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(54) Title: HIGH ELONGATION STEEL CORD WITH PREFORMED STRANDS

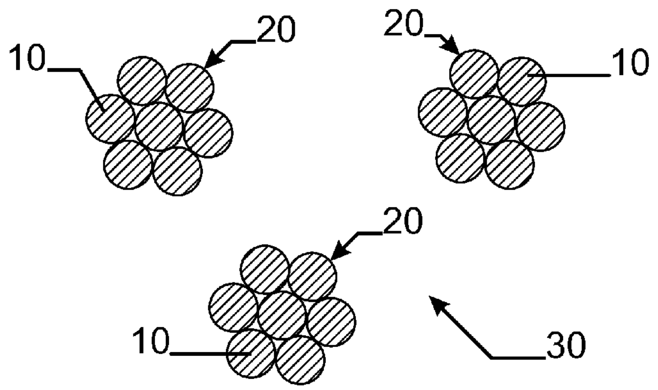

Fig. 2

(57) Abstract: A steel cord (30) with a high elongation at break of at least 5% comprises n strands (20), each of said strands (20) has m filaments (10) twisted together, n ranges from 2 to 7. m ranges from 2 to 9. The strands and the filaments are twisted in a same direction. The lay length of the cord is Lc and the lay length of said strand is Ls. The ratio of Ls to Lc (Ls/Lc) ranges from 0.25 to 1. Lc ranges from 16 mm to 26 mm. The strands are helically preformed. The E-modulus of the cord is more than 150000 N/mm2. The helical preforming of the strands allows to obtain a high elongation at break and a high E-modulus despite its long lay length Lc.

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High elongation steel cord with preformed strands

Field of the invention.

The patent relates to a steel cord with a high elongation at break and high E-modulus for reinforcing elastomer product.

Background of the invention.

High elongation at break means the elongation at break of the cord is at least 5%. It is well know that productivity of the cord will increase with the lay length increasing. However, a high lay length of the cord will cause the loss of elongation at break. Once a steel cord is formed with a higher lay length, its elongation at break will be lower. Generally the cord and the strand are twisted in same direction to get a high elongation at break.

In solid mechanics, E-modulus is a measure of the stiffness of a material in the elastic region. It is defined as the ratio of the stress over the strain in the range of stress in which Hooke's Law holds. This can be experimentally determined from the slope of a stress-strain curve created during tensile tests conducted on a sample of the material. To linear materials such as steel, E-modulus is essentially constant over a range of strains.

The stiffness of a cord is of principal importance to keep the tire diameter stable in high speed, so the E-modulus is often one of the primary properties considered when selecting a cord structure. As the E-modulus is higher, the steel cord is stiffer.

US 5661966 discloses a steel cord with high lay length and high elongation at break. The steel cord comprising plurality strands has an elongation of more than 5%. The lay length of the cord is 8 to 15 times the diameter of the cord. The filaments of the strand are wavy preformed with a pitch smaller than the lay length of the strands before twisting together. Generally the loss of elongation at break when using long lay length can be compensated by preforming filaments. Although the elongation at break and lay length is high, there is a problem that the E-modulus is small and the steel cord is not very stiff.

3×7 high elongation at break steel cord is a popular cord in the market to reinforce the tire. But there is a drawback that the cord is formed with low lay length. So it is produced with a high cost. The breaking load of the cord is not very high. Also the E-modulus is low so that the cord is not very stiff.

<u>Summary of the invention.</u>

It is an object of the present invention to overcome the problem of the prior arts. It is a further object of the present invention to provide a stiffer steel cord. It is another object of the present invention to provide a steel cord with high elongation at break and high E-modulus.

According to the present invention, a steel cord with a high elongation at break being at least 5% comprises n strands, and each of the strands has m filaments twisted together, and n ranges from 2 to 7 while m ranges from 2 to 9. The strands and filaments are twisted in a same direction. The lay length of the steel cord is Lc and the lay length of the strand is Ls. The ratio of Ls to Lc (Ls/Lc) ranges from 0.25 to 1, and Lc ranges from 16 mm to 26 mm. The strands are helically preformed. The E-modulus of the steel cord is more than 150000 N/mm^2.

