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(54) Title: FIXTURE FOR RESTRAINING A TURBINE WHEEL AND CORRESPONDING METHOD

FIG. 5

(57) Abstract: A fixture (210) for restraining a wheel (17) of a turbomachine. The fixture comprises a dovetail section (320) adapted for insertion into a dovetail slot of the wheel. A mounting section (330) is located adjacent to, or formed integrally with, the dovetail section. The mounting section comprises at least one attachment point configured for securing the fixture to a stationary anchoring point via a restraint.

[Continued on next page]
Declarations under Rule 4.17:
— as to applicant’s entitlement to apply for and be granted a patent (Rule 4.17(H))
— as to the applicant’s entitlement to claim the priority of the earlier application (Rule 4.17(in))

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— with international search report (Art. 21(3))
BACKGROUND OF THE INVENTION

[0001] The apparatus described herein relates generally to turbomachinery and, more specifically, to a fixture for restraining a turbine wheel during a blade removal or installation procedure.

[0002] Turbomachines need regular maintenance to keep up with the cycle type, in which some cases are continuous (6,000 hours/year or more). During an inspection maintenance outage, the blades in the turbine section of the turbomachine may need to be replaced. The top half of the turbine case is removed, and technicians will restrain the rotor from rolling and begin to remove or replace the turbine blades. To restrain the rotor, technicians have tied a strap around a blade and then attached it to somewhere in the turbine compartment. This known method could result in near miss or incidents which involve the rotor rolling due to a broken strap, as well as damage caused to the blade. The known method that uses a strap presents a risk of injury, safety concerns, as well as requiring possible replacement parts due to hardware damage.

BRIEF DESCRIPTION OF THE INVENTION

[0003] In an aspect of the present invention, a fixture for restraining a wheel of a turbomachine is provided. The fixture comprises a dovetail section adapted for insertion into a dovetail slot of the wheel. A mounting section is located adjacent to, or formed
integrally with, the dovetail section. The mounting section comprises at least one attachment point configured for securing the fixture to a stationary anchoring point via a restraint.

[0004] In another aspect of the present invention, a fixture for restraining a wheel of a turbomachine includes a dovetail section adapted for insertion into a dovetail slot of the wheel. The dovetail section has a dovetail shaped profile or fir tree shaped profile adapted to interlock with corresponding notches or recesses in the dovetail slot of the wheel. The dovetail section has an aft end and a forward end, and both the aft end and the forward end have a threaded hole adapted for securing a fastener. A mounting section is located adjacent to, or formed integrally with, the dovetail section. The mounting section has at least one threaded hole adapted for attaching a coupling to the mounting section. A coupling fastener and a washer secures the coupling to the mounting section via the at least one threaded hole. The coupling is attached to the mounting section, and the at least one coupling is adapted to be secured to a stationary anchoring point via a restraint.

[0005] In yet another aspect of the present invention, a method for restraining a wheel of a turbomachine is provided. The method includes a step of inserting a fixture into a dovetail slot in the wheel. The fixture has dovetail section adapted for insertion into the dovetail slot, and a mounting section located adjacent to, or formed integrally with, the dovetail section. The mounting section is adapted to connect to at least one coupling. The inserting step may also include placing a washer over a fastener, and inserting the fastener into a threaded hole in the dovetail section, wherein the washer is adapted to extend over an axial face of the dovetail slot. In addition, the inserting step may include attaching the at least one coupling to the mounting section. An attaching step attaches at least one
counterbore assembly to a stationary structure, and a connecting step connects a restraint to
the at least one coupling and the at least one counterbore assembly. The connecting step may
also include attaching a come-along or ratcheting mechanism having a strap, chain or cable
to both the at least one coupling and the at least one counterbore assembly, and tightening
the come-along or ratcheting mechanism to restrain the wheel. The stationary structure may
be a shell, a flange or a casing of the turbomachine. The dovetail section may have a straight
profile adapted for use with a straight dovetail slot, or an angled profile adapted for use with
an angled dovetail slot, or a curved profile adapted for use with a curved dovetail slot.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a schematic illustration of a gas turbine system.
[0007] FIG. 2 illustrates a perspective view of single turbine wheel.
[0008] FIG. 3 illustrates a perspective view of a fixture for restraining a wheel of a
turbomachine, according to an aspect of the present invention.
[0009] FIG. 4 illustrates a perspective view of the fixture for restraining a wheel of
a turbomachine, according to an aspect of the present invention.
[0010] FIG. 5 illustrates an exploded, perspective view of the fixture in a dovetail
slot of a wheel, according to an aspect of the present invention.
[0011] FIG. 6 illustrates a top, cross-sectional view of the fixture located in a dovetail
slot.
[0012] FIG. 7 illustrates a top, cross-sectional view of the fixture located in a curved,
axial-entry type of dovetail slot.
FIG. 8 illustrates a partial side view of the fixture installed in a wheel and connected to a stationary anchoring point on the turbomachine's casing.

