



(11)

**EP 2 722 407 A3**

(12)

**EUROPEAN PATENT APPLICATION**

(88) Date of publication A3:  
**25.10.2017 Bulletin 2017/43**

(43) Date of publication A2:  
**23.04.2014 Bulletin 2014/17**

(21) Application number: **13189010.5**

(22) Date of filing: **16.10.2013**

(51) Int Cl.:  
**C21D 6/00 (2006.01)**      **C21D 9/00 (2006.01)**  
**C21D 1/18 (2006.01)**      **C21D 1/26 (2006.01)**  
**C22C 38/44 (2006.01)**      **C22C 38/06 (2006.01)**  
**C22C 38/00 (2006.01)**      **F01D 5/28 (2006.01)**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB  
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO  
PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**

(30) Priority: **17.10.2012 JP 2012229408**

(71) Applicant: **Mitsubishi Hitachi Power Systems, Ltd.  
Yokohama 220-8401 (JP)**

(72) Inventors:  
• **Oikawa, Shinji**  
**Tokyo, 100-8280 (JP)**

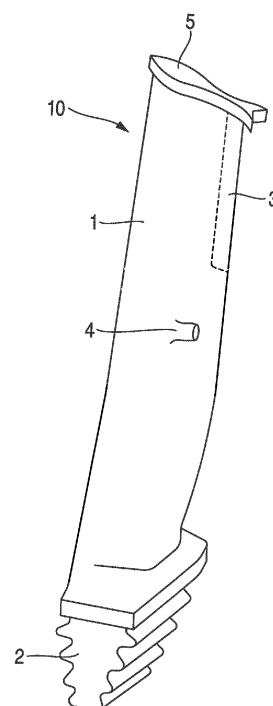
• **Yoda, Hideo**  
**Tokyo, 100-8280 (JP)**  
• **Arai, Masahiko**  
**Tokyo, 100-8280 (JP)**  
• **Doi, Hiroyuki**  
**Tokyo, 100-8280 (JP)**

(74) Representative: **Beetz & Partner mbB  
Patentanwälte  
Steinsdorfstraße 10  
80538 München (DE)**

(54) **Precipitation hardening martensitic stainless steel and long blade for steam turbine using the same**

(57) A precipitation hardening martensitic stainless steel is provided with excellent mechanical property and corrosion resistance and contains, by mass, 0.1% or less of C; 0.1% or less of N; 10.0% ~ 15.0% of Cr; 10.0% ~ 15.0% of Ni; 0.5% ~ 2.5% of Mo; 1.0% ~ 3.0% of Al; 1.0% or less of Si; 1.0% or less of Mn, and the rest is Fe and inevitable impurities. A steam turbine long blade (10) is made of the precipitation hardening martensitic stainless steel.

**FIG.1**



**EP 2 722 407 A3**



## EUROPEAN SEARCH REPORT

Application Number  
EP 13 18 9010

5

10

15

20

25

30

35

40

45

50

55

| 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,P                                                                                                                                                                                                                                                    | EP 2 631 432 A1 (HITACHI LTD [JP])<br>28 August 2013 (2013-08-28)<br>* abstract *<br>* page 6; example Alloy 1; table 1 *<br>* claims 1-7 *                       | 1-9                                                                                                                                                                                                                                                                          | INV.<br>C21D6/00<br>C21D9/00<br>C21D1/18<br>C21D1/26<br>C22C38/44<br>C22C38/06<br>C22C38/00<br>F01D5/28 |
| X,P                                                                                                                                                                                                                                                    | EP 2 617 856 A1 (HITACHI LTD [JP])<br>24 July 2013 (2013-07-24)<br>* abstract *<br>* paragraph [0001] *<br>* page 6; table 1 *                                    | 1-9                                                                                                                                                                                                                                                                          |                                                                                                         |
| X                                                                                                                                                                                                                                                      | EP 2 455 496 A1 (HITACHI LTD [JP])<br>23 May 2012 (2012-05-23)<br>* abstract *<br>* paragraph [0001] *<br>* page 7; table 1 *<br>* paragraph [0036] *             | 1-9                                                                                                                                                                                                                                                                          |                                                                                                         |
| X                                                                                                                                                                                                                                                      | JP H11 209854 A (DAIDO STEEL CO LTD)<br>3 August 1999 (1999-08-03)<br>* abstract *<br>* page 5; example 7; table 1 *                                              | 1,4,5                                                                                                                                                                                                                                                                        | TECHNICAL FIELDS<br>SEARCHED (IPC)<br><br>C21D<br>C22C                                                  |
| X                                                                                                                                                                                                                                                      | EP 1 896 624 A1 (AUBERT & DUVAL SA [FR])<br>12 March 2008 (2008-03-12)<br>* abstract *<br>* page 10; examples E-G,I,J; table 1 *<br>* claim 1 *                   | 1-5                                                                                                                                                                                                                                                                          |                                                                                                         |
| X                                                                                                                                                                                                                                                      | US 2005/126662 A1 (CAO WEI-DI [US])<br>16 June 2005 (2005-06-16)<br>* abstract *<br>* page 7; example Steel 2; table 1 *<br>* page 9; table 4 *<br>* claims 1-5 * | 1-5                                                                                                                                                                                                                                                                          |                                                                                                         |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                                                                                   |                                                                                                                                                                                                                                                                              |                                                                                                         |
| Place of search<br><b>The Hague</b>                                                                                                                                                                                                                    |                                                                                                                                                                   | Date of completion of the search<br><b>15 September 2017</b>                                                                                                                                                                                                                 | Examiner<br><b>Ugarte, Eva</b>                                                                          |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                                                                   | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                                                         |