To obtain a stiff steel cord, the steel cord is formed with long lay length. Lc ranges from 16 mm to 26 mm. Preferably Lc ranges from 18 mm to 24 mm. Most preferably Lc is 20 mm.

According to the present invention, the ratio of Ls to Lc (Ls/Lc) ranges from 0.25 to 1. Preferably the ratio ranges from 0.30 to 0.50. Most preferably the ratio is 0.35.

Also as the lay length increases, the productivity increases. And the cost of the product decreases.

To obtain a high elongation at break steel cord, the strand is helically preformed before being twisted into a steel cord. Due to the helically pre-formation, the strand has a three dimensional deformation. Also the strand can get a good surface, fatigue and adhesion.

According to the present invention, the strand has pitch Ps for the preformation (which is different from the twisting pitch) and amplitude As for the preformation. Preferably Ps is 50 to 120 times diameter D of the filament. Most preferably Ps is 70 to 100 times diameter D. Preferably As is 8 to 12 times diameter D of the filament. Most preferably As is 9 to 11 times diameter D.

Preferably the Ps is equal to Lc, which means that the lay length of the cord Lc is equal to the pitch of the preformation. This has an advantage that the preformation can be done immediately before the twisting, making use of the rotational movement that the strands already have just before the twisting point or cord formation point.

The steel cord with such long lay length has an E-modulus more than 150000 N/mm^2. Preferably the E-modulus is more than 160000 N/mm^2.

Due to the pre-formation on the strands and same twisting direction of strands and filaments, the elongation at break of the steel cord is at least 5%. Even it reaches to 10%.

The filament reinforcing the steel cord has a diameter D ranging from 0.05 mm to 0.60 mm. Preferably diameter D ranges from 0.10 mm to 0.45 mm. Generally diameter D can be 0.10, 0.12, 0.13, 0.15, 0.175, 0.20, 0.22, 0.245, 0.25, 0.265, 0.27, 0.28, 0.30, 0.32, 0.35, 0.38, 0.40, 0.42 or 0.45 mm.

The steel cord has a structure of n × m. The n ranges from 2 to 7, and m ranges from 2 to 9. The cord can be 2×2, 2×3, 2×4, 2×5, 2×6, 2×7, 2×8, 2×9, 3×2, 3×3, 3×4, 3×5, 3×6, 3×7, 3×8, 3×9, 4×2, 4×3, 4×4, 4×5, 4×6, 4×7, 4×8, 4×9, 5×2, 5×3, 5×4, 5×5, 5×6, 5×7, 5×8, 5×9, 6×2, 6×3, 6×4, 6×5, 6×6, 6×7, 6×8, 6×9, 7×2, 7×3, 7×4, 7×5, 7×6, 7×7, 7×8 or 7×9.

The steel cord is used for reinforcing the elastomer product. The elastomer product can be a tyre of passenger car, bus, truck, earthmover and off-the-road tyre.

<u>Brief description of the drawings.</u>

The invention will now be described into more detail with reference to the accompanying drawings wherein

- FIGURE 1 shows a front view of a strand with a helically pre-formation
- FIGURE 2 shows a sectional view of a steel cord comprising preformed strands with a structure of 3×7

- FIGURE 3 shows a sectional view of a steel cord comprising preformed strands with a structure of 4×7
- FIGURE 4 shows a sectional view of a steel cord comprising preformed strands with a structure of 3×6
- FIGURE 5 shows a Force-Elongation curve of two steel cords, one is the invented steel cord and another is prior art steel cord

Description of the preferred embodiments of the invention.

A steel filament 10 can be made as follows:

Wire rod forms the starting material. Wire rod has a typical composition along the following lines: a carbon content ranging from 0.60 % to 1.25 %, a manganese content ranging from 0.20 % to 1.10 %, a silicon content ranging from 0.10 % to 0.90 %, sulfur and phosphorous contents being limited to 0.10 %, additional micro-alloying elements such as chromium (up to 0.20 % - 0.40 %), copper (up to 0.20 %), vanadium (up to 0.30 %), boron, nickel, molybdenum, niobium, copper calcium, aluminum, titanium, and nitrogen may be added.

