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(71) **Applicant** *(for all designated States except US)*: **HALDEX BRAKE PRODUCTS AB** [SE/SE]; Box 501, S-26124 Landskrona (SE).

(72) **Inventor; and**

(75) **Inventor/Applicant** *(for US only)*: **ÖNNESTAM, Kjell** [SE/SE]; Järnvägen 5, S-246 36 Löddeköpinge (SE).

(74) **Agent**: **HRUSCHKA, Jürgen**; Habermann, Hruschka & Schnabel, Montgelasstr. 2, 81679 München (DE).

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(54) **Title**: BRAKE LEVER FOR A BRAKE FOR A VEHICLE

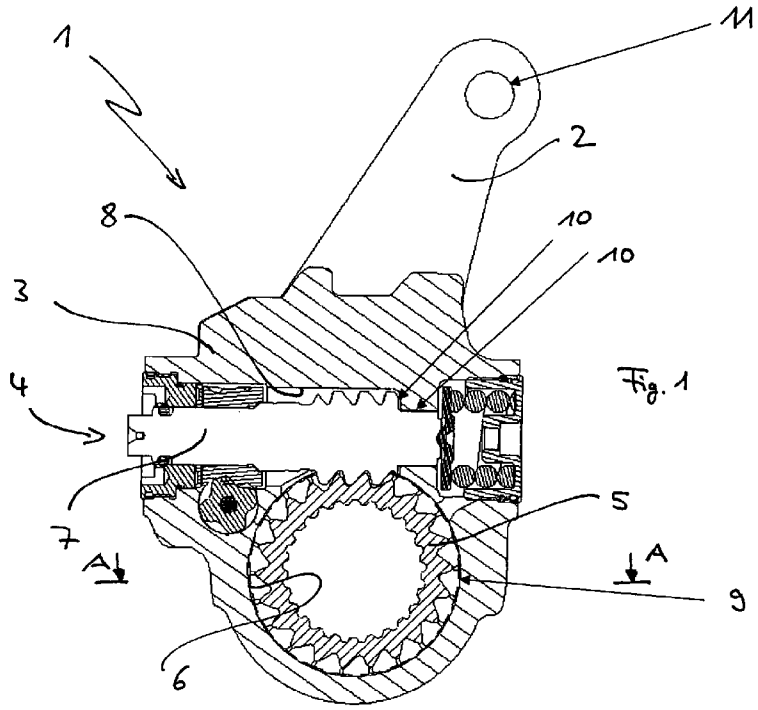

Fig. 1

(57) **Abstract**: This invention refers to a brake lever (1) for a brake of a vehicle for transmitting a brake force from an actuator into a brake actuation mechanism for a frictional engagement of brake pads, wherein the brake lever (1) comprises a housing made of cast iron, which cast iron is solid-solution strengthened ferritic spheroidal graphite cast iron.

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Brake lever for a brake for a vehicle

This invention refers to a brake lever for a brake for a vehicle for transmitting a brake force resulting from an actuator to a brake actuation mechanism to achieve frictional engagement of brake pads.

In particular, this invention refers to a specific material composition for such brake levers.

On heavy road vehicles, busses, trailers and similar both drum brakes and disc brakes are employed which comprise a brake lever, respectively. For example, disc brakes with a corresponding lever arrangement are known from EP 0 553 105 B1 or WO 2004/059187 A1 of the applicant. However, the invention in particular concentrates on drum brakes in which the brake lever attaches to a S-camshaft and which comprises a housing which receives an automatic brake (or slack) adjuster, as this is exemplarily disclosed in EP 0 598 290 B1 and EP 1 064 472 B1 of the applicant or in US 3,392,810.

The brake lever for such drum brakes is intended to transform the linear movement of a rod from a pneumatic or hydraulic actuator into a rotational movement of a shaft of such a drum brake assembly in order to apply the brake linings of the brake shoes during brake actuation. The brake lever itself is preferably made as one piece and comprises a housing section which receives an automatic brake adjuster in order to provide a compensation of the wear of the brake shoes of the drum brake. With respect to the exact functioning of the automatic brake adjuster and of the brake lever in this context it is, for example, referred to EP 0 598 290 B1 of the applicant.