EPO FORM 1503 03.02 (P04C01)



## EUROPEAN SEARCH REPORT

Application Number  
EP 13 18 9010

| 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                                                                                                                                                                                                                       | EP 0 459 547 A1 (UDDEHOLM TOOLING AB [SE])<br>4 December 1991 (1991-12-04)<br>* abstract *<br>* page 5; examples 4,7; table 1 *<br>* claims 1-4,8-9 *<br>-----                                | 1-5                                                                                                                                                                                                                                                                                   |                                         |
| A                                                                                                                                                                                                                       | GB 1 056 561 A (ARMCO STEEL CORP)<br>25 January 1967 (1967-01-25)<br>* abstract *<br>* page 5; table I(a) *<br>* page 7; table II(a) *<br>* page 8; table III(a) *<br>* claims 1-3 *<br>----- | 1-5                                                                                                                                                                                                                                                                                   |                                         |
| A                                                                                                                                                                                                                       | WO 01/31076 A1 (CRS HOLDINGS INC [US];<br>BROWN ROBERT S [US]; DEL CORSO GREGORY J [US];)<br>3 May 2001 (2001-05-03)<br>* page 2; table 1 *<br>-----                                          | 1-5                                                                                                                                                                                                                                                                                   |                                         |
|                                                                                                                                                                                                                         |                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                       | TECHNICAL FIELDS SEARCHED (IPC)         |
|                                                                                                                                                                                                                         |                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                       |                                         |
| The present search report has been drawn up for all claims                                                                                                                                                              |                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                       |                                         |
| Place of search<br>The Hague                                                                                                                                                                                            |                                                                                                                                                                                               | Date of completion of the search<br>15 September 2017                                                                                                                                                                                                                                 | Examiner<br>Ugarte, Eva                 |
| CATEGORY OF CITED DOCUMENTS                                                                                                                                                                                             |                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                       |                                         |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                                                                                               | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                         |

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 13 18 9010

5

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.