FIG. 9 illustrates a perspective view of the fixture located in a dovetail slot of a wheel of a turbomachine.

FIG. 10 illustrates a partial side view of the fixture of FIG. 9 installed in a dovetail slot of wheel, and the fixture is connected to two stationary anchoring points on the turbomachine's casing.

FIG. 11 is a flowchart for a method for restraining a wheel of a turbomachine.

FIG. 12 illustrates a perspective view of the fixture, according to an aspect of the present invention.

FIG. 13 illustrates a perspective view of the fixture having two coupling mounted thereon.

DETAILED DESCRIPTION OF THE INVENTION

One or more specific aspects/embodiments of the present invention will be described below. In an effort to provide a concise description of these aspects/embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with machine-related, system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be
complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0020] When introducing elements of various embodiments of the present invention, the articles "a," "an," and "the" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements. Any examples of operating parameters and/or environmental conditions are not exclusive of other parameters/conditions of the disclosed embodiments. Additionally, it should be understood that references to "one embodiment", "one aspect" or "an embodiment" or "an aspect" of the present invention are not intended to be interpreted as excluding the existence of additional embodiments or aspects that also incorporate the recited features.

[0021] Referring to FIG. 1, a turbomachine, such as a gas turbine, is schematically illustrated with reference numeral 10. The gas turbine 10 includes a compressor 12, a combustor assembly 14, a turbine 16, and a shaft 18. It is to be appreciated that one embodiment of the gas turbine 10 may include a plurality of compressors 12, combustor assemblies 14, turbines 16 and/or shafts 18. The compressor 12 and the turbine 16 are coupled by the shaft 18. The shaft 18 may be a single shaft or a plurality of shaft segments coupled together to form the shaft 18.

[0022] The combustor assembly 14 uses a combustible liquid and/or gas fuel, such as a natural gas or a hydrogen rich synthetic gas, to run the gas turbine 10. The combustor assembly 14 includes a combustor chamber 20 that is in fluid communication with a fuel pre-mixer 22 that is in fluid communication with an airflow 24 and a fuel source 26. The
fuel pre-mixer 22 creates an air-fuel mixture, and discharges the air-fuel mixture into the combustor chamber 20, thereby causing a combustion that creates a hot pressurized exhaust gas. The combustor chamber 20 directs the hot pressurized gas through a transition piece into the turbine 16, causing rotation of the turbine 16. Rotation of the turbine 16 causes the shaft 18 to rotate, thereby compressing air as it flows into the compressor 12. The turbine section 16 has multiple rotatable wheels 17 on which a plurality of blades are mounted. In this example, three stages of turbine wheels 17 are shown, and each wheel would be paired with a stator vane stage (not shown). In general, turbomachines include, compressors, gas turbines and steam turbines.

[0023] FIG. 2 illustrates a perspective view of single turbine wheel 17. The wheel 17 includes a series of circumferentially arranged dovetail slots 201. A turbine blade (not shown) is inserted into each of these dovetail slots 201. During service (or assembly) of the turbomachine 10, the blades may need to be removed or installed. In a service example, the blades are removed and the used blades are either repaired and re-installed or just replaced with new blades. Turbomachines, such as gas or steam turbines, have large and heavy components. The wheel 17 with blades attached is one example of a heavy component, and this wheel is balanced to reduce vibrations. However, as the blades are removed from wheel 17, the wheel's center of gravity changes, and the wheel will want to rotate in either a clockwise or counter-clockwise direction. This can present a serious safety hazard to people working on the turbine, as an unexpected wheel rotation can force a blade (or other wheel component) onto personnel. Therefore, it would be desirable to restrain the rotor from
rotation during a blade removal or installation procedure. A fixture 210 for restraining the wheel 17 is the focus of this disclosure, and will be described in greater detail hereinbelow.

