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Remarks:
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(54) Conformal liner for gas turbine engine fan section

(57) A fan section (18) of a gas turbine engine (10) includes a fan case structure (30) having a first coefficient of thermal expansion. A fan blade (26) is arranged within the fan case structure (30) and has a second coefficient thermal expansion. A continuous ring-shaped liner (44) surrounds the fan blade (26) and includes a third coefficient of thermal expansion that is substantially similar to the second coefficient of thermal expansion and substantially different than the first coefficient of thermal expansion. An elastomeric adhesive (46) operatively connects the liner (44) to the fan case structure (30). The adhesive (46) is configured to accommodate diametrical change in the liner (44) and maintain a desired radial tip clearance (38) throughout various fan section operating temperatures.

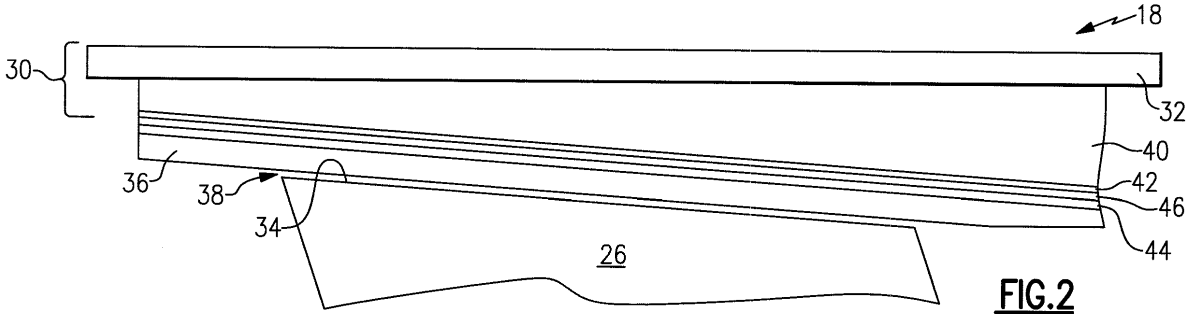

FIG.2

EP 2 775 104 A1

Description

BACKGROUND

[0001] This disclosure relates to a fan section for a gas turbine engine, and, in particular, a conformal liner for the fan section.

[0002] One type of gas turbine engine includes a core engine having compressor and turbine sections that drive a fan section. The fan section includes circumferentially arranged fan blades disposed within a fan case. The fan section is subject to large temperature fluctuations throughout engine operation. A minimized clearance tight seal is desired between the tips of the fan blades and the fan case throughout engine operation at the various operating temperatures.

[0003] One system has been proposed to accommodate thermal expansion and contraction in a fan section having composite fan blades. The composite fan blades are arranged within a composite liner of generally the same material. Several pins at discrete circumferential locations along the liner are used to support the liner relative to a metallic fan case and permit the fan case to expand and contract relative to the composite liner.

SUMMARY

[0004] A fan section of a gas turbine engine includes a fan case structure having a first coefficient of thermal expansion. A fan blade is arranged within the fan case structure and has a second coefficient thermal expansion. A continuous, ring-shaped liner surrounds the fan blade and includes a third coefficient of thermal expansion that is substantially similar to the second coefficient of thermal expansion and substantially different than the first coefficient of thermal expansion. A desired radial tip clearance is provided between the liner and the fan blade. An elastomeric adhesive operatively connects the liner to the fan case structure. The adhesive is configured to accommodate diametrical change in the liner and maintain the desired radial tip clearance throughout various fan section operating temperatures.

[0005] In a further embodiment of any of the above, the adhesive has a 300% elongation or greater.

[0006] In a further embodiment of any of the above, the adhesive is silicone rubber.

[0007] In a further embodiment of any of the above, the second coefficient of thermal expansion is greater than the first coefficient of thermal expansion by at least 10 x 10^{-6}/°F (18 x 10^{-6}/°C).

[0008] In a further embodiment of any of the above, the fan structure includes a composite fan case.

[0009] In a further embodiment of any of the above, the fan case structure includes a honeycomb structure operatively connected radially inward of and to the composite fan case.

[0010] In a further embodiment of any of the above, the fan case structure includes a composite septum interconnecting the adhesive and the honeycomb.

[0011] In a further embodiment of any of the above, the second and third coefficients of thermal expansion are within 1 x 10^{-6}/°F (1.8 x 10^{-6}/°C) of one another.

[0012] In a further embodiment of any of the above, the fan blade and the liner are constructed from the same series aluminum alloy.