15-09-2017

10

15

20

25

30

35

40

45

50

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date       |
|-------------------------------------------|---------------------|----------------------------|---------------------------|
| EP 2631432                                | A1                  | 28-08-2013                 | CN 103290333 A 11-09-2013 |
|                                           |                     | EP 2631432 A1              | 28-08-2013                |
|                                           |                     | JP 2013209742 A            | 10-10-2013                |
|                                           |                     | US 2013224033 A1           | 29-08-2013                |
| EP 2617856                                | A1                  | 24-07-2013                 | CN 103215521 A 24-07-2013 |
|                                           |                     | EP 2617856 A1              | 24-07-2013                |
|                                           |                     | JP 5764503 B2              | 19-08-2015                |
|                                           |                     | JP 2013147698 A            | 01-08-2013                |
|                                           |                     | US 2013186106 A1           | 25-07-2013                |
| EP 2455496                                | A1                  | 23-05-2012                 | CN 102465240 A 23-05-2012 |
|                                           |                     | EP 2455496 A1              | 23-05-2012                |
|                                           |                     | JP 5528986 B2              | 25-06-2014                |
|                                           |                     | JP 2012102638 A            | 31-05-2012                |
|                                           |                     | US 2012114496 A1           | 10-05-2012                |
| JP H11209854                              | A                   | 03-08-1999                 | NONE                      |
| EP 1896624                                | A1                  | 12-03-2008                 | AT 478165 T 15-09-2010    |
|                                           |                     | BR PI0613291 A2            | 28-12-2010                |
|                                           |                     | CA 2612718 A1              | 11-01-2007                |
|                                           |                     | CN 101248205 A             | 20-08-2008                |
|                                           |                     | DK 1896624 T3              | 20-09-2010                |
|                                           |                     | EP 1896624 A1              | 12-03-2008                |
|                                           |                     | ES 2349785 T3              | 11-01-2011                |
|                                           |                     | FR 2887558 A1              | 29-12-2006                |
|                                           |                     | JP 5243243 B2              | 24-07-2013                |
|                                           |                     | JP 2008546912 A            | 25-12-2008                |
|                                           |                     | SI EP1896624 T1            | 29-10-2010                |
|                                           |                     | US 2010139817 A1           | 10-06-2010                |
|                                           |                     | WO 2007003748 A1           | 11-01-2007                |
| US 2005126662                             | A1                  | 16-06-2005                 | AT 402273 T 15-08-2008    |
|                                           |                     | EP 1689903 A1              | 16-08-2006                |
|                                           |                     | HK 1087738 A1              | 26-09-2008                |
|                                           |                     | JP 4685028 B2              | 18-05-2011                |
|                                           |                     | JP 2007514057 A            | 31-05-2007                |
|                                           |                     | US 2005126662 A1           | 16-06-2005                |
|                                           |                     | US 2005130559 A1           | 16-06-2005                |
|                                           |                     | WO 2005078149 A1           | 25-08-2005                |
| EP 0459547                                | A1                  | 04-12-1991                 | AT 131541 T 15-12-1995    |
|                                           |                     | CA 2043146 A1              | 30-11-1991                |
|                                           |                     | DE 69115356 D1             | 25-01-1996                |
|                                           |                     | DE 69115356 T2             | 09-05-1996                |

EPO FORM P0459

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

55

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 13 18 9010

5

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.

15-09-2017

10

15

20

25

30

35

40

45

50

55

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---------------------|----------------------------|---------------------|
|                                           |                     | EP 0459547 A1              | 04-12-1991          |
|                                           |                     | ES 2082111 T3              | 16-03-1996          |
|                                           |                     | HK 56096 A                 | 03-04-1996          |
|                                           |                     | JP 3301439 B2              | 15-07-2002          |
|                                           |                     | JP H04231438 A             | 20-08-1992          |
|                                           |                     | SE 466265 B                | 20-01-1992          |
|                                           |                     | US 5202089 A               | 13-04-1993          |
| -----                                     |                     |                            |                     |
| GB 1056561 A                              | 25-01-1967          | DE 1458323 A1              | 27-03-1969          |
|                                           |                     | GB 1056561 A               | 25-01-1967          |
|                                           |                     | JP S4822566 B1             | 06-07-1973          |
|                                           |                     | SE 318115 B                | 01-12-1969          |
| -----                                     |                     |                            |                     |
| WO 0131076 A1                             | 03-05-2001          | AT 240417 T                | 15-05-2003          |
|                                           |                     | AU 1083201 A               | 08-05-2001          |
|                                           |                     | BR 0015059 A               | 23-07-2002          |
|                                           |                     | CA 2387880 A1              | 03-05-2001          |
|                                           |                     | DE 60002745 D1             | 18-06-2003          |
|                                           |                     | DE 60002745 T2             | 11-03-2004          |
|                                           |                     | EP 1222317 A1              | 17-07-2002          |
|                                           |                     | ES 2199184 T3              | 16-02-2004          |
|                                           |                     | IL 149084 A                | 19-06-2005          |
|                                           |                     | JP 4941854 B2              | 30-05-2012          |
|                                           |                     | JP 2003513167 A            | 08-04-2003          |
|                                           |                     | MX PA02003989 A            | 13-12-2002          |
|                                           |                     | US 6238455 B1              | 29-05-2001          |
|                                           |                     | WO 0131076 A1              | 03-05-2001          |
| -----                                     |                     |                            |                     |

EPO FORM P0459

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