[0024] FIG. 3 illustrates a perspective view of the fixture 210 for restraining a wheel 17 of a turbomachine 10. The fixture 210 includes a dovetail section 320 adapted for insertion into the dovetail slot 201 of the wheel 17. The dovetail section 320 has a dovetail shaped profile or fir tree shaped profile, which include a plurality of ridges and valleys, adapted to interlock with corresponding notches or recesses in the dovetail slot 201 of wheel 17. Typically, the peak height of each ridge decreases in height as the peaks become nearer to the bottom (radially inner portion) of the dovetail section. A mounting section 330 is located on top of and adjacent to, or formed integrally with, the dovetail section 320. In one example, the dovetail section 320 and mounting section 330 are cast as, or machined from, a single piece of material, and this material may be 4140-HT (heat treated) high alloy tool steel as it has good strength, toughness, and mechanical properties. Alternatively, any other suitable material may be used as desired in the specific application. Fixture 210 also includes at least one coupling 340 attached to the mounting section 330. The coupling 340 may be a coupling ring, hoist ring, shackle or other suitable coupling device. A fastener 342, such as a shoulder head screw with washer, may be used to attach the coupling ring 340 to the mounting section 330. The coupling 340 may be attached so that it swivels about an axial axis, and so that it can be oriented as shown in FIG. 3 or FIG. 4, or any position in between the illustrated positions.

[0025] In use, the coupling 340 is secured to a stationary anchoring point via a restraint. To lock the fixture into the dovetail slot 201, stops 350, 360, 450 are used on axial
ends or axial faces thereof. The fixture 210 has a forward axial face (or end) 370 and an aft axial face (or end) 371. The stop 350 is configured as a T-shaped stop and the top of the “T” extends past the outline of the dovetail slot 201. In this manner, the stop 350 rests against a forward axial face of wheel 17 and prevents axial movement of the fixture. The stop 350 is attached to the dovetail section 320 by means of a fastener 352, such as a shoulder screw or bolt. The aft axial face 371 has a fastener 362 and washer 360 that function as a stop. The washer 360 is sized so that it overlaps the dovetail slot boundary, and in so doing prevent axial movement of the fixture. When both stops 350, 360 are installed, the dovetail section 320 is locked in the dovetail slot 201, and the fixture will not slide out of the slot 201.

[0026] FIG. 4 illustrates a perspective view of the fixture 210 for restraining a wheel 17 of a turbomachine 10. Wheels 17 may have varying thicknesses. A thicker wheel may require a stop 350 as shown in FIG. 3. However, for a thinner wheel a stop 450 may be used. Stop 450 is comprised of a plate having holes for one or more fasteners 452. The fasteners 452 may be configured to screw into an axial face of mounting section 330 (as shown) and/or into dovetail section 320. As an example only, the axial length of the dovetail section 320 and mounting section 330 may be sized to match the thinnest wheel of the target turbomachine. In this manner, T-stops 350 may be used to adjust the fixture to thicker wheels, and the stop plate 450 may be used on the thinnest wheel. The various stops 350, 450, 360 may also be fabricated from 4140-HT (heat treated) high alloy tool steel, or any other suitable material. In addition, both the aft end and the forward end have one or more internally threaded holes 481, 482 adapted for securing fasteners. The mounting section 330 includes at least one internally threaded hole 483 adapted for attaching the coupling 340 to
the mounting section 330, and fastener 342 and an optional washer secures the coupling ring 340 to the mounting section 330 via the threaded hole 483. The mounting section 330 includes at least one attachment point configured for securing the fixture 210, and this attachment point can be the coupling 340, the threaded hole 483, or any other suitable device/feature located on or in the mounting section.

