(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 873 355 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
02.01.2008 Bulletin 2008/01

(51) Int Cl.:
F01D 5/22 (2006.01)

(21) Application number: 06013266.9

(22) Date of filing: 27.06.2006

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

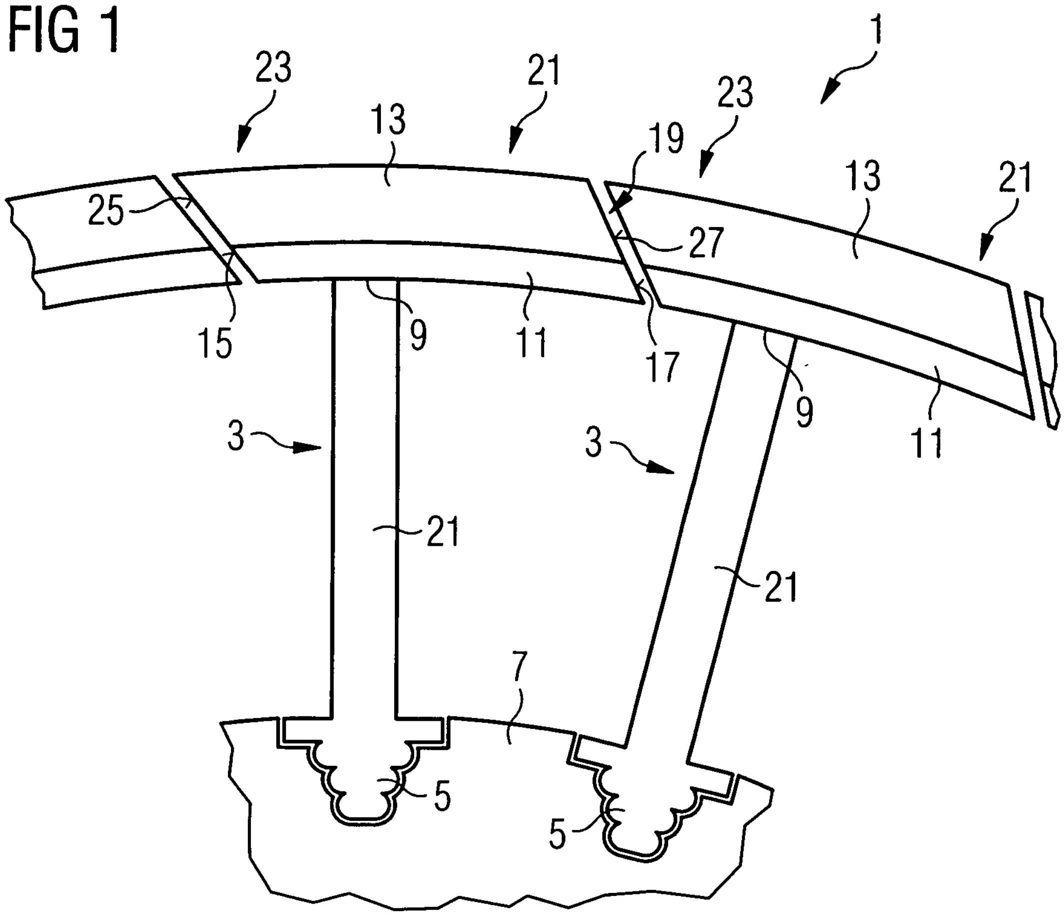
(71) Applicant: SIEMENS AKTIENGESELLSCHAFT
80333 München (DE)

(72) Inventor: Howell, Robert
LN6 OSU Lincoln (GB)

(54) Turbine rotor blade

(57) A turbine rotor blade (3) is provided. The turbine rotor blade (3) has a root end (5) by which it can be fixed to a turbine rotor hub (7), and a tip end (9) remote from the root end (5) which carries a shroud segment (11). The rotor blade (3) is adapted to form a blade ring together with further rotor blades (3) fixed to the rotor hub (7), whereby the shroud segments (11) of the blade rings' rotor blades (3) together form a shroud ring which circumferentially surrounds the rotor hub (7). The shroud segment (11) comprises a projection (17) so as to allow for overlapping the shroud segment (11) of a neighbouring rotor blade in the blade ring in circumferential direction of the rotor hub (7).

FIG 1



EP 1 873 355 A1

Description

[0001] The present invention relates to a turbine blade, in particular to a gas turbine blade having a shroud at its tip end.

