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(54) **Title:** HEAT EXCHANGER

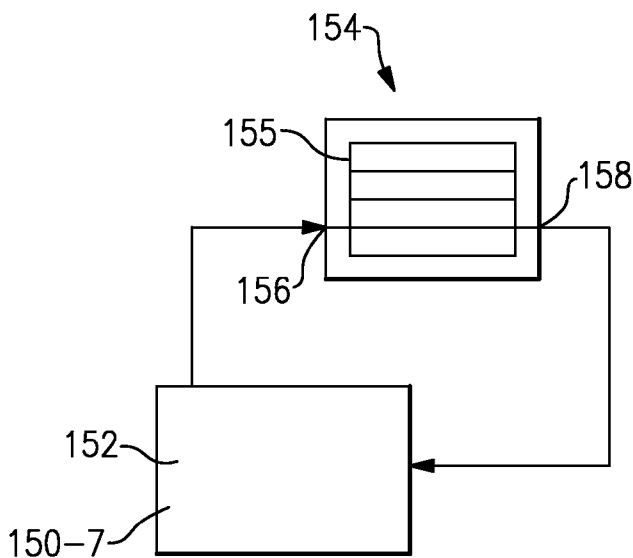


FIG. 2

(57) **Abstract:** A gas turbine engine has a fan, a compressor section, a combustor, and a turbine section. The fan delivers a portion of air into the compressor, and into a duct, as bypass air. A bleed air system bleeds a quantity of air from the compressor into a chamber at least at low power conditions of the engine. The bleed air system has an opening which may be selectively closed to block bleed air, or opened to allow bleed flow from the compressor into the chamber. A heat exchanger is positioned such that a first surface of the heat exchanger is contacted by bypass air in the duct, and a second surface of the heat exchanger is contacted by bleed air when the bleed air system directs air from the compressor into the chamber.

WO 2013/113038 A1

HEAT EXCHANGER

BACKGROUND

[0001] This application relates to a cooler for use in a gas turbine engine.

[0002] Gas turbine engines are known, and typically include a fan delivering air into a compressor. The air is compressed and passed into a combustion section. From the combustion section, the air is mixed with fuel and ignited, and then passes over turbine rotors.

[0003] A number of accessories are associated with gas turbine engines. As an example, a generator generates electricity. Various fluid supply systems such as oil supply, fuel supply, etc. deliver fluids around the gas turbine engine. Many of these accessories require some degree of cooling and may receive lubricant, which also requires cooling. Thus, there are a number of heat exchangers in a gas turbine engine.

[0004] Typically, so-called air-to-fluid heat exchangers have been placed in a location where a single source of air will pass over the heat exchanger.

[0005] As one example, a heat exchanger may be placed in a bypass air duct, such that cooling air being driven by the fan will pass across the heat exchanger.

[0006] Alternatively, heat exchangers have been placed in other locations where air may be driven through the gas turbine engine.

[0007] The current known location for such heat exchangers have resulted in unduly large heat exchangers.

SUMMARY

[0008] In a featured embodiment, a gas turbine engine has a fan, a compressor section, a combustor, and a turbine section. The fan delivers a portion of air into the compressor, and a portion of air into a duct, as bypass air. A bleed air system bleeds a quantity of air from the compressor into a chamber at least at low power conditions of the engine. The bleed air system has an opening that may be selectively closed to block bleed air, or opened to allow bleed flow from the compressor to the chamber. A heat exchanger has fluid containing passages to be cooled. The heat exchanger is positioned such that a first surface is contacted by bypass air in the duct, and a second surface is contacted by bleed air when the system is directing air from the compressor into the chamber.

[0009] In a further embodiment according to the previous embodiment, fins are formed on the first surface of the heat exchanger extending into the bypass air flow.

[0010] In a further embodiment according to the previous embodiment, fins are also formed on the second surface of the heat exchanger and extend toward the bleed air flow.

[0011] In a further embodiment according to the previous embodiment, the fins on the second surface extend for a greater height away from the fluid containing passages than do the fins on the first surface.

