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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 June 2006 (22.06.2006)

PCT

(10) International Publication Number
WO 2006/065144 A1

(51) International Patent Classification:
E21B 33/14 (2006.01) *E21B 33/127* (2006.01)

(21) International Application Number:
PCT/NO2005/000456

(22) International Filing Date:
12 December 2005 (12.12.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
20045478 16 December 2004 (16.12.2004) NO

(71) Applicant *(for all designated States except US)*: **EASY WELL SOLUTIONS AS** [NO/NO]; P.O. Box 8034, N-4068 STAVANGER (NO).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **FREYER, Rune** [NO/NO]; Professor Olav Hansensv. 11, N-4021 STAVANGER (NO).

(74) Agent: **LANGAN, Hans**; Zacco Norway AS, P.O. Box 2003, Sentrum, N-0125 Oslo (NO).

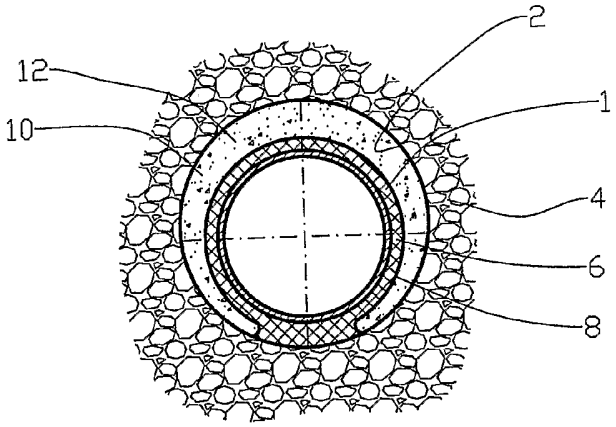
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, 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, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** A METHOD AND A DEVICE FOR SEALING A VOID INCOMPLETELY FILLED WITH A CAST MATERIAL



II–II

(57) **Abstract:** A method and a device for sealing a void (12) incompletely filled with a cast material (10), in which an expandable material (6) is placed in the void (12) which is to be filled with a cast material (10), the expandable material (6) expanding, when expanding after the cast material (10) has cured, into spaces (16) which are not filled with cast material (10).

WO 2006/065144 A1

A METHOD AND A DEVICE FOR SEALING A VOID INCOMPLETELY FILLED WITH A CAST MATERIAL

This invention relates to a method for sealing a void incompletely filled with a cast material. More particularly, the method comprises the placing of an expandable material in the void which is to be filled with cast material, the expandable material expanding, when expanding, after the cast material has cured, into spaces which are not filled with cast material. The method is particularly suitable for sealing openings in an annulus round a cast-in casing as it is known from the recovery of petroleum. The invention also comprises a device for practicing the invention.

When cementing the annulus between a casing and the formation wall in a borehole, especially when approximately horizontal wells are involved, it can be very difficult or impossible to achieve complete filling of the annulus with a cast material.

The reason for this condition is essentially that a fluid present on the underside of the casing is difficult to drain completely. This fluid may include drilling fluid.

Fluid present in said annulus during the curing of the cast material, and in particular fluid present in the lower portion of the annulus, could form a channel along the borehole, which may extend so far that it connects different zones of the borehole.

It is obvious that channels of this kind are undesirable as an uncontrollable fluid transport may occur in the channel. For example, formation water from a zone may flow into a nearby petroleum-producing zone.

It is known to use an expandable material to shut off an annulus. Thus, Norwegian patent 312478 discloses a packer which is made of a swellable material. After the packer has been placed at a desired location, the material of the packer absorbs a fluid and thereby swells until it seals the annulus.

The invention has as its object to remedy or reduce at least one of the drawbacks of the prior art.

The object is realized in accordance with the invention through the features specified in the description below and in the following Claims.

Sealing of a void which is incompletely filled with a cast material, is realized according to the invention by placing

an expandable material in the void which is to be filled with cast material. The expandable material then expands into spaces which are not filled with cast material after the cast material has cured, typically by displacing a fluid.

When, for example, a casing is to be cemented in a borehole, at least one sleeve-shaped plug is placed so that it encircles the casing, before the casing is run into the borehole.

When the casing has been run to its predetermined position in the borehole, the annulus encircling the casing is filled with drilling fluid, the expandable material attempting, to a certain degree, to centralize the casing in the borehole.

When a cast material, normally in the form of concrete, then flows into the annulus, the fluid present in the annulus is essentially displaced as the volume fills with concrete.