[0027] FIG. 5 illustrates an exploded, perspective view of the fixture 210 in a dovetail slot 201 of a wheel 17 of a turbomachine. The fixture 210 is inserted into the dovetail slot 201 and is restrained from moving radially or circumferentially. However, the fixture could slide out axially forward or aft. To prevent this, axial stops are installed. The forward axial stop 350 is attached/secured to the forward side of the fixture. The aft axial stop 360 is then installed on the aft side of the fixture. When both stops are installed the fixture is locked to the wheel. The coupling 340 may then be attached to the mounting section 330. It is to be understood that one or more coupling rings may be used, for example, one coupling ring on each axial face/end of the fixture, or one or more coupling rings may be located on the top (or radially outer surface) of the mounting section 330, or any combination thereof. As shown in FIG. 5 dovetail section 320 has a straight profile adapted for use with a straight dovetail slot 201.

[0028] FIG. 6 illustrates a top, cross-sectional view of the fixture located in a dovetail slot. The dovetail section 620 has an angled profile adapted for use with an angled dovetail slot 601. The axial extending sides of slot 601 are not orthogonal to the axial faces thereof. FIG. 7 illustrates a top, cross-sectional view of the fixture located in a dovetail slot. The dovetail section 720 has a curved profile adapted for use with a curved dovetail slot 701.
This curved, axial-entry type of configuration may be used in steam turbines, or any other turbomachine as desired.

[0029] FIG. 8 illustrates a partial side view of the fixture installed in a wheel and connected to a stationary anchoring point on the turbomachine's casing. The stationary anchoring point 800 may include at least one counterbore assembly 810 having a coupling ring 812 attached thereto. The counterbore assembly 800 is adapted to be secured to a stationary structure 820, such as a turbomachine casing, shell or flange. In the example shown, the stationary structure 820 is the bottom half of a turbine case. The counterbore assembly 810 has a counterbore insert 814 that has a portion adapted to extend into a hole 822 of the turbine case 820. A head of the counterbore insert 814 is larger than the hole 822 diameter. The shaft portion of the counterbore insert (the portion that goes into the turbine casing hole 822) includes an internally threaded hole that is configured for use with fastener 813. Alternatively, the counterbore insert may be a cylindrical element having two opposing internally threaded holes, one for use with fastener 813 and another for a bolt (e.g., which would take the place of 814). The fastener 813 connects the coupling ring 812 to the counterbore insert 814, and therefore to the turbine case 820. If desired a washer 815 may be interposed between the turbine case 820 and coupling ring 812. The coupling 340 is secured to the coupling ring 812 on stationary anchoring point 800 by restraint 830, which may be a chain, chain with come-along, cable or wire. Come-alongs may also be referred to as ratchet pullers, ratchet mechanisms or cable (or chain) pullers. Lever chain hoists or similarly functioning devices may be used as well for restraint 830.
[0030] FIG. 9 illustrates a perspective view of the fixture 210 in a dovetail slot 201 of a wheel 17 of a turbomachine. The fixture 201 includes two couplings 340 and 940. Coupling ring 940 is attached to a forward end of the mounting section and is located on a forward axial side of the wheel 17, and coupling 340 is attached to an aft end of the mounting section and is located on the aft axial side of wheel 17. This type of configuration allows two restraints 830 to be attached to the fixture. The restraints may extend in the same direction, or extend in generally opposing directions.

[0031] FIG. 10 illustrates a partial side view of the fixture 201 of FIG. 9 installed in a dovetail slot of wheel 17, and the fixture is connected to two stationary anchoring points on the turbomachine’s casing. The first stationary anchoring point 800 is connected to the fixture 210 via restraint 830 (shown by a dotted line). The second stationary anchoring point 800' is connected to the fixture 210 via restraint 830' (shown by a dotted line). The two stationary anchoring points 800, 800' may be on opposing sides of the turbine case. The restraints 830, 830' may be tightened by the use of a come-along 1010 or 1010'. However, the restraints 830 do not need to be excessively tightened, as simply taking up the slack will be sufficient to prevent or restrain undesired wheel rotation. It is also to be understood that one or more coupling rings could be attached onto the top of the mounting section 330.

[0032] FIG. 11 is a flowchart for a method 1100 for restraining a wheel 17 of a turbomachine. In step 1110 the fixture 210 is inserted into a dovetail slot 201 in the wheel 17. The fixture 210 includes a dovetail section 320 adapted for insertion into the dovetail slot 201, and a mounting section 330 located adjacent to, or formed integrally with, the dovetail section 320. The mounting section 330 is adapted to connect to at least one coupling
340. Step 1110 may also include placing a washer 360 over a fastener 362, and then inserting the fastener 362 into a threaded hole in the dovetail section 320. The washer is adapted to extend over or overlap an axial face of the dovetail slot 201. In addition, at least one coupling 340 may be attached to the mounting section 330 or the fixture 210 in general.