[0012] In a further embodiment according to the previous embodiment, the fins on the first surface extend for a greater length along a flow path of the bypass air than do the fins on the second surface.

[0013] In a further embodiment according to the previous embodiment, the heat exchanger selectively cools a fluid associated with a generator for the gas turbine engine.

[0014] In another featured embodiment, a gas turbine engine has a heat exchanger with a first convective cooling feature and a second convective cooling feature. The first convective cooling feature is disposed at least partially in fluid communication with a bypass air flow of the engine, wherein the second convective cooling feature is disposed at least partially in a bleed air chamber of the engine.

[0015] In a further embodiment according to the previous embodiment, a selectively controllable valve controls bleed air flow from a compressor of the engine to the bleed air chamber.

[0016] These and other features may be best understood from the following drawings and specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Figure 1 schematically shows a gas turbine engine.

[0018] Figure 2 schematically shows an oil cooling system for an accessory in a gas turbine engine.

[0019] Figure 3 shows the location of a heat exchanger.

DETAILED DESCRIPTION

[0020] Figure 1 schematically illustrates a gas turbine engine 20. The gas turbine engine 20 is disclosed herein as a two-spool turbofan that generally incorporates a fan section 22, a compressor section 24, a combustor section 26 and a turbine section 28. Alternative engines might include an augmentor section (not shown) among other systems or features. The fan section 22 drives air along a bypass flowpath while the compressor section 24 drives air along a core flowpath for compression and communication into the combustor section 26 then expansion through the turbine section 28. Although depicted as a turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with turbofans as the teachings may be applied to other types of turbine engines including three-spool architectures.

[0021] The engine 20 generally includes a low speed spool 30 and a high speed spool 32 mounted for rotation about an engine central longitudinal axis A relative to an engine static structure 36 via several bearing systems 38. It should be understood that various bearing systems 38 at various locations may alternatively or additionally be provided.

[0022] The low speed spool 30 generally includes an inner shaft 40 that interconnects a fan 42, a low pressure compressor 44 and a low pressure turbine 46. The inner shaft 40 is connected to the fan 42 through a geared architecture 48 to drive the fan 42 at a lower speed than the low speed spool 30. The high speed spool 32 includes an outer shaft 50 that interconnects a high pressure compressor 52 and high pressure turbine 54. A combustor 56 is arranged between the high pressure compressor 52 and the high pressure turbine 54. A mid-turbine frame 57 of the engine static structure 36 is arranged generally between the high pressure turbine 54 and the low pressure turbine 46. The mid-turbine frame 57 further supports bearing systems 38 in the turbine section 28. The inner shaft 40 and the outer shaft 50 are concentric and rotate via bearing systems 38 about the engine central longitudinal axis A which is collinear with their longitudinal axes.

[0023] The core airflow is compressed by the low pressure compressor 44 then the high pressure compressor 52, mixed and burned with fuel in the combustor 56, then expanded over the high pressure turbine 54 and low pressure turbine 46. The mid-turbine frame 57 includes airfoils 59 which are in the core airflow path. The turbines 46, 54 rotationally drive the respective low speed spool 30 and high speed spool 32 in response to the expansion.

[0024] The engine 20 in one example is a high-bypass geared aircraft engine. In a further example, the engine 20 bypass ratio is greater than about six (6), with an example embodiment being greater than a ratio of approximately 10:1, the geared architecture 48 is an epicyclic gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3:1 and the low pressure turbine 46 has a pressure ratio that is greater than about 5:1. In one disclosed embodiment, the engine 20 bypass ratio is greater than about 10:1, the fan diameter is significantly larger than that of the low pressure compressor 44, and the low pressure turbine 46 has a pressure ratio that is greater than about 5:1. Low pressure turbine 46 pressure ratio is pressure measured prior to inlet of low pressure turbine 46 as related to the pressure at the outlet of the low pressure turbine 46 prior to an exhaust nozzle. The geared architecture 48 may be an epicycle gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.5:1. It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine is applicable to other gas turbine engines including direct drive turbofans.