The wire rod is drawn in a first series of dry drawing steps into a steel wire with an intermediate diameter. The steel wire is then subjected to a heat treatment such as patenting in order to allow for further drawing. The steel wire can be coated with a brass coating, e.g. by means of a diffusion process applied to a zinc and a copper coating.

The brass coated steel wire is then drawn until a steel filament 10 with a final filament diameter.

For a final filament 10, the tensile strength of the final steel filament 10 may vary between 2000 MPa and 5000 MPa. May be the tensile strength is more than 3500 MPa. Even the tensile strength is more than 4000 MPa.

Figure 1 shows a front view of helically preformed strand 20. The strand 20 is formed with 7 filaments 10 with a diameter D of 0.22 mm. The filaments 10 are parallel and then twisted with a twisted pitch, so that the strand 20 has a lay length Ls of 7 mm. 3 strands 20 are helically preformed.

Figure 2 shows the sectional view of a first preferred embodiment steel cord 30 with a structure of 3 × 7. 3 strands are twisted with a long lay length in the same direction with the filaments into steel cord 30.

Finally the lay length of the steel cord 30 Lc is 20 mm. The strand 20 has preformation pitch Ps of 19.9 mm and preformation amplitude As of 2.10 mm.

Due to the long lay length and preformed strands, the steel cord 30 has high E-modulus and high elongation at break.

Compared with a prior art 3 × 7 steel cord which strands are not preformed and lay length is low, some properties are measured. The table below shows the results.

Table 1

	Steel Cord 30	Prior art 3 × 7 steel cord
Diameter of the filament (mm)	0.22	0.22
Lay length of the strand (mm)	7	4.8
Lay length of the cord (mm)	20	8
Diameter of the cord (mm)	1.449	1.443
Filaments with pre-formation	No	No
Strands with pre-formation	Yes	No
Structural elongation (%)	2.0	1.9
Elongation at break of the cord (%)	5.12%	5.14%
Breaking load of the cord (N)	2339	2084
E-modulus of the cord (N/mm^2)	163287	105510

From the Table 1, compared with the prior art steel cord, the diameter and structural elongation of the steel cord 30 has no obvious difference. But the breaking load of the steel cord 30 increases obviously. Especially the E-modulus of the steel cord 30 is nearly 55% higher than that of the prior art steel cord. In other words the steel cord 30 is stiffer than the prior art steel cord.

Figure 5 shows the Force-Elongation curve 32 of the steel cord 30 and the Force-Elongation curve 40 of prior art steel cord. Also the difference on the E-modulus between the steel cord 30 and the prior art steel cord is great. The E-modulus of the steel cord 30 is higher than that of the prior art steel cord.

Figure 3 shows a sectional view of a second preferred embodiment steel cord 50 comprising 4 helically preformed strands 20 and having a lay length Lc of 20 mm. The elongation at break is 5.5%. The E-modulus of the steel cord 50 is 175324 N/mm^2.

Figure 4 shows a sectional view of a third preferred embodiment steel cord 70 comprising 3 helically preformed strands 60 and having a lay length Lc 23 mm. Each strand 60 comprises 6 filaments. The lay length of the strand 60 Ls is 11.2 mm. The strand 60 has preformation pitch Ps of 29.8 mm and preformation amplitude As of 2.16 mm. The elongation at break of the steel cord 70 is 5.6%. The E-modulus of the steel cord 70 is 155324 N/mm^2.

