



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
08.07.2015 Bulletin 2015/28

(51) Int Cl.:
F02C 7/24 (2006.01) **F01D 25/00** (2006.01)
F01D 25/30 (2006.01) **F02C 7/00** (2006.01)

(21) Application number: **13833779.5**

(86) International application number:
PCT/JP2013/072820

(22) Date of filing: **27.08.2013**

(87) International publication number:
WO 2014/034643 (06.03.2014 Gazette 2014/10)

(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

(72) Inventors:
• **YAMASAKI, Yoshihiro**
Akashi-shi
Hyogo 673-8666 (JP)
• **HOSOKAWA, Yasufumi**
Akashi-shi
Hyogo 673-8666 (JP)

(30) Priority: **29.08.2012 JP 2012188346**

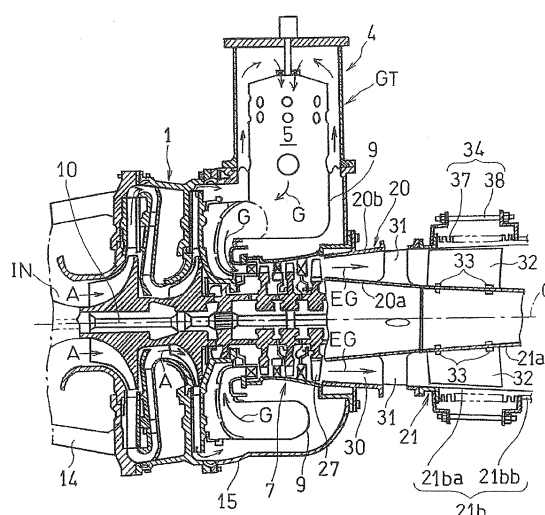
(74) Representative: **Von Kreisler Selting Werner - Partnerschaft**
von Patentanwälten und Rechtsanwälten mbB
Deichmannhaus am Dom
Bahnhofsvorplatz 1
50667 Köln (DE)

(71) Applicant: **Kawasaki Jukogyo Kabushiki Kaisha**
Kobe-shi, Hyogo 650-8670 (JP)

(54) **GAS TURBINE DEVICE**

(57) A gas turbine device in which the low frequency vibrations or the low frequency noises during the low load operation can be effectively suppressed with no increase of the pressure loss of the exhaust gas being triggered includes a gas turbine engine provided with an exhaust diffuser forming an upstream portion of an exhaust gas passage, an exhaust strut provided in the diffuser (20), and a swirling flow blocking plate. The swirling flow blocking plate is disposed on a downstream side of the exhaust strut in the exhaust gas passage so as to extend in an axial direction.

Fig. 2



Description

CROSS REFERENCE TO THE RELATED APPLICATION

[0001] This application is based on and claims Convention priority to Japanese patent application No. 2012-188346, filed August 29, 2012, the entire disclosure of which is herein incorporated by reference as a part of this application.

BACKGROUND OF THE INVENTION

(Field of the Invention)

[0002] The present invention relates to a gas turbine device for driving a power machinery such as, for example, an electric generator by means of a gas turbine engine.

(Description of Related Art)

[0003] The gas turbine device is generally apt to generate considerable high frequency noises, but those high frequency noises can be effectively reduced with, for example, the use of a packaging utilizing an enclosure and/or the use of an induction and exhaust silencer. In contrast thereto, low frequency noises also generated from the gas turbine device are difficult to reduce. This aspect of the gas turbine device will now be discussed with particular reference to Figs. 5 and 6 of the accompanying drawings.

[0004] In the gas turbine device, the flow velocity of exhaust gas discharged from the final stage rotor vane of the gas turbine engine is generally within a relatively high speed range of 300 to 400 m/sec. Therefore, in order to improve the performance, the flow velocity of the exhaust gas is reduced by causing the exhaust gas to flow through a long exhaust diffuser DF to thereby reduce the dynamic pressure of the exhaust gas so that the exhaust gas may regain the static pressure. The exhaust diffuser DF referred to above includes, as shown in Figs. 5 and 6, an inner tube 28 and an outer tube (not shown) disposed around the inner tube 28 so as to enclose the inner tube 28, with an exhaust gas passage being defined between it and the inner tube 28 for the passage there-through of the exhaust gas discharged from the turbine final stage rotor vane.

[0005] Also, the exhaust gas passage referred to above is provided with a plurality of exhaust struts 31 disposed circumferentially thereof for the support of the inner tube 28 and, also, for the supply of a lubricant oil. In this respect, see the patent document 1 listed below. Each of the exhaust strut 31 is of a flattened oval-sectioned shape and is so disposed with its longitudinal axis oriented in an axial direction C of the exhaust diffuser DF so that it will not constitute a considerable flow resistance to the flow of the exhaust gas.

[0006] In the meantime, in order to increase the performance of the exhaust diffuser DF, the standard gas turbine engine has been so designed as to achieve the flow in the axial direction C during the rated operation (full load operation). In other words, during the rated operation, as shown in Fig. 5, the vector V of the exhaust gas absolute flow (true flow), which is a composite of the vector V1 of the turbine rotational direction and the vector V2 of the relative flow velocity of the exhaust gas from the turbine final stage rotor vane, comes to lie in a direction substantially parallel to the axial direction C. The exhaust gas flow S1 in this state will become that in which vortexes generated at a downstream side site of the direction of flow of the exhaust gas in the exhaust struts 31 has been suppressed.

