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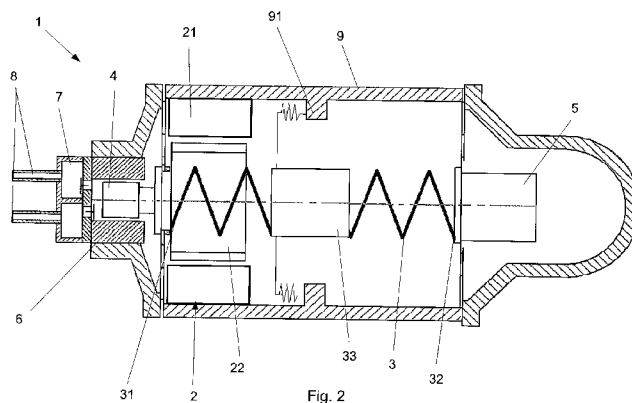
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(54) Title: LINEAR COMPRESSOR



(57) Abstract: The present invention refers to a linear compressor based on resonant oscillating mechanism, which comprises an oscillating arrangement essentially formed by at least one linear motor (2) defined by a movable portion (22) and a fixed portion (21), at least a resonance spring (3), at least one piston (4) and at least one balancing body (5), wherein the movable portion (22) of the linear motor (2) is cooperatively associated with the piston (4), defining a piston - motor assembly. The piston - motor assembly is operatively associated to the end (31) of the resonant spring (3) and at least one balancing body (5) is functionally associated with the end (32) of the resonant spring (3). This construction allows the attenuation of the vibration that the resonant oscillating mechanism applies to the compressor housing through the cancellation of the forces generated by the motor and the forces generated by the compression of gas in the cylinder.

"LINEAR COMPRESSOR"

Field of the Invention

The present invention refers to a linear compressor based on resonant oscillating mechanism, in particular based on a resonant spring-mass system, for maintaining the oscillating movement of its components. The linear compressor in question provides a resonant oscillating arrangement responsible for attenuation of vibration imposed on their outer housing.

Background of the Invention

Briefly, linear compressors consist of a piston which is responsible for admission and compression of the working fluid, coupled to a linear motor. The linear motor is responsible for imposing the linear oscillatory motion to the piston, which is responsible for the compression of the fluid. Compressors that make use of a linear motor on their drive have the advantage of occupying a substantially small volume compared to the compressors driven by a conventional rotary motor.

The use of a compact compressor is regarded as preferred and as the volume occupied by a compressor which is driven by a linear motor is significantly lower than the volume occupied by a compressor driven by a rotary engine, various solutions arose to seek the increase of the performance of the compressors driven by linear motors, the so-called linear compressors.

Based on the resolution of this drawback, linear compressors began to emerge provided with means focused on minimizing the force that the linear motor needs to perform in each cycle. One of these solutions reside in the use of a physical principle to conserve energy of the system, using the alternative movement of the linear motor and extending it in such a way that the effort made by the linear motor is aided by the inertia of the system. The resonance phenomenon is used.

The resonance is the tendency (or facility) that a body has to oscillate with large amplitudes at certain frequencies, called natural frequency or resonant frequency.

Once a force is imposed at a frequency near the natural frequency of a body, there is a gradual accumulation of mechanical energy, resulting in the increase of the amplitude of oscillation of the system.

Thus, solutions appeared which comprise a linear motor mounted under supports comprising springs, which have the function of accumulating the energy delivered by the engine. In addition to the accumulation of energy, these springs have the function of transmitting the movement of the motor to the piston. These springs are commonly called as resonant springs.

The use the resonant of springs helps linear motor to work and reduces the effort required to move the set, resulting in lower electricity consumption of the linear motor that

drives the system, due to the fact that most part of the energy required to move the piston is already stored in the spring resonant.