The brake lever thus has to be considered as being the crucial component of the entire arrangement with respect to the dynamic and static applied loads as present in such a drum brake. Generally, the brake lever is configured as an elongated device

with a housing section, into which the automatic brake adjuster is inserted, and with a lever section which comprises a free end being connected to the actuator.

So far, the brake lever and in particular the housing for receiving the brake adjuster normally have been made of spheroidal graphite cast iron, which is existing with different ferritic and pearlitic grades, which means that the base material of the cast iron consists of ferrite to pearlite. Spheroidal graphite in this context means that the free carbon is embedded in a ferrite- and/or pearlite matrix in spherical, i.e. globular or nodular form. At this it is a specific form of deposition of the carbon in a spherical shape, i.e. as compared to steel, carbon is not directly embedded in the elementary cell of the iron but forms differently shaped stages of graphite within the alloy.

Herewith, a larger percentage of pearlite in the matrix provides an increased hardness and strength, while a larger percentage of ferrite is responsible for a better ductility and for better machining properties.

Instead of cast iron the housing of a brake lever according to the prior art can be also made of forged steel.

The housing or the housing section of the brake lever in which the brake adjuster is arranged comprises several internal surface sections which are supposed to large contact pressure and wear, since elements of the brake adjuster do abut against these sections, use these sections as a counter bearing or as corresponding supporting or bearing faces for movable components of the brake adjuster.

For that reason it is required to provide hardening and heat treatment to these internal surfaces. In this connection, for example, also nitriding of these surfaces is employed. Such hardening procedures are very costly. Moreover, such hardening procedures require chemicals which have negative impacts on the environment and both on the safety and welfare of the workers during the industrial manufacture to a substantial extent.

The free end of the brake lever is connected with a rod of a pneumatic or hydraulic actuator in that a bolt is passing through a hole in the upper lever section and a clevis

of the actuator rod. The hole in the upper lever section is often reinforced in that a bushing is pressed into it which is able to provide a better wear resistance against the friction effects during brake actuation. Also, this additional manufacturing step with the additional component is negatively influencing the overall costs of the manufacture of such a brake lever.

Generally, it is an object of the present invention to provide a brake lever for a brake which can be made with less costs on the one hand and which provides substantially better material properties with respect to both the machining and the working cycle and functional safety on the other.

It is a further object of the invention to prevent the deficiencies for brake levers known in the field of drum brakes.

These objectives are solved by a brake lever according to claim 1.

Accordingly, the quintessence of the invention is that the housing of the brake lever is made of solid-solution strengthened ferritic spheroidal graphite cast iron. Preferably the brake lever is made of such cast iron in one piece.

Solid-solution strengthened ferritic spheroidal cast iron is a type of cast iron in which the spheroidal graphite is embedded in a matrix which predominantly consists of ferrite and which is predominantly solidified from silicon solid solution. Carbon is predominantly present in the form of spheroidal graphite particles. Compared to ferritic to pearlitic graphite cast irons the solid-solution strengthened ferritic grades present for an equivalent tensile strength a higher proof strength and an overall higher elongation.

A significant advantage of these solid-solution strengthened ferritic grades is the reduced hardness variation resulting in an improved machinability for components made of such cast iron. In other words, the level of the mechanical properties of such components is determined by the extent of the solid-solution strengthening of the ferritic matrix of the cast iron used therefor, which extent in turn normally is influenced by the silicon content.

Preferably the maximum pearlite content in the matrix of the cast iron, which predominantly consists of ferrite, is in the area of 5%.

According to the invention the cast iron for the brake lever shall comprise a tensile strength R_m between 400 and 650 MPa, preferably of 600 MPa.

Preferably the 0.2%-proof stress $R_{p0,2}$ is in a range of 70% to 90%, preferably of 80% of the tensile strength R_m.