It has turned out to be difficult, however, to drain all the fluid away from the annulus, and some fluid accumulates at the bottom of the annulus. After casting, the sleeve-shaped plug of expandable material is partly in this fluid and partly embedded in the cast material.

The expandable material will expand, for example due to swelling on contact with the fluid or by diffusion of the fluid into openings in the expandable material. Adjacent fluid is displaced by the expandable material, which thereby has the effect that, for example, a fluid channel in the lower portion of an annulus is shut off.

The expandable material may be formed, for example, by a swellable material or by a foam-like diffusible material which is compressed before being placed in the borehole, cavities in the material filling up with fluid with time, whereby the material expands. The expandable material may be designed to expand on contact with, for example, water, oil, gas or other suitable materials.

A swellable material may be selected, for example, from the group including an elastic polymer such ad EPDM rubber, styrene/butadiene, natural rubber, ethylene/propylene monomer rubber, styrene/propylene/diene monomer rubber, ethylene/vinyl acetate rubber, hydrogenated acrylonitrile/butadiene rubber, acrylonitrile/butadiene rubber, isoprene rubber, chloroprene rubber or polynorbornene. The swellable material may further include mixtures of the mentioned materials, possibly with the addition of other dissolved or mixed-in materials, such as cellulose fibre, as it is described in US patent 4,240,800. Further alternatives may be a rubber in a mechanical mixture with polyvinyl chloride, methyl methacrylate, acrylonitrile, ethyl acetate or other polymers which will expand on contact with oil.

A diffusible material can be selected from the group including nitrile rubber. As mentioned above, the diffusible material is made of an elastic material with a considerable portion of closed cavities, the material allowing the diffusion of a fluid through the material into the cavities.

The expandable materials may be provided with one or more reinforcements, for example in the form of a fibre cloth.

In what follows is described a non-limiting example of a preferred method and embodiment which are visualized in the accompanying schematic drawings, in which:

Figure 1 shows a casing which is provided with sleeves of an expandable material, and which is placed in an approximately horizontal borehole in the ground, cast material having been filled into the annulus between the casing and the borehole wall;

Figure 2 shows the same as Figure 1 after some time has passed, the expandable material having sealed an opening in the cast material;

Figure 3 shows a section I-I of Figure 1; and

Figure 4 shows a section II-II of Figure 2.

In the drawings the reference numeral 1 identifies a casing which is located in a borehole 2 of a formation 4.

The casing 1 is encircled by several sleeves 6 made of an expandable material.

The sleeves 6 are fitted to the casing 1 before the casing is run into the borehole 2, and the sleeves 6 thereby help the casing 1 not to be laid down completely on the bottom of the borehole 2.

Most advantageously, the sleeve 6 is provided with an externally penetratable, preferably durable cloth material 8. This material may also contain reinforcement in the form of metal bodies or synthetic fibre. The penetratable cloth material 8 inhibits the expandability of the sleeve 6 only to an insignificant degree.

After the casing 1 has been placed in the borehole 2, cast material 10, here concrete, is filled into a void 12 in the form of an annulus between the casing 1 and the borehole 2, see Figure 1.

As appears from Figures 1 and 3, the annulus 12 is not completely filled with cast material 10, as some drilling fluid 14 is present in the lower portion of the annulus 12.

This drilling fluid 14 which has not been displaced by the cast material 10, has the effect that a flow-permitting cannel 16 is formed along the borehole 2.

After some time the expandable material of the sleeve 6 has expanded, through the influence of the drilling fluid 14, for example, and displaced the drilling fluid 14 present between the sleeve 6 and the borehole 2, see Figures 2 and 4. The expandable material of the sleeve 6 now abuts the wall of the borehole 2, thereby sealing the longitudinal channel 16 to fluid flow.

C L A I M S

1. A method for sealing a void (12) incompletely filled with a cast material (10), c h a r a c t e r i z e d i n that an expandable material (6) is placed in the void (12) which is to be filled with a cast material (10), the expandable material (6) expanding, after the cast material (10) has cured, into spaces (16) which are not filled with cast material (10).

2. A method in accordance with claim 1, c h a r a c - t e r i z e d i n that an expandable material in the form of a sleeve (6) is connected in an encircling manner to a pipe (1) before the pipe (1) is run into a borehole (2).

3. A method in accordance with claim 1, c h a r a c - t e r i z e d i n that the expanding material (6) is essentially enveloped in a cast material (10).