A first example of linear compressor provided with resonant springs is described in the document US 2006/005700, which discloses a linear compressor provided with an assembly of resonant springs, associated with the piston, which is in turn associated with the movable core of a linear motor. Said assembly of resonant springs consists of two pairs of springs, each pair disposed in a face of a plate associated with the piston. Thus, when performing the linear movement of the piston in one direction, the pair of springs arranged in the respective face of the plate acts on the assembly and moves it in the opposite direction when they reach a certain level of openness, reducing the effort that the motor needs to operate in alternating manner. This embodiment has, however, the inconvenience of using a large amount of springs, which complicates the mounting of the assembly. Furthermore, this embodiment prevents the minimization of the compressor assembly, preventing its application in small devices.

A second example of a linear compressor provided with resonator springs is described in document PI 0601645-6, which discloses a minimized compressor, comprising a single resonant spring associating a linear motor and a piston, and give it a reciprocating motion performed by the linear motor. This embodiment, while enabling a more compact arrangement of the linear compressor, has the disadvantage of not providing the existence of any deviation in the position between the piston and the linear motor, since each component is disposed at one end of the resonant spring. Furthermore, such a constructive arrangement, to use a single spring arranged along the entire length of the compressor, without any guiding element, results in undesirable efforts of the piston and of the motor, which may preclude their correct functioning.

A third example of the linear compressors provided with resonant springs is illustrated schematically in Figure 1 with a resonant linear compressor CL, according to the state of the art, comprising a piston P mounted within a cylinder CM and associated with a first end of a resonant spring MR, which has its second end associated with a movable portion (moving magnet) PM of a linear motor. The resonant spring MR has a neutral portion PN associated to the housing C of the compressor by a fastening means MF. Therefore, it should be noted that the linear compressor CL of the state of the art employs the piston P being mounted on a first end PE of the housing C, and the motor mounted on a second end SE of the housing C, that is, each component in one of the ends of the compressor. These components are intermediated by the resonant spring MR, however, this motor and piston arrangement is not favorable due to the resulting vibration in the compressor housing, since the forces generated by the engine and the forces generated by the compression of gas in the cylinder are in phase, that is, in the same direction, and therefore they are added,

resulting in a greater force on the housing.

Thus, it is noted that the current state of the art lacks a resonant compressor comprising a constructive simplified arrangement which can be minimized and, moreover, provided with means to reduce vibration of the housing.

5 Objectives of the Invention

It is one of the objectives of the present invention to provide a linear compressor based on resonant oscillating mechanism capable of attenuating the vibration that said resonant oscillating mechanism applies to its carcass. In this sense, then it is another objective of the present invention to provide a linear compressor whose resonant oscillation
10 arrangement is able to promote the cancellation (even partially) of the forces generated by the motor and of the forces generated by compression of the gas in the cylinder.

It is another objective of the present invention to provide a linear compressor based on resonant oscillating mechanism whose resonant oscillating arrangement reduces the amplitude of the resultant forces (movement) imposed on its housing.

15 Summary of the Invention

The objectives of the present invention are fully achieved by the linear compressor shown herein, which comprises an oscillating arrangement essentially comprising at least one linear motor (defined by a movable portion and a fixed portion), at least one resonant spring and at least one piston. The oscillating arrangement further comprises at least one
20 balancing body.

According to the concepts of the present invention, the movable portion of the linear motor is cooperatively associated with the piston defining a piston-drive assembly.

In this sense, the piston - motor is functionally associated to one of the ends of the resonant spring, while at least one balancing body is functionally associated with the
25 opposite end of the resonant spring.

Thus, the mentioned balancing body is capable of exerting an oscillatory movement, which can be synchronized to the resonant oscillatory motion of the motor piston assembly, or, synchronously opposite to the resonant oscillatory motion of the piston - motor assembly.

Brief Description of Figures

30 The present invention will be described in detail based on the figures listed below.

Figure 1 illustrates a schematic view of the assembly of the resonant linear compressor belonging to the current state of the art.

Figure 2 illustrates a schematic view of the assembly of the resonant linear compressor that is object of the present invention.