[0002] In a gas turbine engine, a fuel is burned in a burner assembly to produce hot pressurized exhaust gases which are then fed to a turbine stage where they, while expending and cooling, transfer momentum to turbine blades of a rotor thereby imposing rotational movement on the rotor. A usual turbine stage comprises alternating cascades of turbine blades fixed to and rotating with the rotor and stationary turbine vanes. A cascade of turbine blades is formed by a blade ring with a number of turbine blades spread regularly around the circumference of the rotor.

[0003] The efficiency of the gas turbine engine depends on the efficiency of transforming momentum from the expanding and cooling exhaust gases to the turbine blades. In order to keep the fraction of exhaust gases which transfer momentum to the turbine rotor as high as possible, it is common practise to provide the blade tip with a tip shroud which forms a segment of a circumferential ring around the outer ends of the blades. An example of a rotor with shrouded rotor blades is, e.g., shown in US 5,211,540.

[0004] It is desirable to have minimum tolerances between the shroud and the casing of the turbine stage in order to minimise leakage of hot exhaust gases, i.e. hot exhaust gases bypassing the shrouded blade cascade through the tolerances. Leaking exhaust gas would lead to a loss of usable momentum of the exhaust gas, which in turn would reduce the efficiency of the gas turbine stage.

[0005] Shroud curl occurs when the shroud of the blade has been exposed to hot gases over a longer period of time, hence during operation in the load range. Curl is caused by creep in the material leading to plastic deformation. The purpose of the shroud is twofold. Besides preventing leakage over the blade tip and improving the efficiency of the turbine, it also improves the dynamic/vibration qualities of the blade. Depending on the shape of the contact surface between the shroud vibrations e.g. dynamic movements can be prevented or damped out. Furthermore due to the contact between the shrouds the Eigen frequencies of the individual blades are increase compared to if they are moving freely. During barrelling and start-up the shrouds may not be in full contact. However, when the centrifugal force is applied to the blade it will somewhat straighten out the initial twist/stagger of the airfoil over the height of the blade ("untwist"). Doing so contact forces are applied between the blades in the shroud region. If curl occurs the contact may be lost and the blade can be transferred to a operating regime where high cycle fatigue is activated and eventually leading to blade failure. A shortened service life of the shrouded blades can be the consequence.

[0006] It is therefore an objective of the present invention to provide a turbine rotor blade with a shroud segment which reduces the propensity of curling in the shroud.

[0007] It is a further objective of the invention to provide an improved turbine rotor by which the leakage can be reduced.

[0008] These objects are solved by a turbine rotor blade, as claimed in claim 1, and by a turbine rotor, as claimed in claim 6, respectively.

[0009] An inventive turbine rotor blade has a root end by which it can be fixed to a turbine rotor hub and a tip end remote from the root end which carries a shroud segment. The rotor blade is adapted to form a blade ring together with further rotor blades fixed to the rotor hub. The shroud segments of the blade ring's rotor blades together form a shroud ring which circumferentially surrounds the rotor hub. In the inventive turbine rotor blade the shroud segment comprises a projection so as to allow for overlapping the shroud segment of a neighbouring rotor blade in the blade ring in circumferential direction of the rotor.

[0010] By such an overlapping, it can be achieved that neighbouring shrouds are interlocked. This redistributes the load of the shroud between the blades and thereby preventing the curl.

[0011] In an implementation of the overlapping which is particularly advantageous, the shroud has a short side and a long side in circumferential direction with respect to the rotor. The projection is formed in the long side so as to allow for overlapping the short side of a neighbouring rotor blade's shroud segment on the short side's radial inner side. Since the long side is more flexible than the short side, a curl would occur on the long side rather than on the short side. When the long side is located radial inwards with respect to the short side in the overlapping zone, the less flexible short side prevents the long side from curling outwards.

[0012] The overlapping can be realized by giving the shroud's end faces in circumferential direction contours which are inverse to each other, e.g. stepped, sloped or teethed contours.

[0013] If one or more fins extend radial outwards from the shroud, the contours of the end faces can be continued through the fin's circumferential end faces.

[0014] An inventive turbine rotor comprises a rotor hub and at least one blade ring having a number of inventive turbine blades fixed to the rotor hub. The shroud segments of the rotor blades form a shroud ring. With such a rotor, tolerances between the outer circumference of the shroud ring and the inner wall of the turbine stage's casing can be kept small as curling outwards of the shrouds can be reduced. In turn, the leakage of hot pressurised exhaust gases through the blade ring can be reduced.