[0013] In a further embodiment of any of the above, the desired radial tip clearance is about 0.030 inch at -65°F (0.76 m at -54°C) ambient.

[0014] In a further embodiment of any of the above, a rub strip is supported on and radially inward of the liner between the liner and the fan blade.

[0015] A fan case structure includes a composite fan case structure having a first coefficient of thermal expansion. A continuous, ring-shaped liner has a second coefficient of thermal expansion that is substantially different than the first coefficient of thermal expansion. The second coefficient of thermal expansion is greater than the first coefficient of thermal expansion by at least 10 x 10^{-6}/°F (18 x 10^{-6}/°C). An elastomeric adhesive operatively connects the liner to the fan case structure. The adhesive has a 300% elongation or greater. The adhesive is configured to accommodate diametrical change in the liner through various operating temperatures.

[0016] In a further embodiment of any of the above, the composite fan case structure includes a structure constructed from resin and at least one of carbon fibers and fiberglass. The liner is an aluminum alloy.

[0017] In a further embodiment of any of the above, the adhesive is silicone rubber.

[0018] In a further embodiment of any of the above, a rub strip is supported radially inward from and by the liner. The composite fan case structure includes a composite septum interconnecting the adhesive to a honeycomb structure that is supported by and radially inward from a composite fan case.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The disclosure can be further understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a schematic, cross-sectional side view of an example gas turbine engine.

Figure 2 is an enlarged, cross-sectional side view of a fan case structure in a fan section of the gas turbine engine shown in Figure 1.

Figure 3 is a further enlarged view of the fan case structure shown in Figure 2.

Figure 4 is a schematic, cross-sectional end view to the fan section.

DETAILED DESCRIPTION

[0020] An example gas turbine engine 10 is schematically illustrated in Figure 1. The gas turbine engine 10 includes a compressor section 12, a combustor section 14 and a turbine section 16, which are arranged within a core housing 24. In the example illustrated, high pressure stages of the compressor section 12 and the turbine section 16 are mounted on a first shaft 20, which is rotatable about an axis A. Low pressure stages of the compressor section 12 and turbine section 16 are mounted on a second shaft 22 which is coaxial with the first shaft 20 and rotatable about the axis A. The first and second shafts 20, 22 are supported for rotation within the core housing 24.

[0021] A fan section 18 is arranged within a fan case structure 30, which provides a bypass flow path 28 between the fan case structure 30 and the core housing 24. In the example illustrated, the first shaft 20 rotationally drives circumferentially arranged fan blades 26 that provide flow through the bypass flow path 28. In one example, the fan blades 26 are constructed from an aluminum alloy. It should be understood that the configuration illustrated in Figure 1 is exemplary only, and the disclosure may be used in other configurations. Although a high bypass engine is illustrated, it should be understood that the disclosure also relates to other types of gas turbine engines, such as turbo jets.

[0022] Referring to Figures 2-4, the fan section 18 includes a fan case structure 30 comprising multiple components in one example. A honeycomb structure 40, which may be constructed from aluminum, is supported radially inward from and on the fan case 32. A septum 42 is arranged radially inward from and supported by the honeycomb structure 40.

[0023] In one example, the fan case structure 30 includes a composite fan case 32, which is constructed from carbon fiber and resin in one example. In one example, the septum 42 is a composite structure constructed from fiberglass and resin. As can be appreciated, composite structures have relatively low coefficients of thermal expansion and are dimensionally stable throughout the various operating temperatures.

[0024] A continuous, ring-shaped liner 44, which is an aluminum alloy, for example, is supported by the fan case structure 30, and in the example shown, by the septum 42, using an elastomeric adhesive 46. In one example, the adhesive 44 has a room temperature radial thickness 48 of 0.100 in. (2.54 mm) and greater than 300% elongation, which may be provided by a silicone rubber.

[0025] The liner 44 has a coefficient of thermal expansion that is substantially the same as the coefficient of thermal expansion of the fan blades 26 and substantially different than the fan case structure 30. In one example, the fan blades 26 and liner 44 have coefficients of thermal expansion that are within 1 x 10^{-6}/°F (1.8 x 10^{-6}/°C) of one another and are constructed from the same series aluminum alloy, which may be AM54027 in one example. In one example, the liner/fan blade coefficient of thermal expansion is greater than the fan case structure thermal expansion by at least 10 x 10^{-6}/°F (18 x 10^{-6}/°C)

[0026] The liner 44 includes a rub strip 36 that provides an abradable material immediately adjacent to tips 34 of the fan blades 26, providing a blade tip clearance 38. It is desirable to maintain a desired radial blade tip clearance throughout various fan section operating temperatures. In one example, a desired radial tip clearance is about 0.030 in. at -65°F (0.76 mm at -54°C) ambient, which is typically encountered during cruise altitude. Thus, the elastomeric adhesive 46 is selected to accommodate changes in a diameter 50 (only radial lead line is shown in Figure 3) of the liner 44 as the liner 44 expand and contract during operation.