[0007] On the other hand, at the low load operation of the gas turbine engine, particularly during the non-load operation thereof, where the power machinery is an electric generator and the gas turbine engine is driven at the constant rotational speed at all times, as shown in Fig. 6, the vector V1 of the turbine rotational direction becomes the same as that during the rated operation, but the vector V2 of the relative flow of the exhaust gas from the final stage rotor vane becomes shorter because of reduction of the flow velocity of the exhaust gas. For this reason, the vector V of the exhaust gas absolute flow, which is the composite of the vector V1 of the turbine rotational direction and the vector V2 of the relative flow velocity of the exhaust gas, comes to incline at a large angle relative to the axial direction C and thus the exhaust gas will form a swirling flow and then flows within the exhaust gas passage. By the effect of the exhaust gas flow S2 which has been so inclined, strong vortexes Vr are generated on downstream side in the direction of the flow of the exhaust gas in each of the exhaust struts 31.

[0008] In the event that the strong vortexes so generated in the manner described above is, after having flown towards a downstream side along with the swirling flow of the exhaust gas, broken down by self-excited oscillation or exfoliation thereof, a low frequency noise or a low frequency vibration, which is generally referred to as vortex whistle, is generated. The frequency of this vortex whistle is proportional to the flow of the exhaust gas or the swirling velocity and does not depend on the axial length of the exhaust diffuser.

[Prior Art Document]

[Patent Document]

[0009] Patent Document 1: JP Laid-open Patent Publication No. 2011-226651

SUMMARY OF THE INVENTION

[0010] Generation of the low frequency vibrations or the low frequency noises, which is referred to as the vortex whistle, during the low load operation of the gas turbine engine.

bine engine of the type discussed above results from the reduction in number of the exhaust struts 31 for the purpose of reducing the exhaust pressure loss that is aimed in recent years. For example, while about eight to ten exhaust struts 31 has hitherto been installed, the recent trend is to employ four to six exhaust struts disposed equidistantly in the circumferential direction as shown in Figs. 4 and 5. Reducing the number of the exhaust struts 31 installed as discussed above may result in that the swirling flow of the exhaust gas moves directly through a large space between the neighboring exhaust struts 31 to thereby form a stream S2 of the exhaust gas then swirling together with intensive vortexes. Accordingly, if a large number of the exhaust struts 31 are used as is the case with the conventional art, the swirling of the exhaust gas can be prevented by the exhaust struts 31 to a certain extent, but the pressure loss of the exhaust gas will then increase.

[0011] In view of the foregoing, the present invention has for its object to provide a gas turbine device in which the low frequency vibrations or the low frequency noises during the low load operation can be effectively suppressed with no increase of the pressure loss of the exhaust gas being triggered.

[0012] In order to accomplish the foregoing object, a gas turbine device according to the present invention includes a gas turbine engine provided with an exhaust diffuser forming an upstream portion of an exhaust gas passage; an exhaust strut provided in the exhaust diffuser; and a swirling flow blocking plate disposed on a downstream side of the exhaust strut in the exhaust gas passage and extending in an axial direction.

[0013] Particularly when the number of the exhaust struts installed is set to be small, a swirling flow of the exhaust gas will be generated during a period in which the gas turbine engine is under the low load operation. The swirling flow of the exhaust gas referred to does, after having flowed towards a downstream side through a space delimited by the neighboring exhaust struts that are spaced a large distance from each other, impinge upon the swirling flow blocking plate, which extends in an axial direction on the downstream side of the exhaust struts, with the swirling of the exhaust gas consequently blocked and is then forcibly deflected so as to flow in the axial direction. Accordingly, since although generation of vortexes of the exhaust gas, which takes place in a downstream side site of the exhaust strut, cannot be suppressed, the swirling flow of the exhaust gas effective to flow those vortexes towards the downstream side can be suppressed, instability (fluctuation of vortex centers) resulting from a swirling velocity distribution disappears and the occurrence of self-induced oscillation and exfoliation of the vortexes are suppressed, wherefore generation of the low frequency vibration or the low frequency noise, which is an abnormal noise generally referred to as the vortex whistle, can be effectively suppressed. Also, since the swirling flow blocking plate is disposed on a downstream side of the exhaust strut at which the flow

velocity of the exhaust gas is lowered, and pressure loss of the exhaust gas can be further reduced from this standpoint.

[0014] In one embodiment of the present invention, a plurality of the exhaust struts spaced from each other in a circumferential direction may be employed, and the swirling flow blocking plate may be disposed at a position circumferentially intermediate between the neighboring exhaust struts. According to this structure, the swirling flow of the exhaust gas having passed through the space delimited between the neighboring exhaust struts can be further effectively deflected by the swirling flow blocking plate with the swirl thereof being consequently suppressed.

[0015] In one embodiment of the present invention, the swirling flow blocking plate may have an axial length that is greater than an axial length of the exhaust strut. Specifically, the axial length of the swirling flow blocking plate may be within the range of 2 to 4 times the axial length of the exhaust strut. According to this structure, not only can the pressure loss of the exhaust gas be reduced with the exhaust strut reduced in length, but also the swirling of the exhaust gas can be effectively suppressed in the presence of the long swirling flow blocking plate.

[0016] In one embodiment of the present invention, the four to six exhaust struts, which are spaced from each other in the circumferential direction, may be employed. When the number of the exhaust struts is so reduced, the resistance in the exhaust gas passage is reduced to allow the exhaust pressure loss to be reduced.

[0017] In one embodiment of the present invention, the exhaust diffuser may include an inner casing and an outer casing disposed coaxially with each other, and the inner casing and the outer casing may be connected with each other through the exhaust struts. By so doing, the diffuser which is robust in structure can be obtained.