CLAIMS

1. A steel cord with a high elongation at break being at least 5% comprising n strands, said strands being helically preformed, each of said strands has m filaments twisted together, said n ranging from 2 to 7, said m ranging from 2 to 9, said strands and said filaments being twisted in a same direction, the lay length of said cord being Lc and the lay length of said strand being Ls, characterized in that the ratio of said Ls to said Lc (Ls/Lc) ranges from 0.25 to 1, said Lc ranges from 16 mm to 26 mm, the E-modulus of said steel cord is more than 150000 N/mm^2.
2. A steel cord as claimed in claim 1, characterized in that said Lc ranges from 18 mm to 24 mm.
3. A steel cord as claimed in claim 2, characterized in that said Lc is 20 mm.
4. A steel cord as claimed in any one of claim 1 to 3, characterized in that said ratio of said Ls to said Lc (Ls/Lc) ranges from 0.30 to 0.50.
5. A steel cord as claimed in claim 4, characterized in that said ratio of Ls to said Lc (Ls/Lc) is 0.35.
6. A steel cord as claimed in any one of claim 1 to 5, characterized in that said helically preformed strand has a preformation pitch Ps and a preformation amplitude As, said Ps is 50 to 120 times diameter D of the filament and said As is 8 to 12 times diameter D of the filament.

7. A steel cord as claimed in claim 6, characterized in that said Ps is 70 to 100 times diameter D and said As is 9 to 11 times diameter D.
8. A steel cord as claimed in claim 6 or 7, characterized in that said Ps is equal to said Lc.
9. A steel cord as claimed in any one of claim 1 to 8, characterized in that said n is 3 while said m is 7.
10. The use of steel cord as claimed in any one of claim 1 to 9 is reinforcing elastomer product.