35 Detailed Description of Figures

According to the main concept of the present invention, there is shown a linear compressor based on resonant oscillating mechanism (driven by a linear motor and which

makes use of a resonant spring to assist its operation through the accumulation of energy resulting in an increased oscillation amplitude), where the resonant arrangement itself is capable of minimizing the unbalanced forces from the gas compression in the cylinder and the oscillating operation of the motor. With this, the vibration that the resonant arrangement
5 applies to the housing of the linear compressor is attenuated.

Figure 2 shows a schematic (cross-sectional) view of the preferred construction of the linear compressor 1, which is designed in accordance with the concepts and objectives of the present invention.

Thus, the preferred construction of a linear compressor 1 comprising an oscillating
10 arrangement essentially comprising a linear motor 2, a resonant spring 3, a piston 4, and a balancing body 5. Notably, the linear compressor 1 also comprises a cylinder 6 and other elements conventionally existing in compressors (for example, as a head assembly 7 and connections 8 for suction and discharge of the working fluid). Preferably, the linear compressor 1 is also integrated by a housing 9 which has the function of accommodating all
15 components that form the mentioned linear compressor 1.

The linear motor 2 comprises, in general, a fixed portion 21 (stator or back iron) and a movable portion 22 (cursor / magnet). The linear motor 2 is, therefore, a conventional linear motor.

According to the present invention, the fixed portion 21 of the linear motor 2 is fixed
20 to the casing 9 of the linear compressor, or any intermediate element (not shown) also fixed to the frame 9 of the linear compressor 1. Since the movable portion 22 of the linear motor 2 is cooperatively associated with the piston 4 defining a piston - motor assembly.

The resonant spring 3 includes a physically resilient body, that is, capable of suffering physical "deformation" when subjected to an external force and capable of returning
25 to its original "form" when free of external force.

Preferably, the resonant spring 3 is a substantially helical tubular metal body defining two distal ends 31 and 32. The resonant spring 3 further comprises a neutral point 33 (where vibrations or deformations are much smaller than the ends 31 and 32) arranged in the middle of its length. Said neutral point 33 allows the resonant spring 3 to be attached to
30 the casing 9 of the linear compressor 1, or any intermediate element (not shown) also attached to the housing 9 of the linear compressor 1.

The piston 4 is one conventionally piston used in linear compressors, that is, it comprises a piston defined by an essentially cylindrical body with an open end and one closed end (working end).

35 The balancing body 5, as induced by its nomenclature, consists of a body with a specific mass. Preferably, the balancing body 5 has a mass similar to the mass of the piston - motor assembly.

The cylinder 6, the head 7 and the connections 8 for suction and discharge of working fluid comprise conventional components already belonging to the current state of the art, therefore, already known to those skilled versed in the art.

5 The housing 9 which provides attachment means 91 to the neutral point 33 of the resonant spring 3 (or to any intermediate element disposed between said resonant spring 3 and the housing 9) also comprises a conventional housing already belonging to the current state of the art.

10 According to the main concepts of the present invention, the oscillating arrangement is especially detached from other oscillatory arrangements of the same type and belonging to the current state of the art due to the fact that the piston - motor assembly (defined by the cooperative association between the movable portion 22 of the linear motor 2 and the piston 4) is functionally associated with the end 31 of the resonant spring 3, while the balancing body 5 is functionally associated with the end 32 of the resonant spring 3.

15 In this sense, the movement of the movable portion 22 of the linear motor 2 is integral and directly transmitted to the piston, thereby moving the piston - motor assembly, and consequently, the end 31 of the resonant spring 3. This movement is transmitted to the end 32 of the resonant spring 3 and, consequently, to the balancing body 5.

Thus, each component of the oscillating arrangement described herein has its particular function, namely:

20 The piston - motor assembly (defined by the cooperative association between the movable portion 22 of the linear motor 2 and the piston 4) serves to impose movement on the resonant spring 3 and function of compressing, effectively, the working fluid.

The resonant spring 3 has a function to amplify the oscillating movement, by accumulating mechanical energy.

25 The balancing body 5 has the task of balancing the system, so that the forces generated by piston - motor assembly (at the time of compression of the working fluid) are annulled (by the forces generated by the movement of the balancing body itself).