4. A device for sealing a void (12) incompletely filled with a cast material (10), c h a r a c t e r i z e d i n that before casting, an expandable material (6) is placed in the void (12), the expandable material (6) being arranged to expand into spaces (16) which are not filled with cast material (10).

5. A device in accordance with claim 4, c h a r a c - t e r i z e d i n that the expandable material (6) is formed by a sleeve encircling a pipe (1).

6. A device in accordance with claim 5, characterized in that the pipe (1) is located in a borehole (2).

AMENDED CLAIMS

received by the International Bureau on 02 May 2005

1.
A device for expanding into a cavity (16) in a borehole (2), said cavity (16) being at least partly defined by a casting material (10) disposed in the borehole (2), characterized by an annular element (6) disposed on a tubular element (1) in the borehole and comprising an expandable material capable of extending from a retracted state to an expanded state.

2.
The device of claim 1, wherein the cavity (16) is at least partly defined by the borehole (2) wall.

3.
The device of claim 1, wherein the cavity (16) is at least partly defined by the tubular element (1).

4.
The device of any of claims 1 – 3, wherein the cavity (16) at least partly holds a fluid.

5.
The device of claims 1 and 4, wherein the annular element (6) is adapted to extend from the retracted state to the expanded state as a reaction to exposure to a fluid in the cavity (16).

6.
The device of claim 1, wherein the casting material (10) comprises hardended concrete.

7.
The device of claim 1, wherein the cavity (16) comprises an elongated channel substantially defined by the casting material (10) , the tubular element (1) and the borehole (2) wall.

8.
A method for providing a barrier in a cavity (16) in a borehole (2), said cavity (16) being at least partly defined by a casting material (10) disposed in the borehole (2), characterized by the steps of:
- on a tubular element (1), disposing one or more annular elements (6) comprising an expandable material capable of extending from a retracted state to an expanded state;
- extending the tubular element (1) into the borehole;
- providing a casting material (10) into a first volume (12) defined by a the borehole (2) wall and the outer surface of said tubular element (1);
whereby the expandable material may extend into said cavity (16).

9.
The method of claim 8, wherein the annular elements (6) comprise a plurality of elements placed at substantially regular intervals along a length of the tubular element (1).

10.
The method of claim 8, wherein the expandable element (6) is adapted to extend from the retracted state to the expanded state as a reaction to exposure to a fluid in the cavity (16).

11.
The method of claim 8, wherein the expandable material extends into the cavity (16) after the casting material (10) has hardended.

12.
The method of claim 8, wherein the cavity (16) comprises an elongated channel substantially defined by the casting material (10) , the tubular element (1) and the borehole (2) wall.