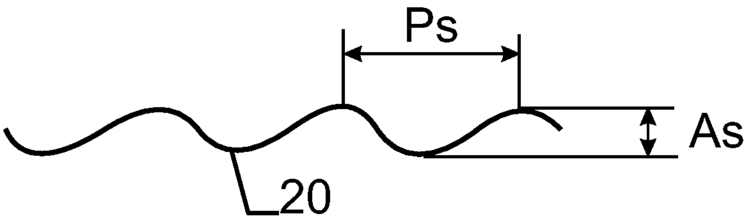

Fig. 1

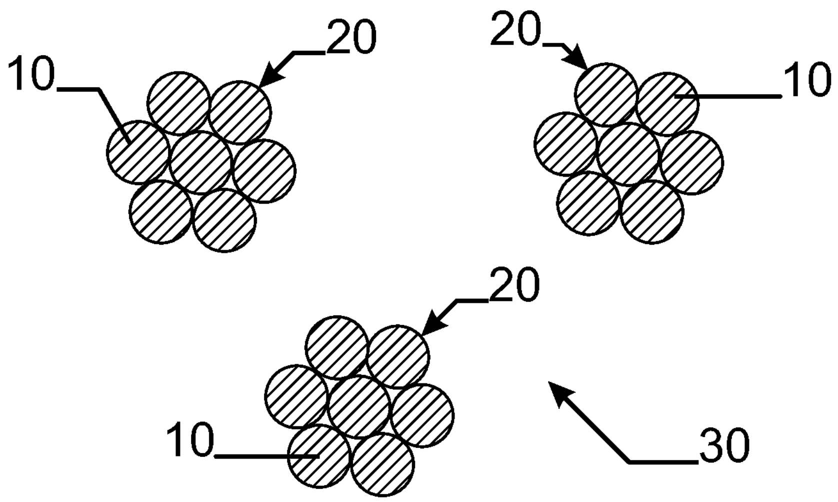

Fig. 2

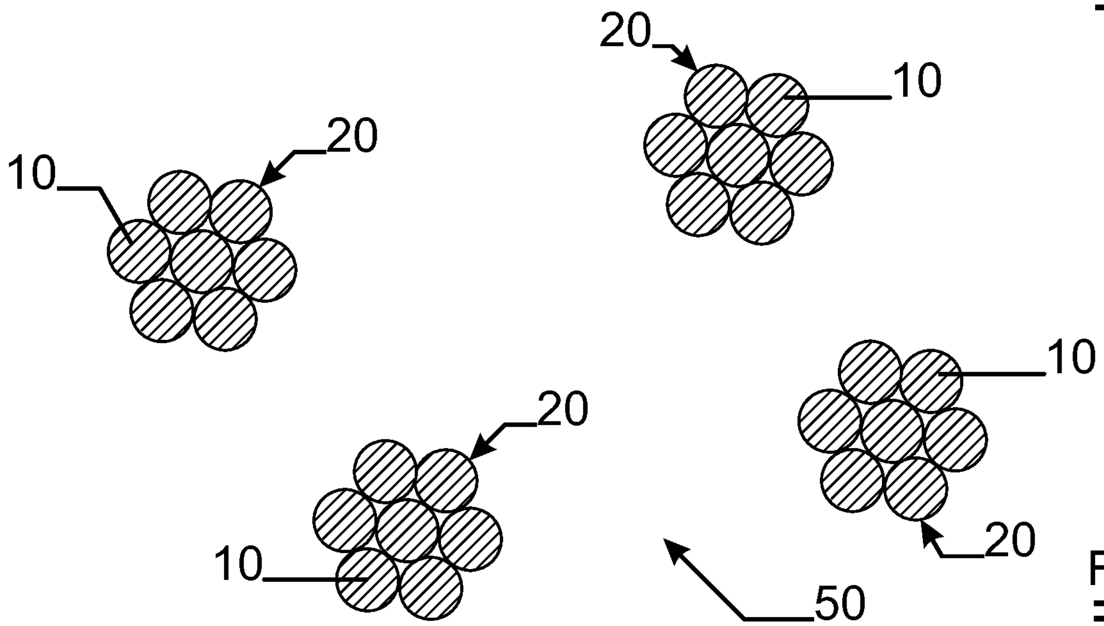

Fig. 3

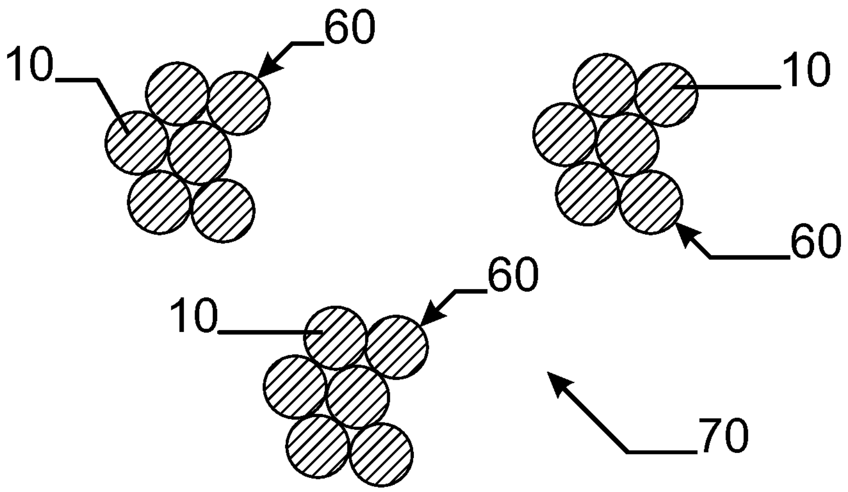

Fig. 4

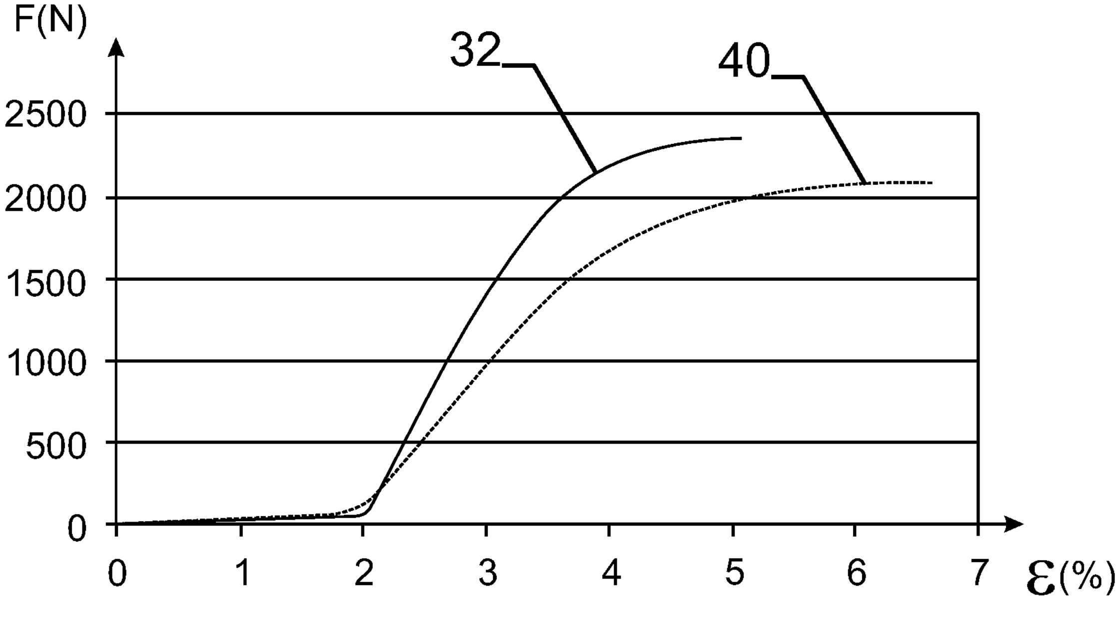

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/052943

A. CLASSIFICATION OF SUBJECT MATTER
INV. D07B1/06
ADD.

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)
D07B

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006 283199 A (KANAI HIROAKI) 19 October 2006 (2006-10-19) abstract	1
A	"POLYGONALLY PREFORMED STEEL ELEMENTS" 1 July 1994 (1994-07-01), RESEARCH DISCLOSURE, MASON PUBLICATIONS, HAMPSHIRE, GB, PAGE(S) 359 - 365 , XP000461309 ISSN: 0374-4353 page 3, paragraph 4 page 9; table IV	1
A	US 5 661 966 A (MATSUMARU KAZUO [JP]) 2 September 1997 (1997-09-02) cited in the application the whole document	1

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[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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 June 2010	17/06/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Uhlig, Robert

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/052943