[0015] Further features, properties and advantages of the invention will become clear from the following description of embodiments in conjunction with the accompanying drawings.

[0016] Figure 1 shows a first embodiment of the inventive turbine rotor blade in a view onto the rotor blade's leading edge.

[0017] Figure 2 shows the rotor blades shown in Figure 1 seen from radially outwards.

[0018] Figure 3 shows a second embodiment of the inventive turbine rotor blade.

[0019] Figure 4 shows a third embodiment of the inventive turbine rotor blade.

[0020] Figure 5 shows a fourth embodiment of the inventive turbine rotor blade.

[0021] Figure 6 shows a fifth embodiment of the inventive turbine rotor blade.

[0022] Figure 1 shows a section of a blade ring 1 comprising a number of inventive turbine blades 3. Each turbine blade 3 has a root end 5 by which it is fixed to a rotor hub 7. The rotor hub 7 and the blade rings fixed thereto form a rotor for a gas turbine engine. Remote from the root end 5 the turbine blade 3 comprises a tip end 9, to which a shroud segment 11 is fixed. The shroud segments 11 of the blade ring's turbine blades 3 form a shroud ring which extends circumferentially around the rotor hub 7.

[0023] The circumferential end faces 15 and 17 of each shroud segment 11 are sloped with respect to the radial direction of the rotor. By the slope, an overlapping region 19 between neighbouring shroud segments 11 is formed. Each shroud segment has, in circumferential direction, a long side 21 and a short side 23. The slope is such that the long side 21 overlaps the short side of a neighbouring shroud segment 11 radially inwards. The short side 23 then prevents the more flexible long side 21 from curling outwards, e.g. in a transition mode of the gas turbine engine of which the rotor is a part.

[0024] From each shroud segment 11 a fin 13 extends radially outwards. The slope in the shroud segment's end faces 15, 17 is continued in the circumferential end faces 25, 27 of the fins 13.

[0025] A second embodiment of the inventive turbine rotor blade 3 is shown in Figure 3. The second embodiment differs from the first embodiment in that the circumferential end faces 15, 17 of the shroud segment 11 and the circumferential end faces 25, 27 of the fin 13 are not sloped, but stepped.

[0026] A third embodiment of the inventive turbine rotor blade is shown in Figure 4. This embodiment differs from the embodiment shown in Figure 1 in that the end faces 15, 17 of the shroud segment 11 and the end faces 25, 27 of the fin 13 have a dove tail structure at the long side 21 and a spike structure at the short side which is inverse to the dove tail structure of the long side 21.

[0027] Figure 5 shows a fourth embodiment of the inventive turbine rotor blade 3. The fourth embodiment differs from the first embodiment in that the end faces 15, 17 of the shroud segment 11 and the end faces 25, 27 of the fin 13 are teethed. The teething at the short side's end faces 15, 25 is inverse to the teething at the long side's end faces 17, 27.

[0028] A fifth embodiment of the inventive turbine rotor blade 3 is shown in Figure 6. The fifth embodiment differs from the first embodiment in that the circumferential end faces 15, 17 of the shroud segment 11 and the circumferential end phases 25, 27 of the fin 13 show a Z-notch structure.

[0029] Except for the differences explained with respect to Figures 3 to 6, the second to fifth embodiment do not differ from the first embodiment, as it was described with respect to Figures 1 and 2.

[0030] Although the overlapping structures are present in the end faces of the shroud segments 11 and in the end faces of the fins 13 throughout the embodiments, the overlapping structures could be confined to the end faces of the shroud segments 11. In this case the dove tail and the spike of the third embodiment, or the Z-notch structure of the fifth embodiment would be located completely in the end faces 15 and 17 of the shroud segment 11.

[0031] With the inventive turbine rotor blade, the curling of the shroud can be reduced compared to state of the art shrouds.

Claims

1. A turbine rotor blade (3) having a root end (5) by which it can be fixed to a turbine rotor hub (7), and a tip end (9) remote from the root end (5) which carries a shroud segment (11), the rotor blade (3) being adapted to form a blade ring together with further rotor blades (3) fixed to the rotor hub (7), whereby the shroud segments (11) of the blade rings' rotor blades (3) together form a shroud ring which circumferentially surrounds the rotor hub (7), **characterised in that** the shroud segment (11) comprises a projection (17) so as to allow for overlapping the shroud segment (11) of a neighbouring rotor blade in the blade ring in circumferential direction of the rotor hub (7).