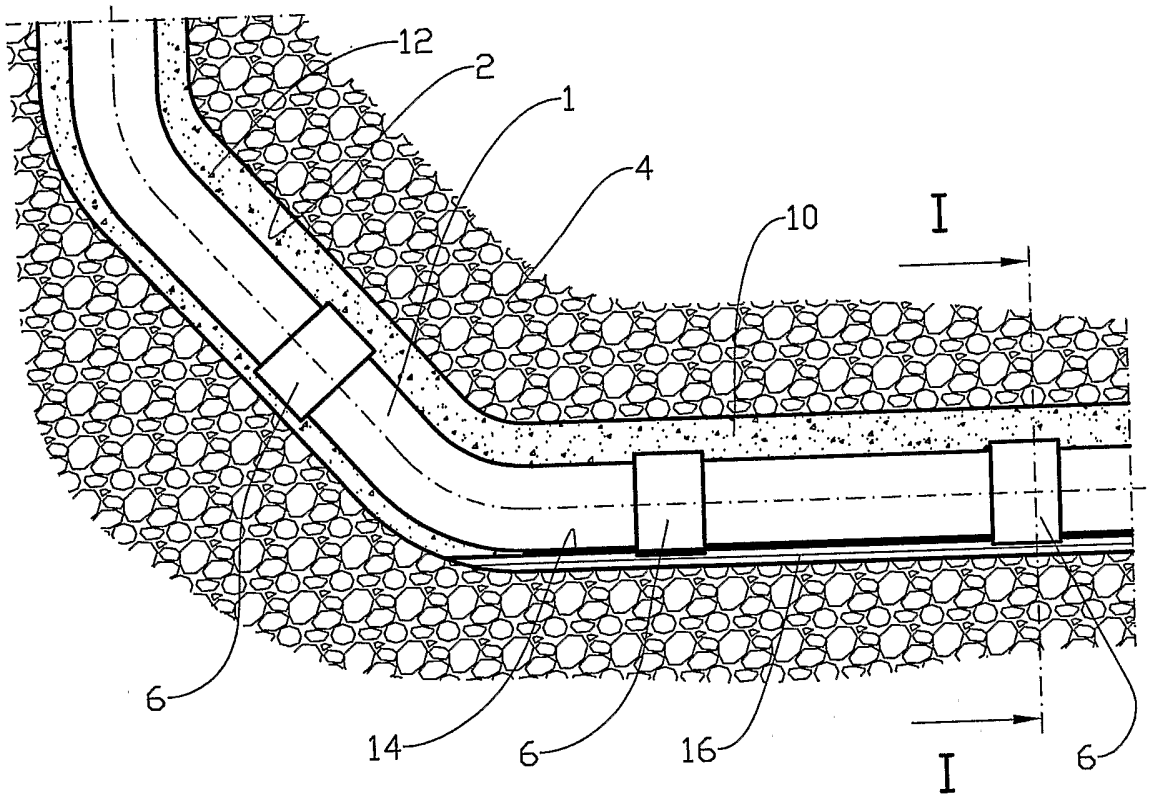


Fig. 1

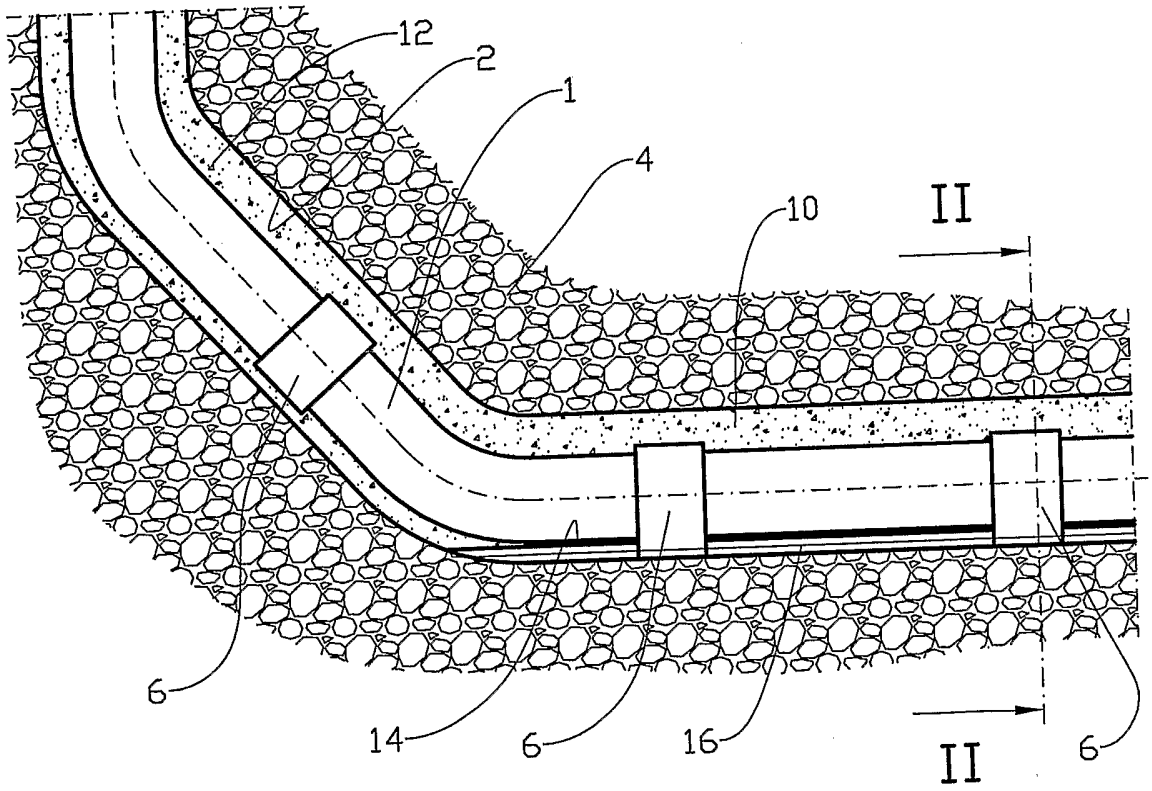
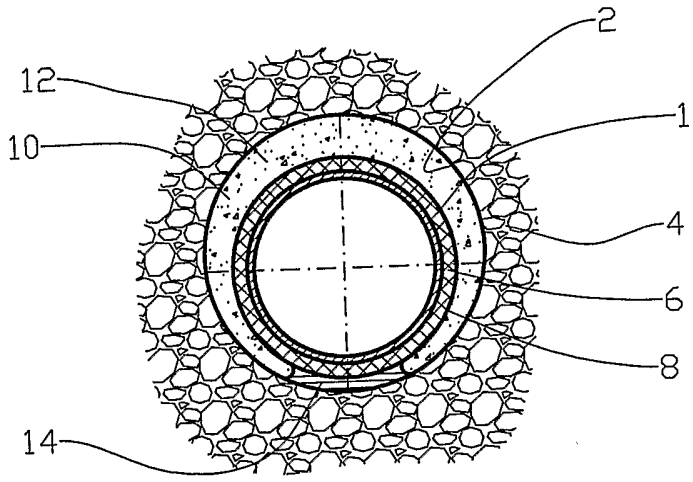
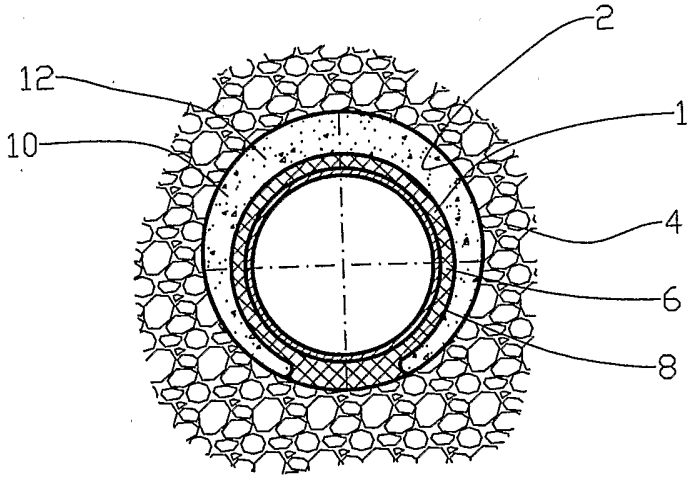