According to the invention the cast iron shall comprise a hardness in HBW (hardness according to Brinell) which corresponds to a range between 42% and 50% of the 0.2%-proof stress $R_{p0,2}$ in MPa.

Moreover, according to the invention the cast iron shall have an elongation A between 8% and 18%, preferably between 10% and 12%.

For providing such properties a solid-solution strengthened ferritic spheroidal graphite cast iron can be used which is known under the material denomination EN-GJS-600-10/5.3110 according to the preliminary European standard. It has a tensile strength R_m of 600 MPa, a 0.2%-proof stress $R_{p0,2}$ of 470 MPa, a hardness of 200 to 230 HBW and an elongation A of 10%.

When comparing this solid-solution strengthened ferritic spheroidal graphite cast iron with conventional spheroidal graphite cast iron used up to now, with respect to a better machinability one would select a spheroidal graphite cast iron with the material denomination EN-GJS-500-7/5.3200 which comprises a tensile strength R_m of 500 MPa and a hardness of about 150 to 230 HBW. However, with respect to the 0.2%-proof stress $R_{p0,2}$ of 320 MPa and elongation A of 7%, this cast iron shows less favourable properties which are opposed to an easy machinability. Whereas, if spheroidal graphite cast iron is selected which comprises a 0.2%-proof stress $R_{p0,2}$ of 480 MPa with a tensile strength R_m of 800 MPa, also less favourable figures with respect to a hardness of 245 to 335 HBW and an elongation A of only 2% do arise.

Such a cast iron, for example, would be known under the material denomination EN-GJS-800-2/5.3301.

Also, the fact, that this solid-solution strengthened ferritic spheroidal graphite cast iron comprises a silicon content between 3 and 4,5 %, is elemental to the invention. As already mentioned above, it is mainly the increased strength compared to conventional spheroidal graphite cast irons which is achieved by the solid-solution strengthening at a very large silicon content. Typically, an enhanced strength in the cast iron was achieved by increasing the proportion of pearlite in the matrix, which, however, in turn conflicts to an easy machinability of such materials.

It is an advantage of the invention that for a planned component to be made of solid-solution strengthened ferritic spheroidal graphite cast iron a better balancing between the machining properties on the one hand and the strength on the other can be accomplished.

Machinability mainly is determined by the hardness of the hardest spots within the components to be machined. It may be very hard spots within the cast iron where the material is harder due to cooling time etc. as compared to the adjacent area (macro area). Moreover, very small, locally limited hard spots in the micro area can exist which are formed due to the non-homogenous structure of the material of the spheroidal graphite cast iron. In contrast, solid-solution strengthened ferritic spheroidal graphite cast iron presents a much more homogenous structure as conventional types of cast iron, which comprises these spots and sections of different hardness at a micro-scale. As the proportion of these areas is influenced by cooling time etc., conventional cast irons show large variations between the hardest and the softest spots.

For conventional cast irons with typical ferritic and pearlitic proportions, it is also an disadvantage that always in the area close to the surface a thin layer of material with a reduced content of pearlite is formed which, matter of fact, reduces the usable strength, since the spots with the softest material are the ones mainly determining the usable strength of a component.

For that reason it is a common approach of constructing engineers to start with setting an upper limit for the hardness for a component to be casted under the provision to avoid problems and high costs associated therewith at the subsequent machining. Based on this hardness the constructing engineer then selects the corresponding material and after that finally defines the actually usable strength for his strength calculations.

If the constructing engineer uses solid-solution strengthened ferritic spheroidal graphite cast iron according to the invention, he will thus end up with a significantly higher usable strength for the component to be casted as this would be the case for conventional spheroidal graphite cast iron.

It is obvious that a substantially higher strength can be realized for a brake lever when, according to the invention, using solid-solution strengthened ferritic spheroidal graphite cast iron, whereby at the same time the machinability is within ideal ranges.

For the purpose of illustrating the invention, added figures 1 and 2 do show a brake lever for a drum brake, in which figure 1 is a lateral view of the brake lever with partial cross section and figure 2 is a cross section along A-A of figure 1.