[0027] Although an example embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of the claims. For that reason, the following claims should be studied to determine their true scope and content.

Claims

1. A fan case structure comprising:

    a composite fan case structure (30) having a first coefficient of thermal expansion;
    an continuous ring-shaped liner (44) having a second coefficient of thermal expansion that is substantially different than the first coefficient of thermal expansion, wherein the second coefficient of thermal expansion is greater than the first coefficient of thermal expansion by at least 10 x 10^{-6}/°F (18 x 10^{-6}/°C) and
    an elastomeric adhesive (46) operatively connecting the liner (44) to the fan case structure (30), wherein the adhesive (46) has a 300% elongation or greater, the adhesive (46) configured to accommodate diametrical change in the liner (44) throughout various operating temperatures.

2. The fan case structure according to claim 1, wherein the composite fan case structure (30) includes a structure constructed from resin and at least one of carbon fibers and fiberglass, and the liner (44) is an aluminum alloy.

3. The fan case structure according to claim 1 or 2, wherein the adhesive (46) is silicone rubber.

4. The fan case structure according to any of claims 1 to 3, wherein a rub strip (36) is supported radially inward from and by the liner (44), and the composite fan case structure (30) includes: a composite septum (42) interconnecting the adhesive (46) to a honeycomb structure (40) that is supported by and radially inward from a composite fan case (32).

5. A fan section (18) of a gas turbine engine (10) comprising:

a fan case structure (20) having a first coefficient of thermal expansion;
a fan blade (26) arranged within the fan case structure (30) and having second coefficient of thermal expansion;
a continuous ring-shaped liner (44) surrounding the fan blade (26) and having a third coefficient of thermal expansion that is substantially similar to the second coefficient of thermal expansion and substantially different than the first coefficient of thermal expansion, and a desired radial tip clearance (38) between the liner (44) and the fan blade (27); and
an elastomeric adhesive (46) operatively connecting the liner (44) to the fan case structure (30), the adhesive (46) configured to accommodate diametrical change in the liner (44) and maintain the desired radial tip clearance (38) throughout various fan section operating temperatures.

6. The fan section (18) according to claim 5, wherein the adhesive (46) has a 300% elongation or greater.

7. The fan section (18) according to claim 5 or 6, wherein the adhesive (46) is silicone rubber.

8. The fan section (18) according to any of claims 5 to 7, wherein the second coefficient of thermal expansion is greater than the first coefficient of thermal expansion by at least 10 x 10^{-6}/°F (18 x 10^{-6}/°C).

9. The fan section (18) according to any of claims 5 to 8, wherein the fan case structure (30) includes a composite fan case.

10. The fan section (18) according to claim 9, wherein the fan case structure (30) includes a honeycomb structure (40) operatively connected radially inward of and to the composite fan case (32).

11. The fan section (18) according to claim 10, wherein the fan case structure (30) includes a composite septum (42) interconnecting the adhesive (46) and the honeycomb structure (40).

12. The fan section (18) according to any of claims 5 to 11, wherein the second and third coefficients of thermal expansion are within 1 x 10^{-6}/°F (1.8 x 10^{-6}/°C) of one another.

13. The fan section (18) according to any of claims 5 to 12, wherein the fan blade (26) and the liner (44) are constructed from the same series aluminum alloy.

14. The fan section (18) according to any of claims 5 to 13, wherein the desired radial tip clearance (38) is about 0.030 inch at -65°F (0.76 m at -54°C) ambient.

15. The fan section (18) according to any of claims 5 to 14, comprising a rub strip (36) supported on and radially inward of the liner (44) between the liner (44) and the fan blade (27).