[0025] A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section 22 of the engine 20 is designed for a particular flight condition -- typically cruise at about 0.8 Mach and about 35,000 feet. The flight condition of 0.8 Mach and 35,000 ft, with the engine at its best fuel consumption - also known as “bucket cruise Thrust Specific Fuel Consumption (‘TSFC’)” - is the industry standard parameter of lbm of fuel being burned divided by lbf of thrust the engine produces at that minimum point.

[0026] To make an accurate comparison of fuel consumption between engines, fuel consumption is reduced to a common denominator, which is applicable to all types and sizes of turbojets and turbofans. The term is thrust specific fuel consumption, or TSFC. This is an engine's fuel consumption in pounds per hour divided by the net thrust. The result is the amount of fuel required to produce one pound of thrust. The TSFC unit is pounds per hour per pounds of thrust (lb/hr/lb Fn). When it is obvious that the reference is to a turbojet or turbofan engine, TSFC is often simply called specific fuel consumption, or SFC.

[0027] “Low fan pressure ratio” is the pressure ratio across the fan blade alone, without a Fan Exit Guide Vane (“FEGV”) system. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.45. “Low corrected fan tip speed” is the actual fan tip speed in ft/sec divided by an industry standard temperature

correction of $[(T_{\text{ambient deg R}}) / 518.7]^{0.5}$. The “Low corrected fan tip speed” as disclosed herein according to one non-limiting embodiment is less than about 1150 ft / second.

[0028] This application relates to a heat exchanger in such a gas turbine engine which utilizes cooling air from two distinct sources such that the heat exchanger may be made smaller than the prior art.

[0029] Figure 2 shows a circuit for cooling oil such as may be associated with an accessory 152. In one example, accessory 152 may be a generator. Hot oil leaves the generator 152 after cooling the generator, and enters an inlet 156 associated with a heat exchanger 154. The oil passes through a series of passages 155 from the inlet manifold, to an outlet manifold, and then the outlet 158 of the heat exchanger. This oil is then returned to the generator 152, having been cooled by air.

[0030] Figure 3 shows a location for the heat exchanger 154. The location may be approximately at area X as shown in Figure 1. As shown, the heat exchanger 154 is located such that one side has convective cooling features 160 that are disposed at least partially within the duct 100 that is in fluid communication with bypass airflow B (see Fig. 1). The convective cooling features 160 may be fins, pins, projections, ribs, etc. The features 160 provide surface area for convective cooling. These features 160 may be relatively small, as they will extend into the bypass air flow, and it may be desirable to limit obstruction to this flow. The size and geometry of the features 160 may be optimized to consider both the weight of the heat exchanger, drag within the bypass air flow, and convective cooling magnitude.

[0031] The opposed side of the heat exchanger 154 has features 162 which tend are disposed at least partially within a bleed air supply chamber 200.

[0032] As known, under bleed conditions, bleed air is air downstream of a compressor rotor 164 (which may be part of the low pressure compressor 44, see Figure 1) that is diverted out of the core engine flow and into the chamber 200. This typically occurs at low power conditions, and serve to reduce the load of downstream compressor stages, and the rest of the engine by not driving unnecessary air through the engine. This may occur while the aircraft is idling on the ground, as an example.

[0033] The heat exchanger 154 is located such that the features 162 are in fluid communication with the bleed air flow. The size and geometry of the features 162 may be

optimized to consider both the weight of the heat exchanger, drag within the bleed air flow, and convective cooling magnitude. These low pressure conditions are also coincidentally a most challenging time for the heat exchanger 154 to be adequately cooled by the bypass air alone in duct 100. As an example, there may be a limited amount of bypass air under those conditions. In the past, the heat exchangers cooled by bypass air have been necessarily unduly large, as they must still adequately cool the fluid even under the low power conditions.

[0034] The features 160 extend away from a surface of the heat exchanger 154 for a lesser distance than the features 162 extend away from the opposed surface. This is because the features 160 extend into the bypass air flow, and as mentioned above, it would be desirable to limit their height.