2. The turbine rotor blade (3) as claimed in claim 1, **characterised in that** the shroud (11) has a short side (23) and a long side (21) in the circumferential direction and **in that** the projection (17) is formed in the long side (21) so as to allow for overlapping the short side (23) of a neighbouring rotor blade's shroud segment (11) on the short side's (23) radial inner side.

3. The turbine rotor blade (3) as claimed in claim 1 or claim 2, **characterised in that** the contours of the shroud's end faces (15, 17) in circumferential direction are inverse to each other.

4. The turbine rotor blade (3) as claimed in claim 3, **characterised in that** the end faces (15, 17) are stepped, sloped, or teethed.

5. The turbine rotor blade (3) as claimed in claim 3 or claim 4, **characterised in that** at least one fin (13) extends radially outwards from the shroud (11) and **in that** the contours continue through the fin's (13) circumferential end faces (25, 27).

6. A turbine rotor with a rotor hub (7) carrying at least one blade ring having a number of turbine blades (3) according to any of the preceding claims, the shroud segments (11) of the turbine blades (3) forming a shroud ring.

FIG 1

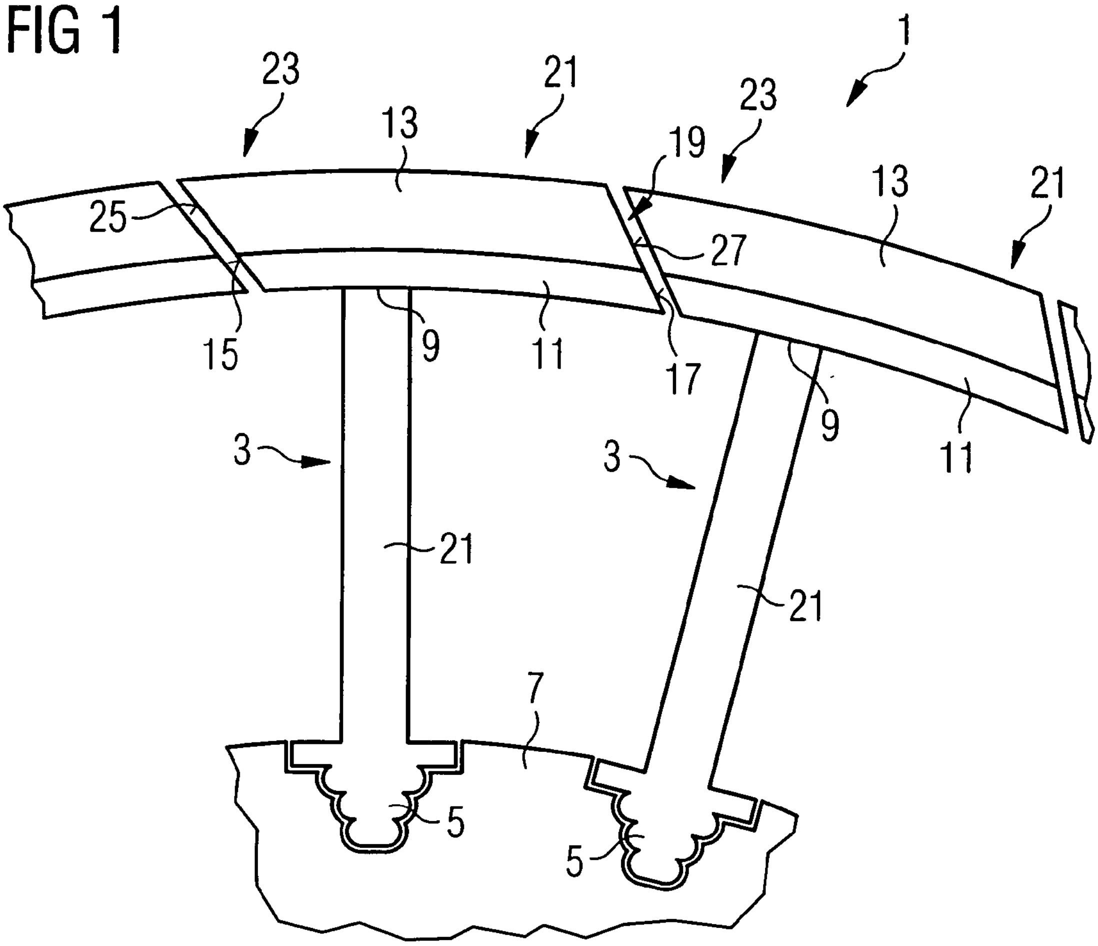

1
23
21
13
23
19
13
21
25
27
15
9
11
17
9
11
3
3
21
21
7
5
5

FIG 2

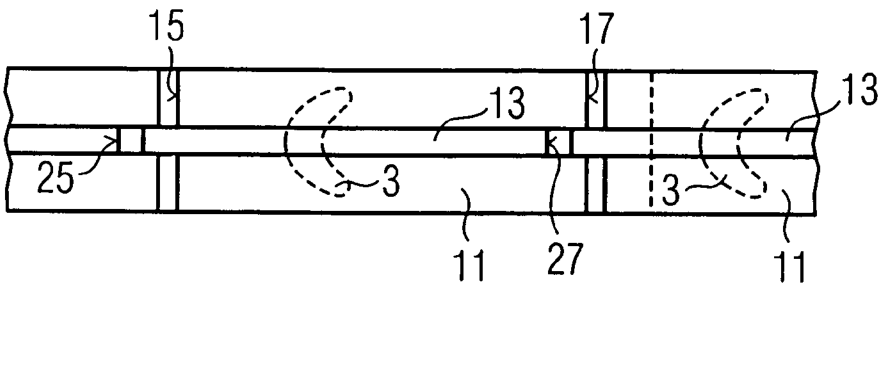

15
17
13
13
25
3
3
11
27
11

FIG 3

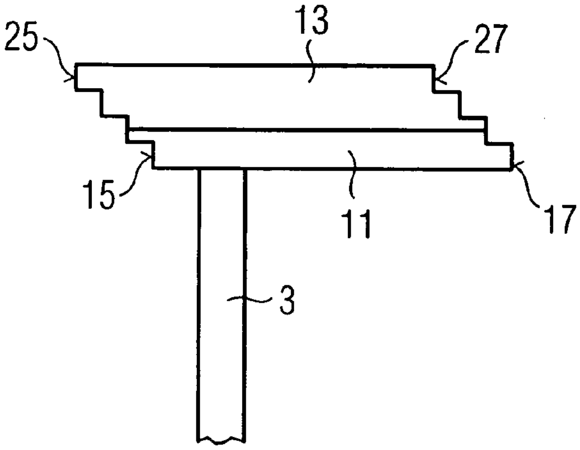


FIG 4

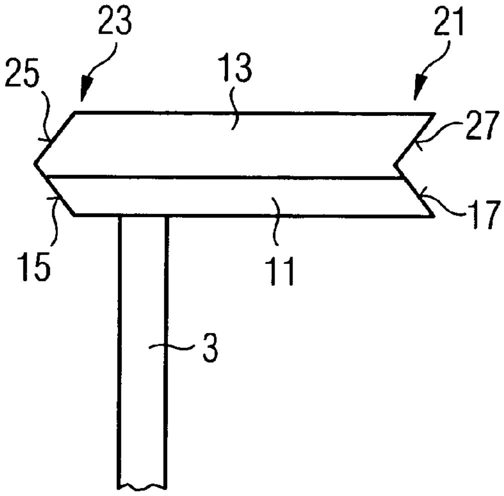


FIG 5

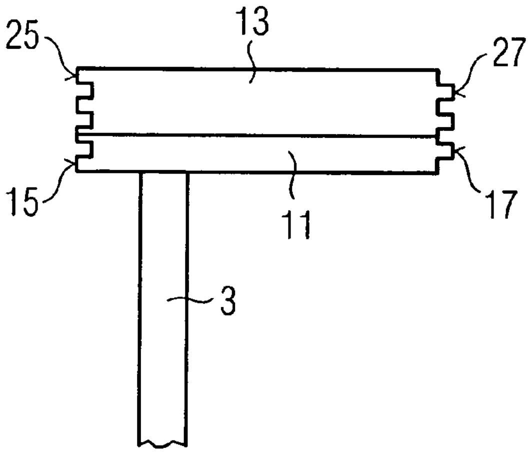
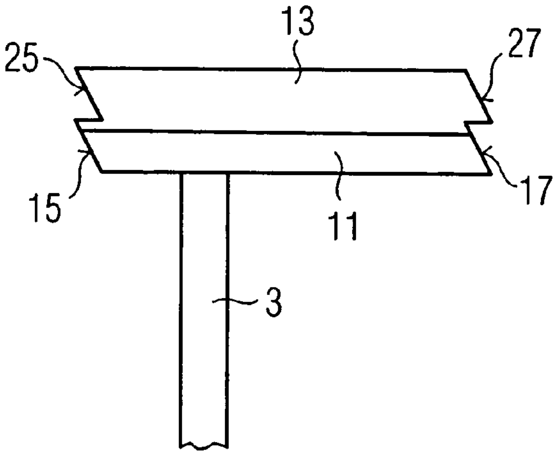