[0033] In step 1120, at least one counterbore assembly 810 is attached to a stationary structure 820. In step 1130 a restraint 830 is connected to the coupling 340 and the at least one counterbore assembly 810. Steps 1120 and 1130 may be repeated until the desired number of restraints are installed. Connecting step 1130 may also include attaching a come-along 1010 having a strap, chain 830 or cable to both the coupling 340 and the counterbore assembly 810 or other coupling ring 812 located on the stationary support. In step 1140, the restraints are tightened to restrain or prevent the wheel 17 from rotating.

[0034] FIG. 12 illustrates a perspective view of the fixture 1200. The fixture 1200 includes a dovetail section 1210 adapted for insertion into the dovetail slot 201 of the wheel 17. The dovetail section 1210 has a dovetail shaped profile or fir tree shaped profile, which includes a plurality of ridges and valleys, adapted to interlock with corresponding notches or recesses in the dovetail slot 201 of wheel 17. Typically, the peak height of each ridge decreases in height as the peaks become nearer to the bottom (radially inner portion) of the dovetail section. A mounting section 1220 is located on top of and adjacent to, or formed integrally with, the dovetail section 1210. In one example, the dovetail section 1210 and mounting section 1220 are cast as, or machined from, a single piece of material, and this material may be 4140-HT (heat treated) high alloy tool steel as it has good strength, toughness, and mechanical properties. Alternatively, any other suitable material may be used.
as desired in the specific application. Fixture 1200 also includes at least one coupling 1230
attached to the mounting section 1220. The coupling 1230 may be a coupling ring, hoist ring,
shackle or other suitable coupling device. The coupling 1230 is attached to the top of the
mounting section (as shown). In this example, a threaded fastener (not shown) that is
attached to the coupling 1230 is screwed into an internally threaded hole (not shown) in the
top 1221 of the mounting section 1220. A washer may be interposed between the bottom of
the coupling 1230 and the top 1221 of the mounting section, if desired. The coupling 1230
may also be attached so that it swivels about a radial axis (with respect to the turbomachine).

[0035] A back plate 1240 is attached to a first axial end of the mounting section, and
is adapted to extend over an axial face of the dovetail slot to restrain axial movement of the
fixture. The back plate 1240 may be a substantially rectangular and planar member, as
shown. A plurality of fasteners 1242 (three are shown) may be used to attach the back plate
1240 to the mounting section 1220. The first axial end of the mounting section includes a
plurality of internally threaded holes configured for use with fasteners 1242. The fasteners
1242 may be screws, bolts or any other suitable fastening device.

[0036] A sliding block 1250 may be attached to the top of the mounting section 1220
near an opposing (or second) axial end of the mounting section. The sliding block 1250 is
adapted to extend over an axial face of the dovetail slot 201 and restrain axial movement of
the fixture 1200. In addition, the sliding block 1250 is adapted to slide up and down along a
radial axis, with respect to the turbomachine, so that the fixture 1200 can be inserted into
the dovetail slot 210 when the sliding block is at an upper position. The fixture 1200 is restrained
from axial movement when the sliding block 1250 is in a lower position, as shown. Two
pins 1252 are attached to the mounting section and act as guides for the radial (or up and down) movement of the sliding block. The pins 1252 can be screwed into the mounting section via corresponding threaded holes. A lock screw 1254, such as a shoulder screw, is used to lock the sliding block in place and prevent radial movement thereof. The lock screw 1254 also locks the sliding block in place to prevent axial movement of the fixture. In use, the coupling 1230 is secured to a stationary anchoring point via a restraint. When both the back plate 1240 and sliding block 1250 are installed and locked in place, the dovetail section 1210 is locked in the dovetail slot 201, and the fixture 1200 will not slide out of the slot 201.

[0037] FIG. 13 illustrates a perspective view of the fixture 1300. The fixture 1300 includes two couplings 1331 and 1332. Couplings 1331 and 1332 are both attached to a top portion of the mounting section 1220. This type of configuration allows two restraints 830 to be attached to the fixture. The restraints may extend in the same direction, or extend in generally opposing directions.