[0035] On the other hand, the features 160 may extend for a greater distance along a flow path of the bypass air B than do the features 162. This is generally as illustrated in Figure 3.

[0036] In one embodiment, the features 160 extend away from a surface of the heat exchanger for .40" (1.02 cm), and extend along the path of the bypass air flow B for 6" (15.2 cm). In this same embodiment, the features 162 extend away from the surface for .5" (1.27 cm), and extend along the flow path for 4" (10.2 cm).

[0037] As is known, a mechanism 68 can selectively close off the passage 166 and block further bleed air flow. Examples of mechanisms include valves and gates that may be mechanically and/or electromechanically controlled. This occurs as the engine moves more toward full power operation. However, under those conditions, the bypass airflow will be greatly increased in volume, and should adequately cool the fluid in the heat exchanger 154 on its own.

[0038] Although an embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this disclosure. For that reason, the following claims should be studied to determine the true scope and content of this disclosure.

CLAIMS

1. A gas turbine engine comprising:
 - a fan, a compressor section, a combustor, and a turbine section, said fan delivering a portion of air into said compressor, and said fan delivering a portion of air into a duct, as bypass air;
 - a bleed air system for bleeding a quantity of air from the compressor into a chamber at at least low power conditions of the engine, said bleed air system having an opening which may be selectively closed to block bleed air, or opened to allow bleed flow from the compressor to the chamber; and
 - a heat exchanger having fluid containing passages to be cooled, said heat exchanger positioned such that a first surface of said heat exchanger is contacted by bypass air in the duct, and a second surface of said heat exchanger is contacted by bleed air when said bleed air system is directing air from the compressor into the chamber.
2. The gas turbine engine as set forth in claim 1, wherein fins are formed on said first surface of said heat exchanger extending into the bypass air flow.
3. The gas turbine engine as set forth in claim 2, wherein fins are also formed on said second surface of said heat exchanger and extend toward the bleed air flow.
4. The gas turbine engine as set forth in claim 3, wherein said fins on said second surface extend for a greater height away from the fluid containing passages than do said fins on said first surface.
5. The gas turbine engine as set forth in claim 4, wherein said fins on said first surface extend for a greater length along a flow path of the bypass air than do the fins on said second surface.
6. The gas turbine engine as set forth in claim 1, wherein said heat exchanger selectively cools a fluid associated with a generator for the gas turbine engine.

7. A gas turbine engine comprising:
a heat exchanger having a first convective cooling feature and a second convective cooling feature, wherein the first convective cooling feature is disposed at least partially in fluid communication with a bypass air flow of the engine, wherein the second convective cooling feature is disposed at least partially in a bleed air chamber of the engine.

8. The engine of claim 7, further comprising a selectively controllable valve that controls bleed air flow from a compressor of the engine to the bleed air chamber.