[0018] In one embodiment of the present invention, the gas turbine device of the present invention may also include an exhaust duct fluidly connected on a downstream side of the exhaust diffuser and comprising inner and outer tubes which are disposed coaxially with each other. In this case, the swirling flow blocking plate is fitted to the inner tube with a gap existing between the outer tube and the swirling flow blocking plate at least at a cold time. According to this structural feature, since the swirling flow blocking plate is supported by the inner tube in the cantilevered fashion, the thermal strain of the swirling flow blocking plate brought about by thermal expansion of the inner tube, which would occur when the swirling flow blocking plate is supported with its opposite ends connected respectively with the inner tube and the outer tube so as to bridge therebetween, does not occur.

[0019] Where the swirling flow blocking plate is fixed to the inner tube, the swirling flow blocking plate may include a set of two plate members overlapped with each other and may be fixed to the inner tube with respective mounting portions at inner diametric ends of the plate members being curved in respective directions opposite

to each other. According to this structure, since the swirling flow blocking plate can be employed in the form of thin plates that are prepared by a sheet metal processing, the pressure loss of the exhaust gas can be advantageously reduced as compared with the exhaust strut. Also, not only does the swirling flow blocking plate have a sufficient strength despite of the fact that it has a simplified structure in which two plate members are overlapped with each other, but also the undesirable increase of the weight and cost can be suppressed. Yet, in the event of the occurrence of the thermal strain in the swirling flow blocking plate, the mounting portion of the curved shape described hereinbefore undergoes a thermal strain to thereby absorb the above described thermal strain, thereby suppressing the undesirable increase of the radial dimension of the swirling flow blocking plate.

[0020] Any combination of at least two constructions, disclosed in the appended claims and/or the specification and/or the accompanying drawings should be construed as included within the scope of the present invention. In particular, any combination of two or more of the appended claims should be equally construed as included within the scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] In any event, the present invention will become more clearly understood from the following description of embodiments thereof, when taken in conjunction with the accompanying drawings. However, the embodiments and the drawings are given only for the purpose of illustration and explanation, and are not to be taken as limiting the scope of the present invention in any way whatsoever, which scope is to be determined by the appended claims. In the accompanying drawings, like reference numerals are used to denote like parts throughout the several views, and:

Fig. 1 is a schematic side view showing the entire construction of a gas turbine device according to one embodiment of the present invention;

Fig. 2 is a longitudinal sectional view showing a gas turbine engine and an exhaust diffuser both employed in the gas turbine device;

Fig. 3 is a rear view showing the exhaust diffuser;

Fig. 4 is a perspective view showing the flow of exhaust gas in the embodiment;

Fig. 5 is a perspective view showing the flow of the exhaust gas during the rated operation of the gas turbine engine; and

Fig. 6 is a perspective view showing the flow of the exhaust gas during the low load operation of the gas turbine engine.

DESCRIPTION OF EMBODIMENTS

[0022] Hereinafter, an embodiment of the present invention will be described in detail with reference to the

accompanying drawings. In particular as shown in Fig. 1, a reduction gear unit 12 having a large weight is fixedly placed on a foundation bed 13, and a gas turbine engine GT is supported by the reduction gear unit 12 in a cantilevered manner through a plurality of, for example, four stays 14. The reduction gear unit 12 has a connecting shaft on an input side drivingly connected with a rotary shaft 10 of the gas turbine engine GT and also has a connecting shaft 17 on an output side connected with a drive shaft 18 of an electric generator 11, which forms a load of the gas turbine engine GT, through a coupling 19. An exhaust gas EG discharged substantially horizontally from the gas turbine engine GT is guided into an exhaust chamber 22 through an exhaust diffuser 20 and an exhaust duct 21, subsequently deflected in a substantially vertical direction so as to flow into a silencer 24 positioned thereabove and then finally discharged to the outside after having been silenced by the silencer 24. The exhaust chamber 22 has a guide plate 23 for deflecting the exhaust gas EG so as to flow upwardly.

[0023] Referring now to Fig. 2, the gas turbine engine GT includes a two-staged centrifugal compressor 1 for compressing an air A sucked thereinto through an air inflow port IN, a combustor 4 for combusting an air/fuel mixture formed by supplying fuel into the air A which has been compressed, and a turbine 7 driven by a combustion gas G. The compressor 1 and the turbine 7 are accommodated within a housing 15, and the combustor 4 is mounted to the housing 15 so as to protrude upwardly. A combustion gas G, generated within a combustion chamber 5 defined in the combustor 4, is, after having been guided into the turbine 7 through a scroll 9, used to rotate the turbine 7 to eventually drive the two-staged centrifugal compressor 1, which is drivingly connected with the turbine 7 through the rotary shaft 10, and the electric generator 11 through the reduction gear unit 12 best shown in Fig. 1.

[0024] The exhaust gas EG discharged from the final stage rotor vane 27 of the turbine 7 is guided to an exhaust gas passage 30 of an annular shape defined between an inner casing 20a and an outer casing 20b, which form respective parts of the exhaust diffuser 20. The outer casing 20b is fixed to the housing 15. The inner casing 20a is supported by the outer casing 20b through radially extending four exhaust struts 31 that are spaced circumferentially equidistantly, say, 90° from each other. In this way, the inner casing 20a of a tubular shape and the outer casing 20b of a tubular shape, which are disposed coaxially relative to each other, are connected together through the exhaust struts 31 to thereby form the exhaust diffuser 20 of a robust structure.