FIG 6



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 01 3266

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2003/012655 A1 (SASAKI TOMOYOSHI [JP] ET AL) 16 January 2003 (2003-01-16) * figures *	1-4,6	INV. F01D5/22
X	US 3 545 882 A (WILLIAMSON DOUGLAS HERBERT) 8 December 1970 (1970-12-08) * figures *	1-4,6	
X	GB 155 156 A (SCHNEIDER & CIE) 16 December 1920 (1920-12-16) * figures *	1-4,6	
X	US 1 527 781 A (BRANDT EDMUND S R) 24 February 1925 (1925-02-24) * figures *	1-4,6	
X	US 1 371 328 A (EUGENE SCHNEIDER) 15 March 1921 (1921-03-15) * figures *	1-4,6	
X	US 3 986 792 A (WARNER RONALD E) 19 October 1976 (1976-10-19) * figures *	1-4,6	TECHNICAL FIELDS SEARCHED (IPC)
			F01D
X	US 2002/071764 A1 (TURNQUIST NORMAN ARNOLD [US] ET AL) 13 June 2002 (2002-06-13) * figures *	1-4,6	
X	CH 418 360 A (ASS ELECT IND [GB]) 15 August 1966 (1966-08-15) * figures *	1-4,6	
X	GB 532 372 A (BRITISH THOMSON HOUSTON CO LTD) 22 January 1941 (1941-01-22) * figures *	1-4,6	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 October 2006	Raspo, Fabrice

1

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 01 3266

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2004/022923 A (HITACHI LTD [JP]; YAMASHITA YUTAKA [JP]; NAMURA KIYOSHI [JP]; SAITOU E) 18 March 2004 (2004-03-18) * figures *	1-4,6	
X	US 1 423 466 A (EDWIN SNYDER JOHN) 18 July 1922 (1922-07-18) * figures *	1-4,6	
A	US 6 491 498 B1 (SELESKI RICHARD [US] ET AL) 10 December 2002 (2002-12-10) * figures *	5	
A	EP 1 413 712 A (SIEMENS AG [DE]) 28 April 2004 (2004-04-28) * figures *	5	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	27 October 2006	Raspo, Fabrice

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 01 3266

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-10-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003012655 A1	16-01-2003	CN 1529788 A	15-09-2004
		EP 1512836 A1	09-03-2005
		WO 03104616 A1	18-12-2003
US 3545882 A	08-12-1970	CH 492871 A	30-06-1970
		DE 1901464 A1	07-08-1969
		FR 2000324 A5	05-09-1969
		FR 2000325 A5	05-09-1969
		GB 1194061 A	10-06-1970
GB 155156 A	16-12-1920	NONE	
US 1527781 A	24-02-1925	NONE	
US 1371328 A	15-03-1921	NONE	
US 3986792 A	19-10-1976	NONE	
US 2002071764 A1	13-06-2002	AT 329138 T	15-06-2006
		EP 1343951 A2	17-09-2003
		JP 2004515698 T	27-05-2004
		WO 0248508 A2	20-06-2002
CH 418360 A	15-08-1966	NONE	
GB 532372 A	22-01-1941	NONE	
WO 2004022923 A	18-03-2004	AU 2002328530 A1	29-03-2004
		CN 1639446 A	13-07-2005
US 1423466 A	18-07-1922	NONE	
US 6491498 B1	10-12-2002	CN 1643236 A	20-07-2005
		EP 1451446 A1	01-09-2004
		WO 03029616 A1	10-04-2003
EP 1413712 A	28-04-2004	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5211540 A **[0003]**