30 Thus, the main objective of the present invention (attenuate the vibration that the resonant oscillating mechanism requires the compressor housing by canceling (even partially) the forces generated by the motor and the forces generated by compression of the gas in the cylinder) is successfully achieved.

35 It is also worth mentioning that, as the piston - motor assembly, the balancing body 5 performs an axial, linear and oscillating movement inside the housing 9 of the linear compressor 1. This movement can be synchronized or synchronously opposite to the resonant oscillatory movement of said piston - motor assembly.

Having described an example of a preferred embodiment of the present invention, it should be understood that the scope of the same includes other possible physical variations,

which are limited solely by the wording of the claims, with the inclusion of the possible equivalent means.

CLAIMS

1. Linear compressor, comprising a oscillating arrangement fundamentally formed by at least one linear motor (2) defined by a movable portion (22) and a fixed portion (21), at least one resonant spring (3) and at least one piston (4); the compressor being especially

5 CHARACTERIZED in that:

the oscillating arrangement comprises at least one balancing body (5);

the movable portion (22) of the linear motor (2) is cooperatively associated with the piston (4) defining a piston - motor assembly;

10 the piston - motor assembly is functionally associated with the end (31) of the resonant spring (3); and

at least one balancing body (5) is functionally associated with the end (32) of the resonant spring (3).

2. Linear compressor according to claim 1, CHARACTERIZED in that the balancing body (5) is capable of having an oscillatory movement.

15 3. Linear compressor according to claim 2, CHARACTERIZED in that the balancing body (5) is capable of performing a resonant oscillating movement synchronized with resonant oscillatory movement of the piston - motor assembly.

20 4. Linear compressor according to claim 2, CHARACTERIZED in that the balancing body (5) is capable of performing a resonant oscillating movement synchronously opposite to the resonant oscillatory movement of the piston - motor assembly.