Brake lever 1 is made as one piece and comprises and upper lever section 2 and a lower housing section 3 for receiving an automatic slack adjuster 4.

A worm wheel 5 of the brake adjuster 4 is rotatably received in a corresponding recess 6 of the housing section 3 and cooperates with corresponding inner spline grooves of a S-camshaft (not shown) for the brake pads. The worm wheel 5 engages with a worm screw 7 which is supported in the housing section 3 perpendicular to the worm wheel 5 in a corresponding recess 8.

With reference to the type and functioning of the remaining components of the automatic slack adjuster arrangement, which shall not be addressed further herein, it is referred to EP 0 598 290 B1 of the applicant.

As it becomes obvious, the recess 6 for the worm wheel 5 comprises corresponding internal support or bearing surfaces 9, as well as the recess 8 for the worm screw 7 comprises corresponding bearing surfaces 10.

A large contact pressure is applied to these inner bearing surfaces 9, 10, so that these bearing surfaces till now have to undergo corresponding hardening procedures, such as for example nitriding, with the disadvantages of an increased environmental burden and cost disadvantages associated therewith as mentioned already above.

When using solid-solution strengthened ferritic spheroidal graphite cast iron, which compared to conventional ferritic or pearlitic types of the same strength, as explained above, comprises a higher useable strength, thus higher resistance will be offered against very high pressure loads, in particular in the spot area, without deforming plastically.

In particular with respect to the inner bearing surfaces 9, 10 in the housing section 3 of the brake lever 1 for a drum brake the use of solid-solution strengthened ferritic spheroidal graphite cast iron according to the invention is of particular advantage since the mentioned subsequent hardening procedures can be omitted completely. All together, machining at the bearing surfaces 9, 10 can be performed more easily.

In the upper area of the lever section 2 a hole 11 is provided which serves for a connection with a rod (not shown) of an actuator. For that, a bolt (not shown) passes through the hole 11. Due to the relative movements between the bolt of the rod and the hole 11 of the lever section 2 during a swivelling movement of the brake lever 1 a corresponding resistance against the friction resulting therefrom has to be offered in order to keep the wear small, so that often the hole 11 is reinforced in that a correspondingly hardened bushing is pressed into the hole for brake levers according to the prior art.

Since the solid-solution strengthened ferritic spheroidal graphite cast iron for the same hardness comprises a better usable strength it will be also not necessary anymore to provide an additional bushing for the hole 11, since the inner surface of

the hole 11 already as such is able to offer a substantially large resistance to the contact pressure of the bolt without deforming. As a consequence the costs can be further reduced by a shortened assembly time and by omitting an additional bushing.

It is self explaining that the brake lever, be it for a disc brake or be it for a drum brake, is a substantial safety critical component of the entire brake arrangement, since in case of malfunction, for example possible breakage of the brake lever, complete loss of the braking function for the corresponding wheel may occur.

Cast irons which comprise similar machining properties and which have similar 0.2%-proof stress as the cast iron according to the invention are, however, as already mentioned above several times, less homogenous and show more casting defects which then can be the sources of growing cracks. Such a breakage risk, however, will be eliminated by the far more homogenous structure of the solid-solution strengthened ferritic spheroidal graphite cast iron, so that its use qualifies in particular for a brake lever.

The recesses 6 and 8 with its cylindrical surfaces do show slightly larger dimensions as the worm wheel 5 and the worm screw 7, so that these cylindrical surfaces will elastically and plastically deform during brake actuation when high forces are applied to them by the worm wheel 5 and the worm screw 7, respectively. Due to the worse machinability often variations in the dimensions or also casting defects occur when using conventional cast irons. Due to the lower ductility when compared to the cast iron according to the invention such defects lead to the risk of cracking formation during the deformation. Moreover, such risk is increased since hardening of the corresponding bearing surfaces 9, 10 further reduces the ductility.