Fig. 2



I-I

Fig. 3



II-II

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2005/000456

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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: E21B

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)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5211238 A (ROBERT B. CARPENTER), 18 May 1993 (18.05.1993) --	1-6
A	US 5402849 A (ALFRED R. JENNINGS, JR.), 4 April 1995 (04.04.1995) --	1-6
A	US 5188176 A (ROBERT B. CARPENTER), 23 February 1993 (23.02.1993) --	1-6
A	US 5942031 A (PING-SUN CHEUNG), 24 August 1999 (24.08.1999) --	1-6

[X] 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
28 March 2006	30-03-2006
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 Christer Bäcknert/MP Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2005/000456

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5476142 A (LAURA KAJITA), 19 December 1995 (19.12.1995) -- --------	1-6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2005/000456

International patent classification (IPC)

E21B 33/14 (2006.01)
E21B 33/127 (2006.01)

Download your patent documents at www.prv.se
Cited patent documents can be downloaded at www.prv.se by following the links e-tjänster/anförda dokument. Use the application number as username. The password is w8grr223js.

Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

US	5211238	A	18/05/1993	WO	9309332	A 13/05/1993
US	5402849	A	04/04/1995	CA	2144846	A 14/04/1994
				EP	0662188	A 12/07/1995
				NO	951156	A 27/03/1995
				US	5320172	A 14/06/1994
				US	5452764	A 26/09/1995
				WO	9408126	A 14/04/1994
US	5188176	A	23/02/1993	WO	9309332	A 13/05/1993
US	5942031	A	24/08/1999	CA	2224201	A,C 10/06/1998
				GB	2320246	A,B 17/06/1998
				GB	9726164	D 00/00/0000
				NO	975786	A 11/06/1998
US	5476142	A	19/12/1995	AU	672528	B 03/10/1996
				AU	7429594	A 13/04/1995
				CA	2131335	A 30/03/1995
				CN	1105286	A 19/07/1995
				EP	0645181	A 29/03/1995
				JP	2637050	B 06/08/1997
				JP	7171557	A 11/07/1995
				US	5407879	A 18/04/1995
				US	5556547	A 17/09/1996
				US	5578219	A 26/11/1996
				ZA	9407532	A 23/06/1995