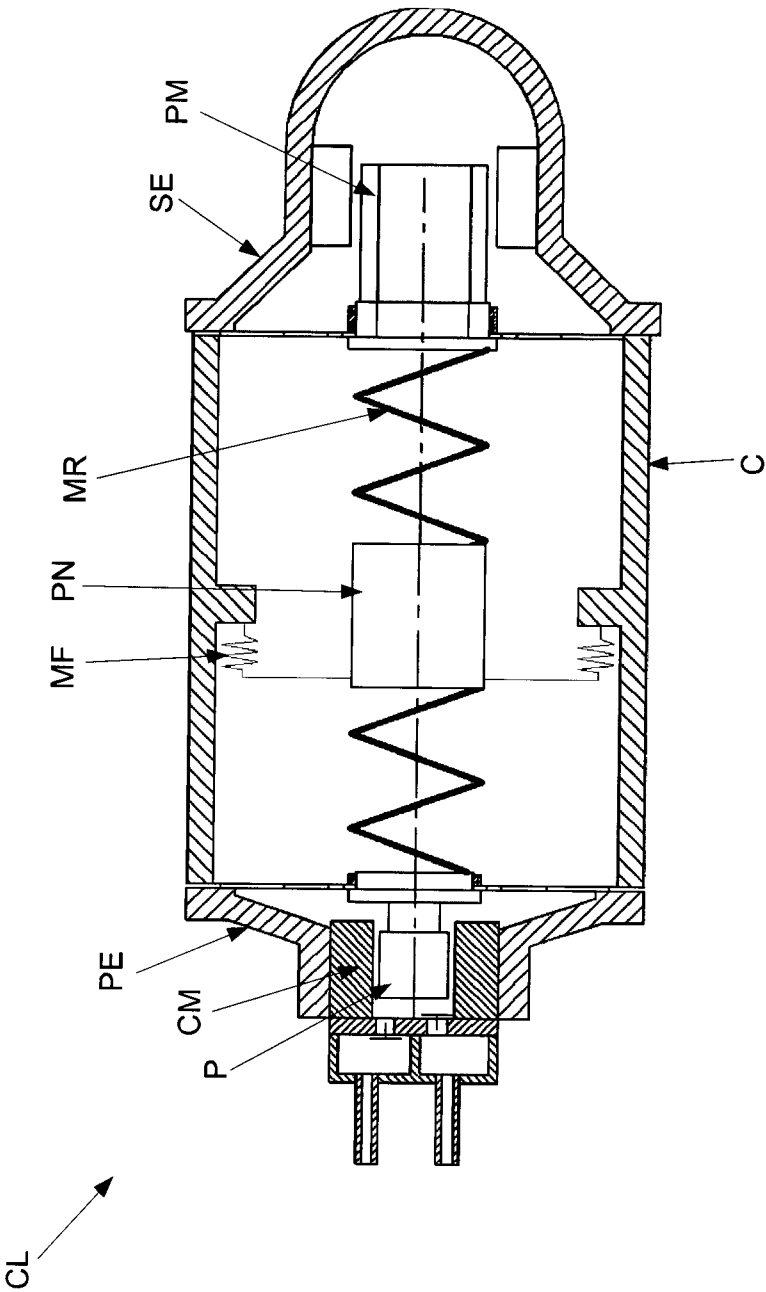


Fig. 1 (Prior Art)