Deformations which result from the pressure applied by the worm wheel 5 and the worm screw 7, respectively, can be better compensated by way of the higher ductility of the surrounding material of the bearing surfaces 9, 10 when using the cast iron according to the invention for the lever 1, so that such crack formations during the deformation can be excluded.

Furthermore, it is also an advantage of the solid-solution strengthened ferritic spheroidal graphite cast iron according to the invention that the required proportion of the carbon solidified in nodules or spheres can be substantially reduced when compared to ferritic and pearlitic types in order to fulfil the minimum tensile properties. In the manufacture of conventional spheroidal graphite cast irons, the carbon is forced to solidify in the shape of spherical nodules instead of in the form of flakes as in grey cast iron. If the nodularisation fails in some way or cannot be brought to an end completely, the cast iron will be more brittle and is inclined thereby to cause crack formation more easily, by which the risk for breakage is increased.

Such deficiencies in the material during manufacture of corresponding components are eliminated when using solid-solution strengthened ferritic spheroidal graphite cast iron which in particular increases the safety in the application for a brake lever substantially.

Claims

1. Brake lever (1) for a brake of a vehicle for transmitting a brake force from an actuator into a brake actuation mechanism for a frictional engagement of brake pads, wherein the brake lever (1) comprises a housing made of cast iron, characterized in that the cast iron is solid-solution strengthened ferritic spheroidal graphite cast iron.

2. Brake lever according to claim 1, in which the matrix of the cast iron predominantly contains ferrite with a maximum pearlite content of 5 %.

3. Brake lever according to claim 1 or 2, in which the cast iron comprises a tensile strength R_m between 400 and 650 MPa, preferably of 600 MPa.

4. Brake lever according to claims 1 to 3, in which the cast iron comprises a 0.2%-proof stress $R_{p0,2}$ between 70% to 90%, preferably of 80% of the tensile strength R_m .

5. Brake lever according to one of claims 1 to 4, in which the cast iron comprises a hardness in HBW which corresponds to a range between 42% and 50% of the 0.2%-proof stress $R_{p0,2}$ in MPa.

6. Brake lever according to one of claims 1 to 5, in which the cast iron comprises an elongation A between 8 and 18%, preferably between 10 and 12%.

7. Brake lever according to one of claims 1 to 6, in which the cast iron comprises a silicon content between 3 and 4,5%.

8. Brake lever according to one of claims 1 to 7, in which the brake is a drum brake and the brake lever (1) is provided for the connection to a S-camshaft, wherein the housing comprising a housing section (3) which receives a brake adjuster (4).

9. Brake lever according to one of claims 1 to 7, in which the brake is a disc brake and the brake lever attaches to a force transmitting element being axially displaceable towards the brake disc.

