION OF SUBJECT MATTER

INV. G02B6/00 F21V8/00
 ADD. B60Q3/00

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)
 G02B

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 829 675 A (MARIANI R) 13 August 1974 (1974-08-13) column 3, line 27 - line 68 column 4, line 53 - column 5, line 44 figures 1,7,8	1-9
X	EP 0 295 634 A2 (MITSUBISHI RAYON CO [JP]) 21 December 1988 (1988-12-21) column 1, line 8 - column 2, line 6 column 2, line 51 - column 3, line 57 claims figures ----- -/--	1,2,4-7



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

3 June 2010

Date of mailing of the international search report

11/06/2010

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040.
 Fax: (+31-70) 340-3016

Authorized officer

Bourhis, J

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2010/022831

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/263405 A1 (NG KEE Y [MY] ET AL NG KEE YEAN [MY] ET AL) 15 November 2007 (2007-11-15) figures 1,2,4,8,9 paragraph [0015] - paragraph [0016] paragraph [0019] - paragraph [0020] paragraph [0030] - paragraph [0034] -----	1-6,8
X	EP 0 547 343 A1 (POLY OPTICAL PROD INC [US]) 23 June 1993 (1993-06-23) figures 1-3,8 column 1, line 8 - line 43 column 2, line 18 - column 4, line 38 column 3, line 54 - column 4, line 42 column 6, line 1 - line 27 column 6, line 49 - column 7, line 42 -----	1,4,5,7
X	DE 198 53 106 A1 (BAYER AG [DE]) 31 May 2000 (2000-05-31) column 1, line 43 - column 2, line 16 column 2, line 68 - column 3, line 4 column 3, line 65 - column 4, line 3 column 5, line 21 - column 6, line 7 examples 4,6,7 figures 1,2,4,5 -----	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2010/022831

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3829675	A	13-08-1974	NONE
EP 0295634	A2	21-12-1988	AU 591598 B2 07-12-1989
		AU 1772888 A 05-01-1989	
		DE 3887387 D1 10-03-1994	
		DE 3887387 T2 26-05-1994	
		JP 6014162 Y2 13-04-1994	
		JP 64003803 U 11-01-1989	
		US 4929169 A 29-05-1990	
US 2007263405	A1	15-11-2007	CN 101070954 A 14-11-2007
EP 0547343	A1	23-06-1993	CA 2080434 A1 01-05-1993
		DE 69223934 D1 12-02-1998	
		DE 69223934 T2 30-04-1998	
		HK 1012697 A1 31-03-2000	
		JP 2957053 B2 04-10-1999	
		JP 6138323 A 20-05-1994	
		US 5499912 A 19-03-1996	
		US 5312569 A 17-05-1994	
DE 19853106	A1	31-05-2000	AT 289038 T 15-02-2005
		AU 750718 B2 25-07-2002	
		AU 1161100 A 05-06-2000	
		CA 2351541 A1 25-05-2000	
		CN 1333867 A 30-01-2002	
		WO 0029785 A1 25-05-2000	
		EP 1131582 A1 12-09-2001	
		ES 2237972 T3 01-08-2005	
		HK 1043823 A1 10-09-2004	
		TW 457469 B 01-10-2001	
		US 6584714 B1 01-07-2003	