[0025] The exhaust duct 21 is fluidly connected with a downstream end of the exhaust diffuser 20. The exhaust duct 21 is provided with a swirling flow blocking plate 32, which is fixed to the exhaust duct 21 by means of a fastening member 33 such as, for example, bolts and nuts, and is so formed as to extend in a direction along the

axial direction C to represent a rectangular thin plate. The exhaust duct 21 includes an inner tube 21 a and an outer tube 21b which cooperatively define the exhaust gas passage 30 therebetween. Thus, the exhaust diffuser 20 forms an upstream portion of the exhaust gas passage 30 of an annular shape and the exhaust duct 21 forms a downstream portion of the exhaust gas passage 30 of the annular shape. The exhaust chamber 22 and the silencer 24, both best shown in Fig. 1, cooperate with each other to define a substantially rectangular sectioned exhaust gas passage 30A, which is in communication with a downstream region of the exhaust gas passage 30.

[0026] An upstream region 21ba of the outer tube 21b, as shown in Fig. 2, which confronts the swirling flow blocking plate 32, is configured to move relative to a downstream region 21 bb thereof in the axial direction C by means of a thermal expansion absorbing mechanism 34. The thermal expansion absorbing mechanism 34 includes a bellows-shaped expandable tubular body 37 which is expandable in a direction parallel to the axial direction, and an adjustment bolt 38 for limiting the stroke of expansion of the upstream region 21ba. With the use of the thermal expansion absorbing mechanism 34, the thermal expansion of the outer tube 21b by the effect of the exhaust gas EG can be absorbed.

[0027] Fig. 3 is a rear view of the exhaust diffuser 20 as viewed from the right side of Fig. 2 that corresponds to the rear of the diffuser 20. The swirling flow blocking plate 32 is disposed at a position circumferentially intermediate between the neighboring two struts of the four exhaust struts 31, which are spaced 90° from each other in the circumferential direction, so as to extend radially, and is fixed to the inner tube 21 a by means of the fastening member 33. Each swirling preventive plate 32 includes a set of two plate members 39 and 40 overlapped with each other to represent a symmetrical shape with respect to a mid center plane passing through the longitudinal axis of the exhaust gas passage 30. In other words, the swirling flow blocking plate 32 is so structured that respective blocking plate portions 30a and 40a of the plate members 39 and 40 are overlapped in tightly contact with each other while respective mounting portions 39b and 40b of respective inner diametric ends of the plate members 39 and 40 are so curved as to extend in respective directions opposite to each other, in which the mounting portions 39b and 40b are in turn fixed to the inner tube 21 a by means of the fastening member 33.

[0028] The fastening member 33 is disposed at two locations on the swirling flow blocking plate 32 that are spaced from each other in the axial direction C. A small gap is defined between a radially outer end of the swirling flow blocking plate 32 and an inner surface of the outer tube 21b at least under a cold state, which occurs during the stop of the engine. Accordingly, the swirling flow blocking plate 32 is supported in a cantilevered fashion by the inner tube 21a.

[0029] Since in the gas turbine device of the structure hereinbefore described the number of the exhaust struts

31 installed is set to four, which is a small number, the exhaust gas pressure loss brought about by a passage resistance can be suppressed, but on the other hand, as shown in and described with particular reference to Fig. 4, the swirling flow TS of the exhaust gas EG occurs during the low load operation of the gas turbine engine GT. The swirling flow TS impinges upon the swirling flow blocking plate 32 at the downstream side of the exhaust strut 31 with the swirling blocked consequently, and is therefore forcibly deflected to form a flow S directed along the axial direction C. Accordingly, since although generation of vortexes of the exhaust gas GT at the downstream side of the exhaust strut 31 cannot be suppressed completely, the swirling flow TS of the exhaust gas EG which tends to cause the vortexes to flow towards the downstream side can be suppressed. As a result thereof, instability (fluctuation of vortex centers) resulting from a swirling velocity distribution disappears and the occurrence of self-induced oscillation of the vortexes is suppressed, whereby generation of the low frequency vibration or the low frequency noise, which is an abnormal noise generally referred to as the vortex whistle, can be suppressed effectively.

[0030] While the vortex whistle referred to previously may often records the peak value at a few tens Hz, the result of actual measurement has affirmed that the use of the swirling flow blocking plate 32 reduces the peak value by a value higher than 10 dB. Accordingly, it has been found that the mere use of the swirling flow blocking plate 32 is effective to prevent the generation of the low frequency vibration or the low frequency noise with a simplified construction.

[0031] It is, however, to be noted that in order to secure the effect of generation suppression of such low frequency noise or low frequency vibration, both discussed above, the length L2 of the swirling flow blocking plate 32 in the axial direction C may be greater than the length L1 of the exhaust strut 31 in the axial direction. In particular, the length L2 of the swirling flow blocking plate 32 in the axial direction C may be more preferably set to a value within the range of two to four times the length L1 of the exhaust strut 31 in the axial direction C. If it is smaller than the two times, the deflecting effect achieved by the swirling flow blocking plate 32 will be insufficient, and if it exceeds the four times, the frictional loss of the exhaust gas EG brought about by the swirling flow blocking plate 32 will become excessive. The exhaust strut 31 is a reinforcing member for connecting the inner casing 20a and the outer casing 20b together and its radial length (height) H1 is within the range of about 1.0 to 2.0 times the axial length L1.

[0032] Also, while the exhaust strut 31 is generally made of casting, the swirling flow blocking plate 32 is formed by means of a sheet metal processing and, therefore, not only can the pressure loss of the exhaust gas EG, when the thickness thereof is reduced, be markedly reduced as compared with the exhaust strut 31, but the undesirable increase of the weight and cost can also be

suppressed. Also, since the swirling flow blocking plate 32 is disposed on the downstream side of the exhaust strut 32 at which the flow velocity of the exhaust gas EG is lowered, the pressure loss of the exhaust gas EG can further be reduced from this standpoint.