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 602 733 A1 (BEKAERT SA NV [BE]) 22 June 1994 (1994-06-22) page 3, line 35 - line 51	1
A	EP 1 983 098 A1 (BRIDGESTONE CORP [JP]) 22 October 2008 (2008-10-22) paragraphs [0021], [0022]; claim 1; figures	1
A	JP 10 131066 A (BRIDGESTONE CORP) 19 May 1998 (1998-05-19) abstract	1
A	WOLF E ET AL: "ALTERNATIVE KONSTRUKTIONEN VON STAHLZUGTRAGERN IN FORDERGURTEN" KAUTSCHUK UND GUMMI - KUNSTSTOFFE, HUTHIG VERLAG, HEIDELBERG, DE, vol. 46, no. 9, 1 September 1993 (1993-09-01), pages 727-731, XP000397379 ISSN: 0948-3276 page 727, right-hand column, last paragraph - page 728, left-hand column, paragraph 3	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/052943

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2006283199 A	19-10-2006	NONE	
US 5661966 A	02-09-1997	NONE	
EP 0602733 A1	22-06-1994	AT 160188 T	15-11-1997
		AU 668433 B2	02-05-1996
		AU 5209593 A	30-06-1994
		BR 9305084 A	26-07-1994
		CA 2109904 A1	19-06-1994
		CN 1091791 A	07-09-1994
		DE 69315181 D1	18-12-1997
		DE 69315181 T2	02-04-1998
		DK 602733 T3	27-07-1998
		ES 2111709 T3	16-03-1998
		JP 3598125 B2	08-12-2004
		JP 6240590 A	30-08-1994
		US 5461850 A	31-10-1995
		ZA 9309119 A	05-08-1994
EP 1983098 A1	22-10-2008	WO 2007083761 A1	26-07-2007
JP 10131066 A	19-05-1998	NONE	