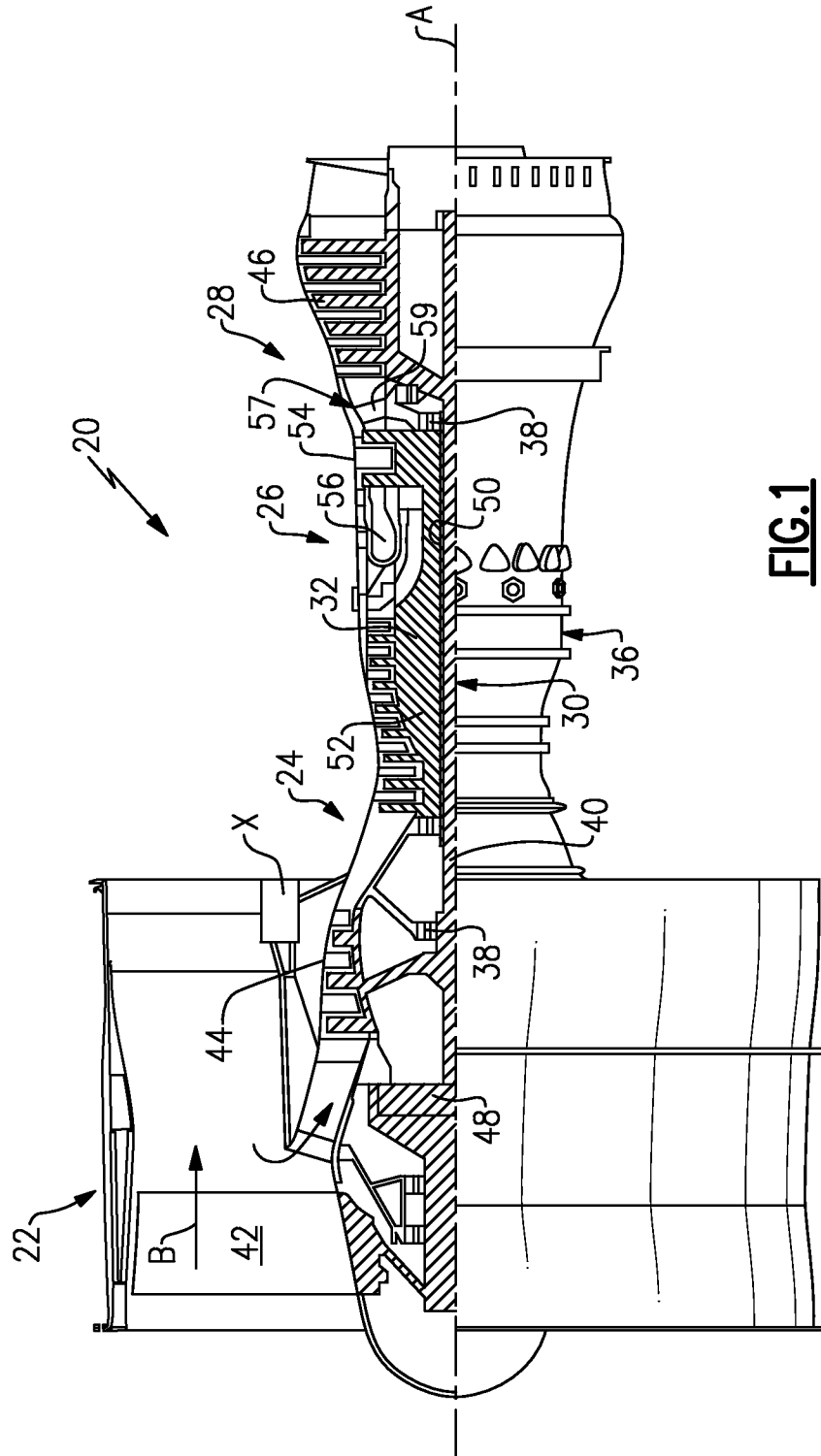


FIG. 1

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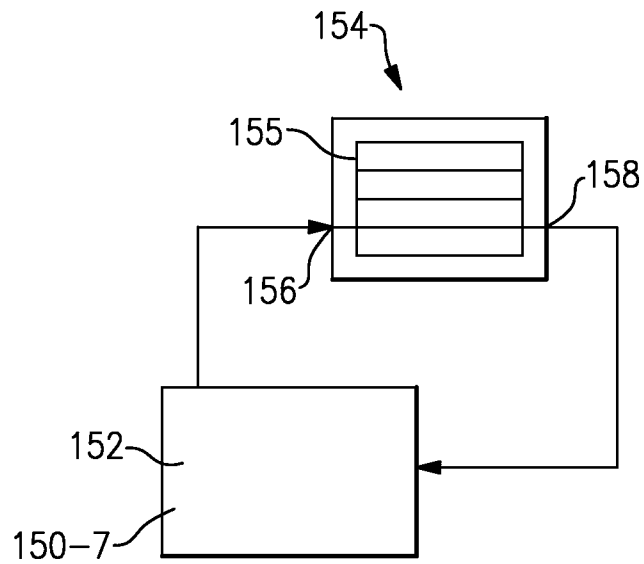