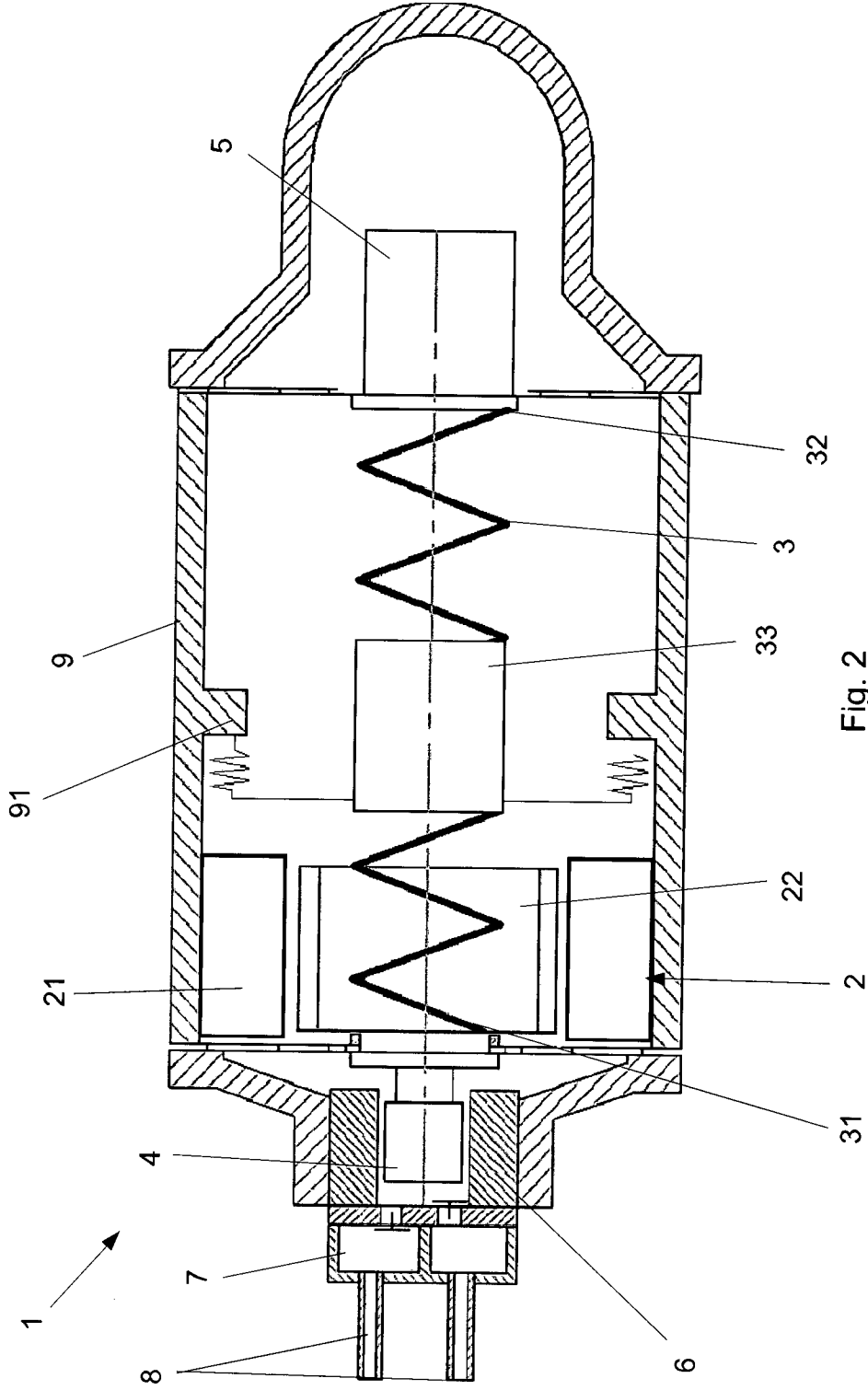


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/BR2012/000245

A. CLASSIFICATION OF SUBJECT MATTER INV. F04B35/04 F04B39/00 F04B53/00 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) F04B		
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 practicable, 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	FR 1 555 302 A (N.V. PHILIPS [NL]) 24 January 1969 (1969-01-24) figure 1 page 2	1-4
X	----- EP 1 381 776 B1 (WHIRLPOOL S.A. [BR]) 8 April 2009 (2009-04-08) figures 3,4 paragraph [0019] - paragraph [0021]	1-4
A	----- US 5 980 211 A (SANYO ELECTRIC CO. [JP]) 9 November 1999 (1999-11-09) figure 2 column 6, line 31 - column 7, line 5 ----- -/--	1-4
☒ 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 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 17 October 2012	Date of mailing of the international search report 26/10/2012	
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 Gnüchtel, Frank	

INTERNATIONAL SEARCH REPORT

International application No
PCT/BR2012/000245

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 02/06698 A1 (EMPRESA BRASILEIRA DE COMPRESSORES S/A [BR]) 24 January 2002 (2002-01-24) figure 3 page 2, line 8 - line 32 page 4, line 19 - page 6, line 1 -----	1-4
A	EP 1 686 264 A1 (LG ELECTRONICS INC [KR]) 2 August 2006 (2006-08-02) figure 1 paragraph [0030] - paragraph [0044] -----	1-4

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/BR2012/000245

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 1555302	A	24-01-1969	DE 1628175 A1 08-07-1971 ES 351164 A1 16-05-1969 FR 1555302 A 24-01-1969 GB 1222425 A 10-02-1971 NL 6703495 A 05-09-1968
EP 1381776	B1	08-04-2009	BR 0101879 A 17-12-2002 CN 1531627 A 22-09-2004 EP 1381776 A1 21-01-2004 ES 2323573 T3 21-07-2009 JP 2004522051 A 22-07-2004 US 2004156730 A1 12-08-2004 WO 02086321 A1 31-10-2002
US 5980211	A	09-11-1999	CN 1168965 A 31-12-1997 US 5980211 A 09-11-1999
WO 0206698	A1	24-01-2002	AT 302359 T 15-09-2005 AU 6716401 A 30-01-2002 BR 0003293 A 26-02-2002 CN 1404557 A 19-03-2003 DE 60112762 D1 22-09-2005 DE 60112762 T2 29-06-2006 EP 1301732 A1 16-04-2003 JP 4956710 B2 20-06-2012 JP 2004503717 A 05-02-2004 KR 20070116193 A 06-12-2007 MX PA02009473 A 12-02-2003 SK 11562002 A3 09-01-2003 US 2003133812 A1 17-07-2003 WO 0206698 A1 24-01-2002
EP 1686264	A1	02-08-2006	CN 1800640 A 12-07-2006 DE 602005004644 T2 29-01-2009 EP 1686264 A1 02-08-2006 JP 4890841 B2 07-03-2012 JP 2006189038 A 20-07-2006 KR 20060081481 A 13-07-2006 US 2006153712 A1 13-07-2006