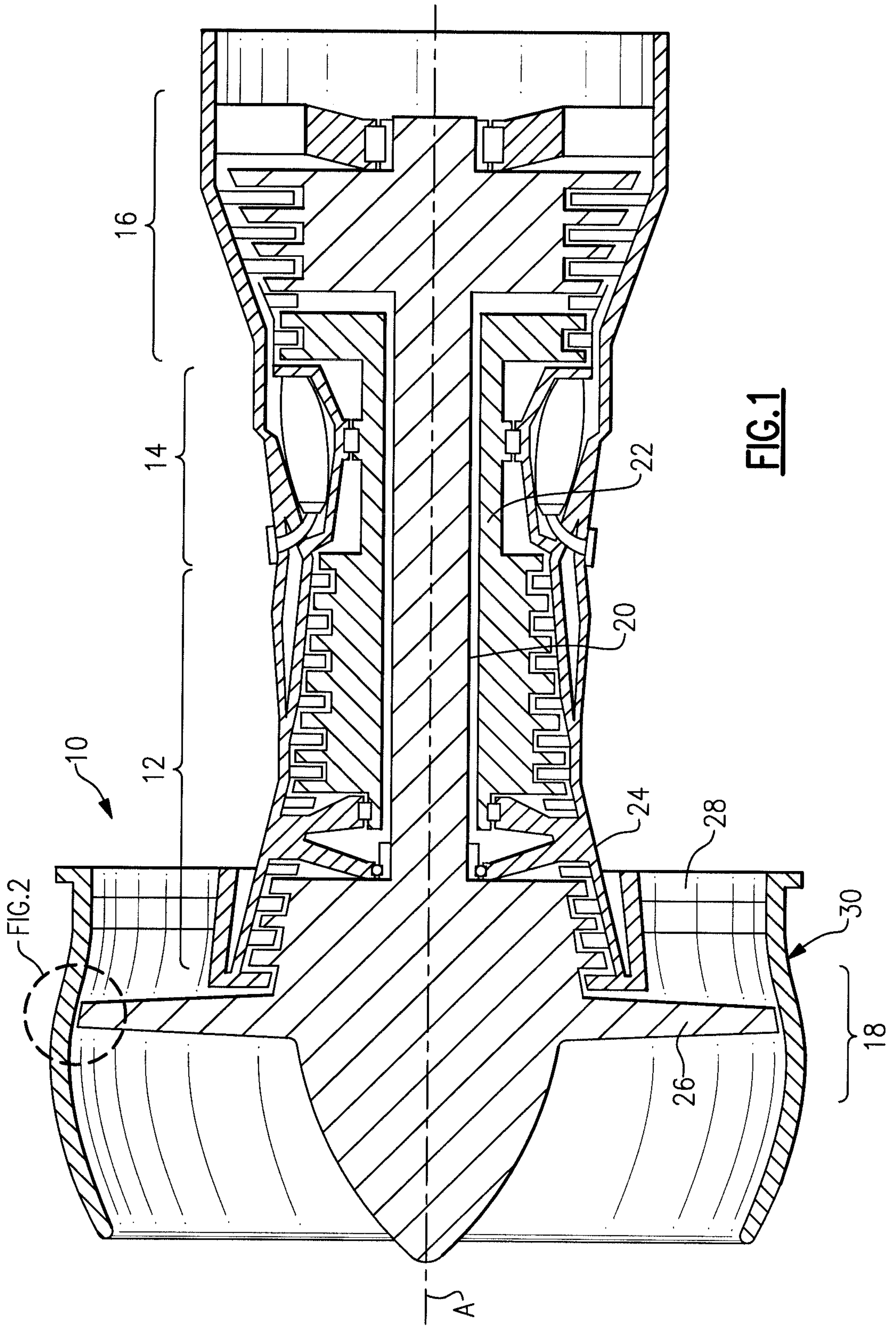

FIG.1

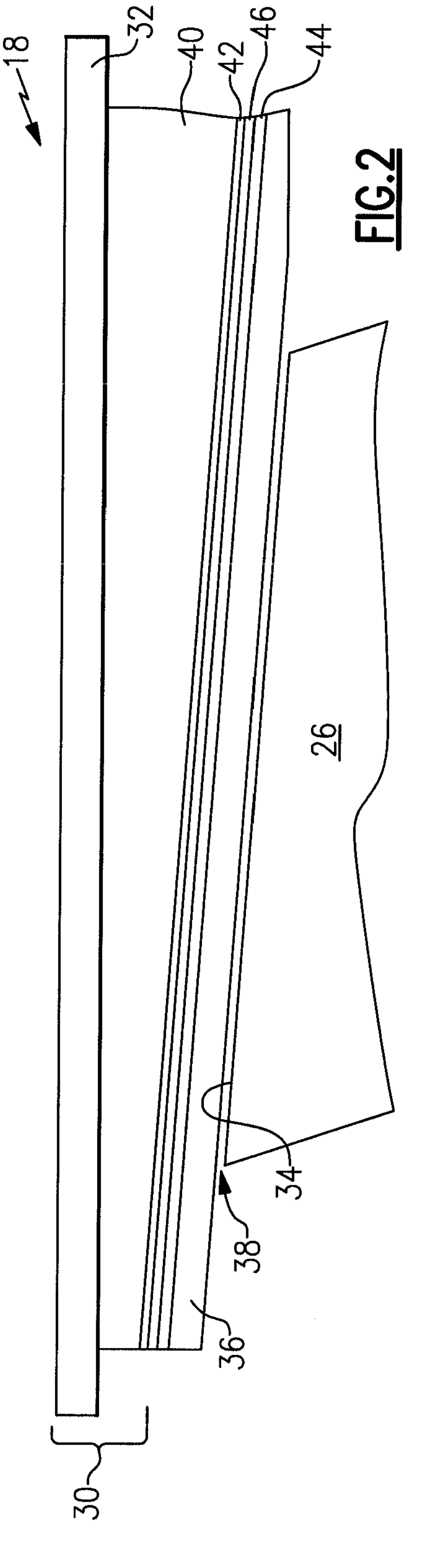

FIG.2

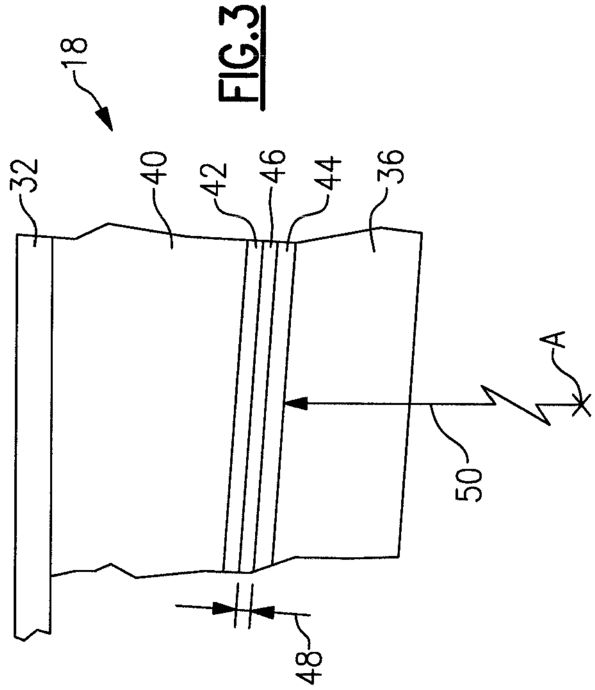

FIG.3

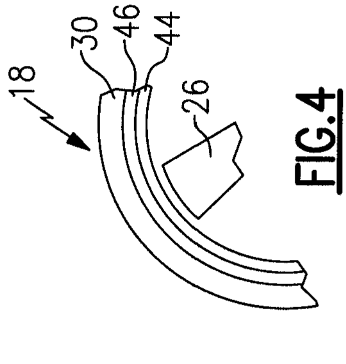

FIG.4

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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 8310

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	GB 2 361 747 A (GEN ELECTRIC [US]) 31 October 2001 (2001-10-31) * page 8, line 14 - page 9, line 12 * -----	1,5	INV. F01D11/12 F01D11/18
A	EP 1 013 889 A1 (UNITED TECHNOLOGIES CORP [US]) 28 June 2000 (2000-06-28) * paragraph [0044] * -----	1,5	
A	US 5 388 959 A (FORRESTER JAMES M [US] ET AL) 14 February 1995 (1995-02-14) * column 2, line 64 - column 3, line 37 * -----	1,5	
A	EP 1 510 657 A1 (SNECMA MOTEURS [FR]) 2 March 2005 (2005-03-02) * paragraphs [0030], [0031] * -----	1,5	

TECHNICAL FIELDS SEARCHED (IPC)

F01D

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	4 August 2014	Pileri, Pierluigi

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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04-08-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2361747 A	31-10-2001	GB 2361747 A	31-10-2001
		US 6382905 B1	07-05-2002
EP 1013889 A1	28-06-2000	DE 69926594 D1	15-09-2005
		DE 69926594 T2	18-05-2006
		EP 1013889 A1	28-06-2000
		JP 2000186507 A	04-07-2000
		US 6203273 B1	20-03-2001
US 5388959 A	14-02-1995	NONE	
EP 1510657 A1	02-03-2005	CA 2478788 A1	18-02-2005
		CN 1590712 A	09-03-2005
		EP 1510657 A1	02-03-2005
		FR 2859002 A1	25-02-2005
		JP 2005061419 A	10-03-2005
		RU 2282039 C2	20-08-2006
		US 2005089390 A1	28-04-2005

EPO FORM P0459

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