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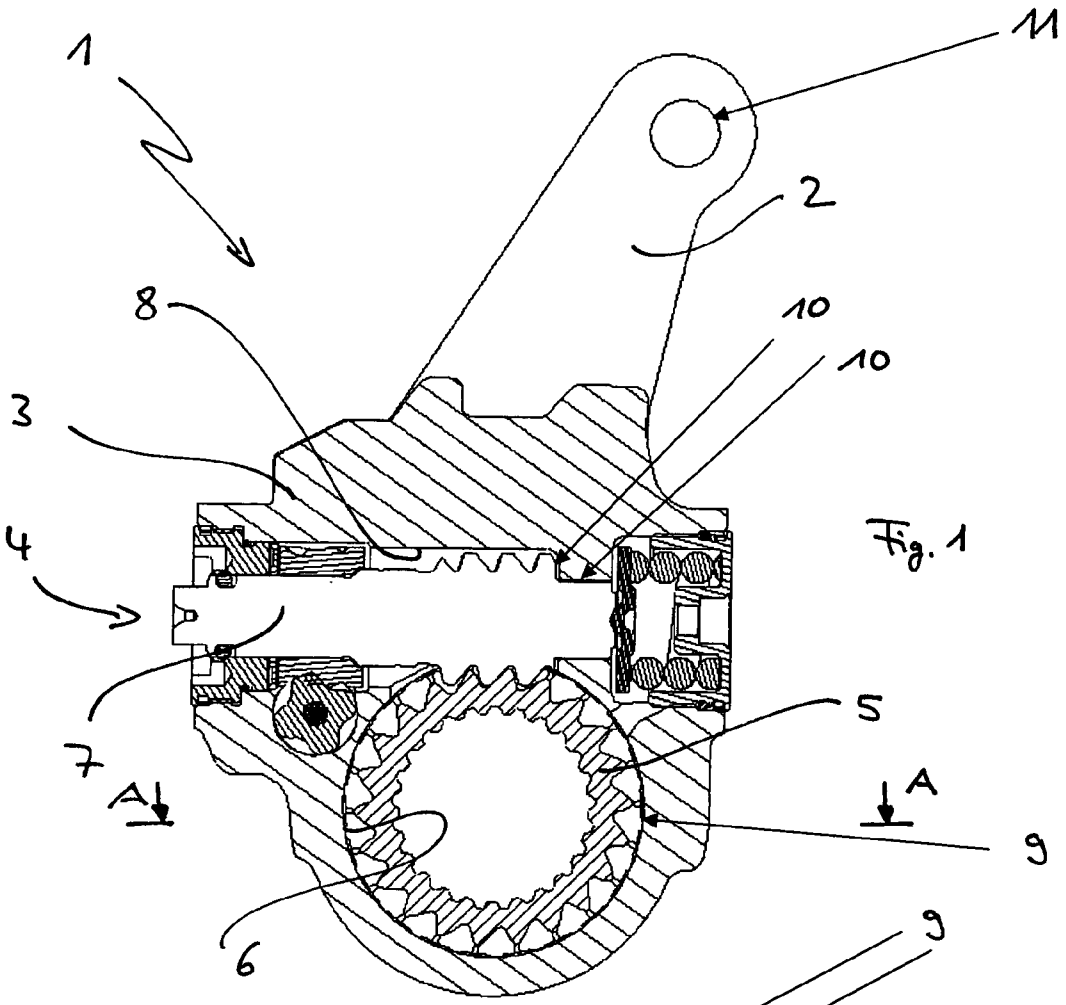

Fig. 1

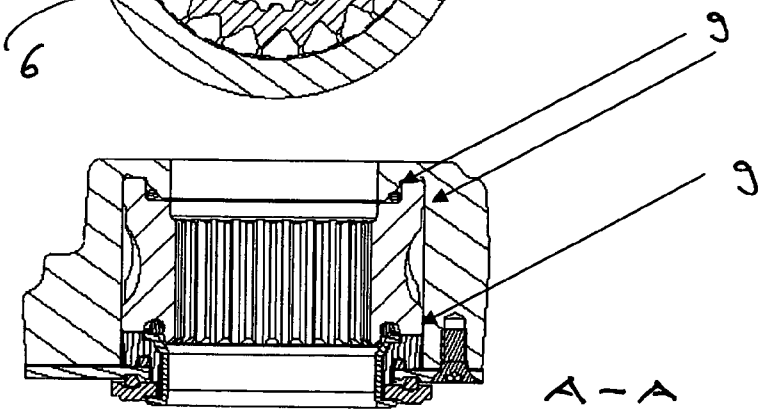

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/005280

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16D65/60 C22C37/04
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)
F16D C22C

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.
Y	EP 0 598 290 B1 (HALDEX AB [SE]) 28 February 1996 (1996-02-28) cited in the application the whole document -----	1-9
Y	Dr. Richard Larker: "Solution strengthened ferritic ductile iron ISO 1083/JS/500-10 provides superior consistent properties in hydraulic rotators", , 4 December 2009 (2009-12-04), XP002632289, Retrieved from the Internet: URL:http://www.foundryworld.com/uploadfile/200912443017589.pdf [retrieved on 2011-04-11] the whole document -----	1-9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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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
11 April 2011	27/04/2011

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	Topolski, Jan

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/005280

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0598290 B1	28-02-1996	AT 134749 T	15-03-1996
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