[0033] In addition, since the swirling flow blocking plate 32 is of the structure in which the set of the two plate members 39 and 40 best shown in Fig. 3 are overlapped with each other and are then fixed, not only does the swirling flow blocking plate 32 have a sufficient strength despite of the fact that they are prepared from thin plates, but in the event of the occurrence of thermal strain in the swirling flow blocking plate 32 under the influence of the high temperature of the exhaust gas EG, the curved mounting portions 39b and 40b of the plate members 39 and 40 are thermally deformed to absorb the previously described thermal strain and, therefore, the radial dimension of the swirling flow blocking plate 32 can be maintained substantially constant. Yet, since the swirling flow blocking plate 32 is supported by the inner tube 21a in the cantilevered fashion, the thermal strain brought about by thermal expansion of each of the inner tube 21a and the outer tube 21b, which would occur when the swirling flow blocking plate is supported with its opposite ends connected respectively with the inner tube 21a and the outer tube 21b so as to bridge therebetween, does not occur.

[0034] In describing the foregoing embodiment, the swirling flow blocking plate 32 has been shown and described as supported by the inner tube 21a in the cantilevered fashion, but the present invention is not necessarily limited thereto and effects similar to those afforded by the previously described embodiment can be appreciated even when the swirling flow blocking plate 32 is supported by the outer tube 21b in the cantilevered fashion.

[0035] The present invention may be implemented based on the aforementioned embodiments with various addition, modification and/or omission made thereupon as long as they are encompassed within the concept of the present invention.

[0036] Although the present invention has been fully described in connection with the embodiments thereof with reference to the accompanying drawings which are used only for the purpose of illustration, those skilled in the art will readily conceive numerous changes and modifications within the framework of obviousness upon the reading of the specification herein presented of the present invention. Accordingly, such changes and modifications are, unless they depart from the scope of the present invention as delivered from the claims annexed hereto, to be construed as included therein.

[Reference Numerals]

[0037]

20 Exhaust diffuser

20a Inner casing
20b Outer casing
30 Exhaust gas passage
31 Exhaust strut
5 32 Swirling flow blocking plate
GT Gas turbine engine
C Axial direction

10 Claims

1. A gas turbine device comprising:

a gas turbine engine provided with an exhaust diffuser forming an upstream portion of an exhaust gas passage;
an exhaust strut provided in the exhaust diffuser; and
a swirling flow blocking plate disposed on a downstream side of the exhaust strut in the exhaust gas passage and extending in an axial direction.

2. The gas turbine device as claimed in claim 1, wherein a plurality of the exhaust struts spaced from each other in a circumferential direction are employed, and the swirling flow blocking plate is disposed at a position circumferentially intermediate between the neighboring exhaust struts.

3. The gas turbine device as claimed in claim 1 or 2, wherein the swirling flow blocking plate has an axial length that is greater than an axial length of the exhaust strut.

4. The gas turbine device as claimed in claim 3, wherein the axial length of the swirling flow blocking plate is within the range of 2 to 4 times the axial length of the exhaust strut.

5. The gas turbine device as claimed in any one of claims 1 to 4, wherein the four to six exhaust struts, which are spaced from each other in the circumferential direction, are employed.

6. The gas turbine device as claimed in any one of claims 1 to 5, wherein the exhaust diffuser includes an inner casing and an outer casing disposed coaxially with each other, and the inner casing and the outer casing are connected with each other through the exhaust struts.

7. The gas turbine device as claimed in any one of claims 1 to 6, further comprising:

an exhaust duct fluidly connected on a downstream side of the exhaust diffuser, wherein the exhaust duct includes an inner tube

and an outer tube disposed coaxially with each other; and
wherein the swirling flow blocking plate is so fixed to the inner tube that a gap is defined between the outer tube and the swirling flow blocking plate at least under a cold state.

5

8. The gas turbine device as claimed in claim 7, wherein the swirling flow blocking plate includes a set of two plate members overlapped with each other and is fixed to the inner tube with respective mounting portions at inner diametric ends of the plate members being curved in respective directions opposite to each other.