[0038] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.
CLAIMS

1. A fixture for restraining a wheel of a turbomachine, the fixture comprising:
   a dovetail section adapted for insertion into a dovetail slot of the wheel;
   a mounting section located adjacent to, or formed integrally with, the dovetail section;
   wherein the mounting section comprises at least one attachment point configured for securing the fixture to a stationary anchoring point via a restraint.

2. The fixture of claim 1, the stationary anchoring point further comprising:
   at least one counterbore assembly having a coupling attached thereto, the at least one counterbore assembly adapted to be secured to a stationary structure.

3. The fixture of claim 2, wherein the stationary structure is at least one of:
   a shell, a flange or a casing of the turbomachine.

4. The fixture of claim 1, the dovetail section having a dovetail shaped or fir tree shaped profile adapted to interlock with corresponding notches or recesses in the dovetail slot of the wheel.
5. The fixture of claim 4, the fixture further comprising an aft end and a forward end, at least one of the aft end and the forward end having a threaded hole adapted for securing a fastener.

6. The fixture of claim 5, further comprising the fastener and a washer secured by the threaded hole, and a stop located on an opposing end of the fixture, the washer and the stop adapted to lock the dovetail section to the dovetail slot.

7. The fixture of claim 5, at least one of the aft end or the forward end having:
   a T-shaped stop or a rectangular shaped stop.

8. The fixture of claim 1, the dovetail section having one of:
   a straight profile adapted for use with a straight dovetail slot, or
   an angled profile adapted for use with an angled dovetail slot, or
   a curved profile adapted for use with a curved dovetail slot.

9. The fixture of claim 1, the mounting section further comprising:
   at least one threaded hole adapted for attaching the coupling to the mounting section, and wherein a fastener secures the coupling to the mounting section via the at least one threaded hole.

10. The fixture of claim 1, further comprising:
a first coupling attached to an aft end of the mounting section, and
a second coupling attached to a forward end of the mounting section.

11. The fixture of claim 1, further comprising:
a coupling attached to the top of the mounting section.

12. A method for restraining a wheel of a turbomachine, the method comprising:
inserting a fixture into a dovetail slot in the wheel, the fixture comprising:
a dovetail section adapted for insertion into the dovetail slot;
a mounting section located adjacent to, or formed integrally with, the dovetail section, the mounting section adapted to connect to at least one coupling;
attaching at least one counterbore assembly to a stationary structure;
connecting a restraint to the at least one coupling and the at least one counterbore assembly.

13. The method of claim 12, the stationary structure comprising at least one of:
a shell, a flange or a casing of the turbomachine.

14. The method of claim 13, the inserting a fixture step further comprising:
placing a washer or a stop over a fastener;
inserting the fastener into a threaded hole in the dovetail section, wherein the washer or the stop is adapted to extend over an axial face of the dovetail slot; and
attaching the at least one coupling to the mounting section.

15. The method of claim 12, the connecting step further comprising:

attaching a come-along having a strap, chain or cable to both the at least one coupling and the at least one counterbore assembly, and tightening the come-along to restrain the wheel.
1100

1110 INSERT DOVETAIL SECTION OF FIXTURE INTO DOVETAIL SLOT

1120 ATTACH COUNTERBORE ASSEMBLY TO STATIONARY STRUCTURE

1130 CONNECT RESTRAINT TO COUPLING RING ON FIXTURE AND STATIONARY STRUCTURE

1140 TIGHTEN RESTRAINT(S) TO RESTRAIN OR PREVENT WHEEL FROM ROTATING

FIG. 11
INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/049106

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01D25/28
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)
F01D B66C

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>A</td>
<td>paragraphs [0009], [0037] - [0041]; figures 7-9</td>
<td>10, 14, 15</td>
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<td>X</td>
<td>EP 2 752 382 AI (MITSUBISHI HEAVY IND LTD [JP]) 9 July 2014 (2014-07-09)</td>
<td>1-9, 11</td>
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<td>A</td>
<td>paragraph [0031]; figures</td>
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Further documents are listed in the continuation of Box C. X See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search
30 October 2017

Date of mailing of the international search report
14/11/2017

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Georgi, Jan
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