FIG.2

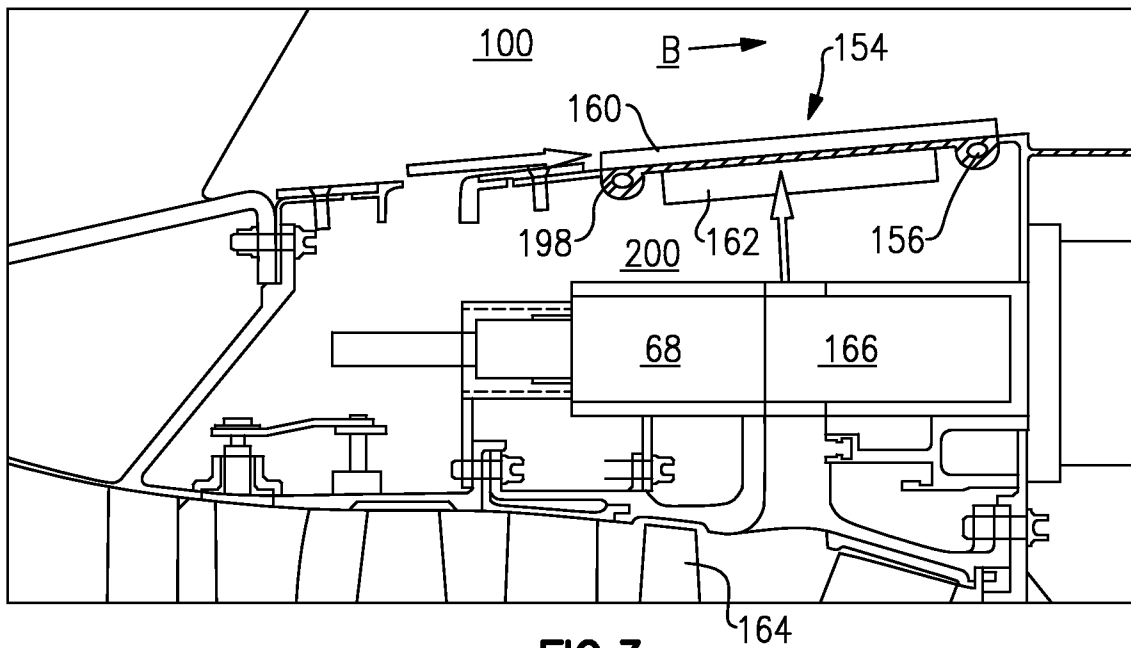


FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/023577**A. CLASSIFICATION OF SUBJECT MATTER***F02C 7/14(2006.01)i, F02C 7/04(2006.01)i, F01D 25/12(2006.01)i*

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)

F02C 7/14; F02C 7/12; F02C 7/18; F02K 3/04; F01D 11/24; F02K 3/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: gas, turbine, heat exchanger, bleed, bypass, air, and fin

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010-0139288 A1 (RAGO, GUISEPPE) 10 June 2010	7
Y	See abstract; paragraphs [0013],[0015],[0016],[0020]; figures 1-3.	1-6,8
Y	US 5,297,386 A (KERVISTIN, ROBERT) 29 March 1994 See abstract; column 2 line 62 - column 3 line 30; figure 1.	1-6,8
A	US 2008-0053060 A1 (OLVER, BRYAN) 06 March 2008 See abstract; paragraphs [0018],[0025]; figures 1,2.	1-8
A	US 2011-0088405 A1 (TURCO, JOHN BIAGIO) 21 April 2011 See abstract; paragraphs [0023],[0025],[0026]; figures 1,2.	1-8
A	US 5,269,133 A (WALLACE, THOMAS T.) 14 December 1993 See abstract; column 3 lines 38-57; figure 1.	1-8

 Further documents are listed in the continuation of Box C. 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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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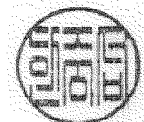
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INTERNATIONAL SEARCH REPORT

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