10

15

20

25

30

35

40

45

50

55

Fig. 1

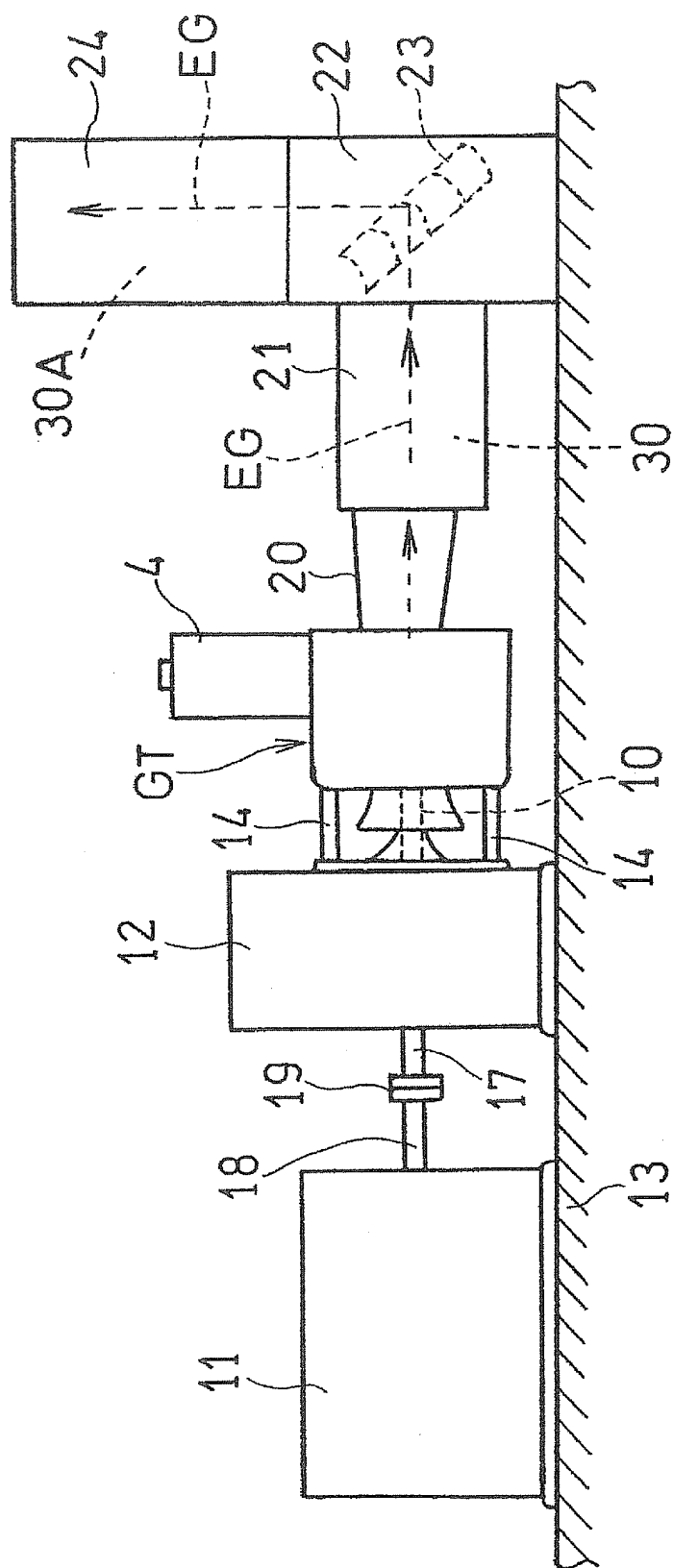


Fig. 2

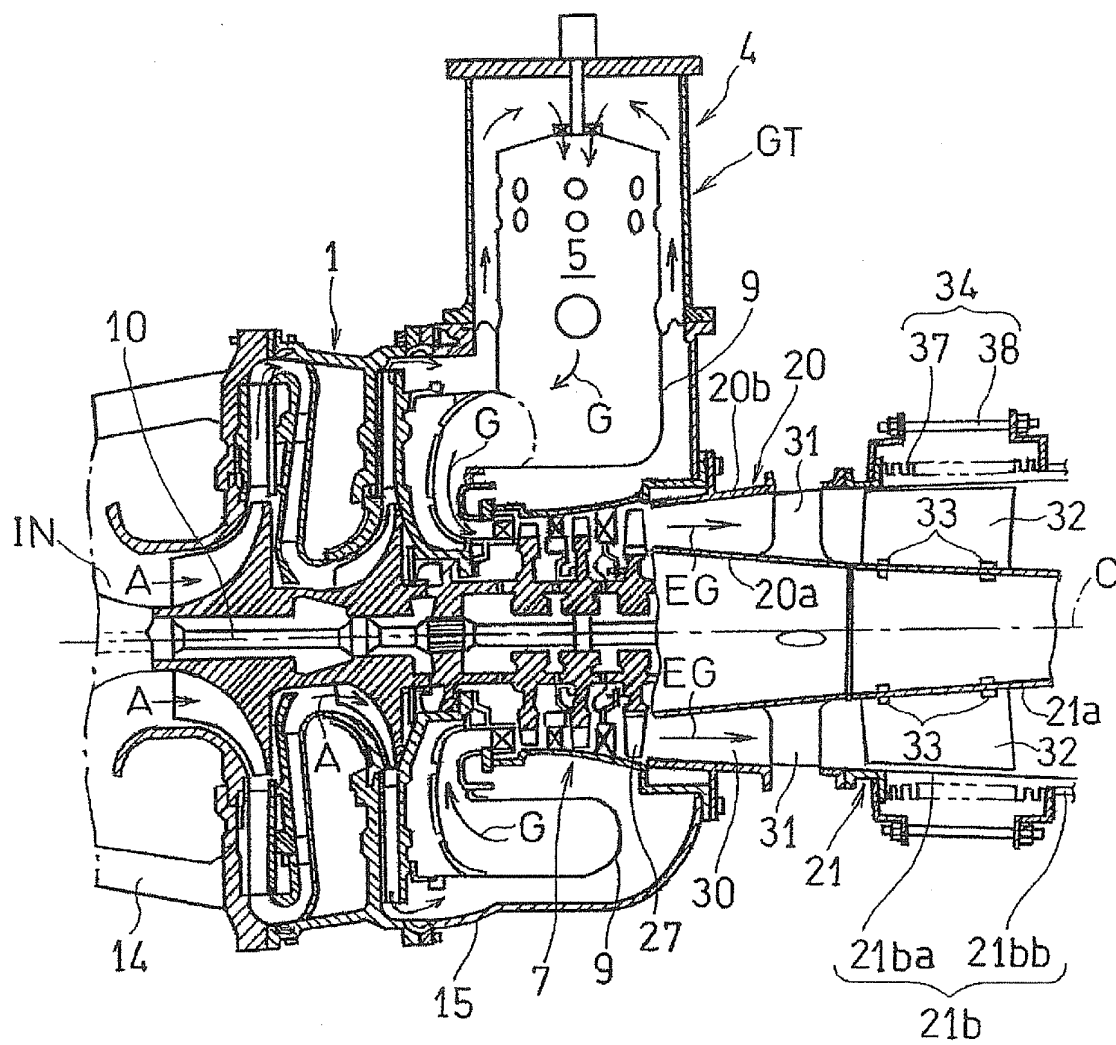


Fig. 3

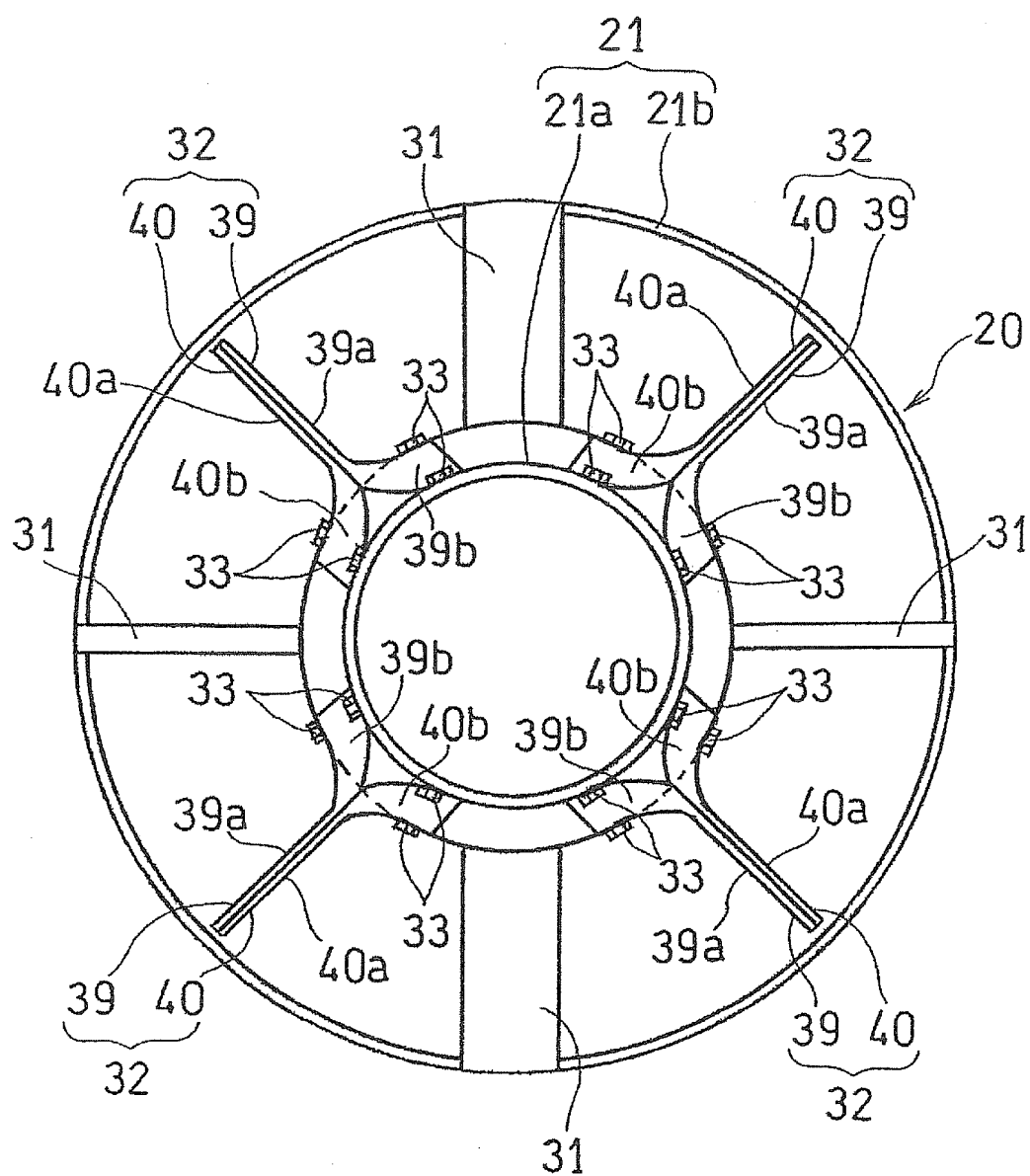


Fig. 4

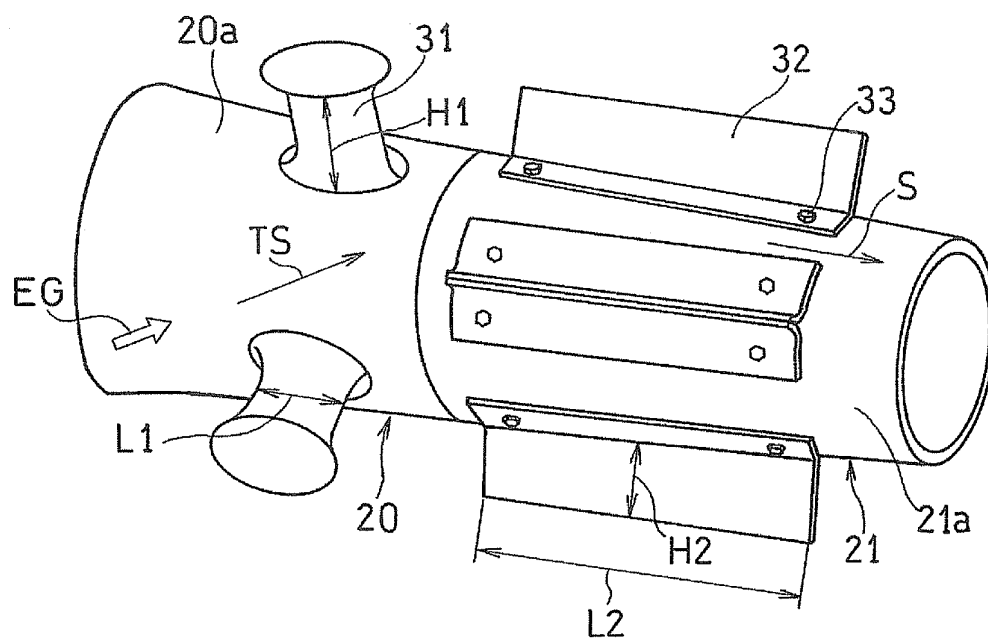


Fig. 5

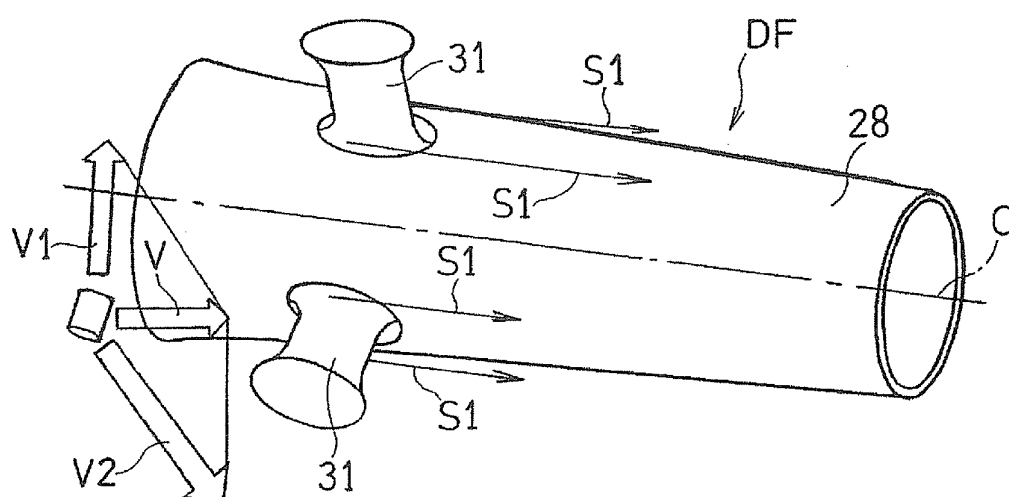
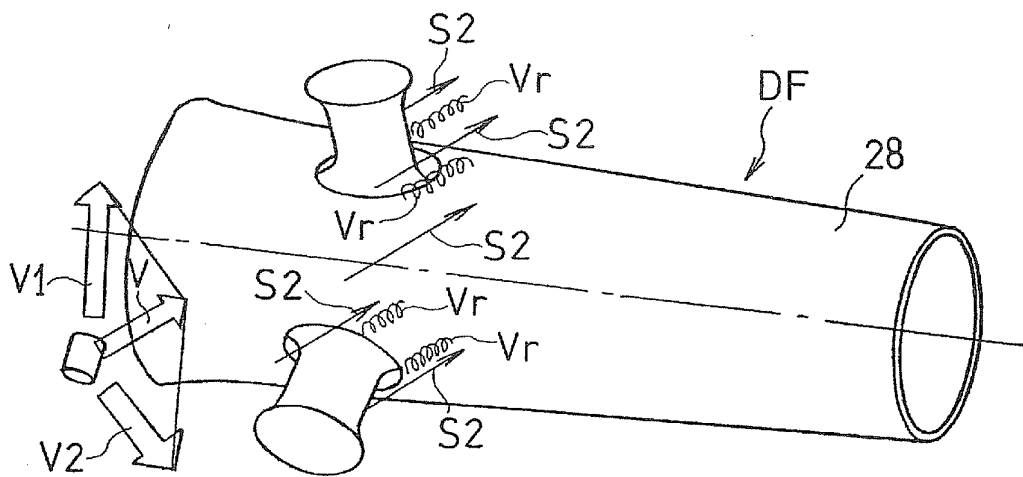


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/072820

A. CLASSIFICATION OF SUBJECT MATTER

F02C7/24(2006.01)i, F01D25/00(2006.01)i, F01D25/30(2006.01)i, F02C7/00(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)
F02C7/24, F01D25/00, F01D25/30, F02C7/00Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 11-159347 A (Mitsubishi Heavy Industries, Ltd.), 15 June 1999 (15.06.1999), paragraphs [0002] to [0005]; fig. 8 to 10 & US 2002/0011065 A1 & CN 1215795 A	1-8
Y	JP 2003-49607 A (Mitsubishi Heavy Industries, Ltd.), 21 February 2003 (21.02.2003), paragraph [0020]; fig. 2 (Family: none)	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 another 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

Date of the actual completion of the international search
12 September, 2013 (12.09.13)Date of mailing of the international search report
24 September, 2013 (24.09.13)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/072820

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 194490/1986 (Laid-open No. 100640/1988) (Mitsubishi Heavy Industries, Ltd.), 30 June 1988 (30.06.1988), page 3, line 14 to page 5, line 8; fig. 1a to 1c (Family: none)	1

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- JP 2012188346 A [0001]
- JP 2011226651 A [0009]