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(54) **Title**: GAS AND STREAM TURBINE DEVICE

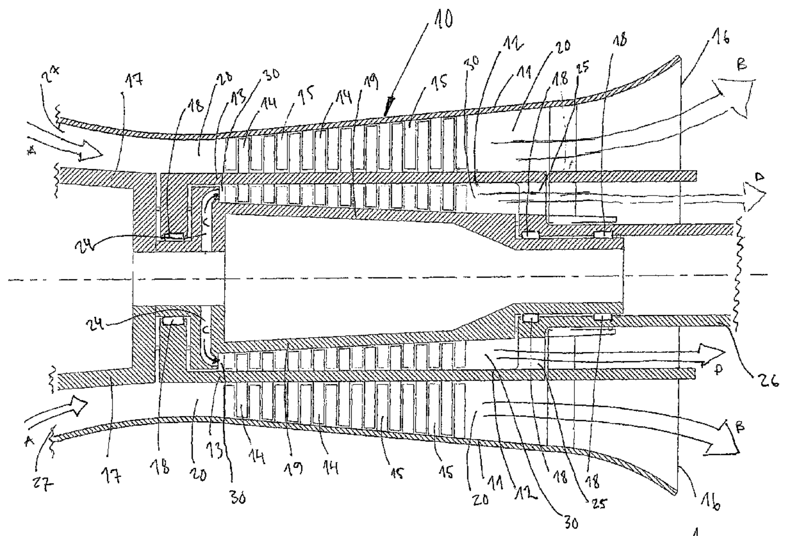

FIG 1

(57) **Abstract**: The present invention relates to a turbine device (10) for converting a flow of gas and a flow of steam into a rotational movement in a shaft(26), said device comprising: -a gas turbine portion (20), -a steam turbine portion (30) arranged concentrically with the gas turbine portion (20), and -an outer stator (11) surrounding the gas turbine portion (20) and the steam turbine portion (30), -a rotor (12) comprising a rotor hub (13) placed in the centre of the outer stator (11). The turbine device according to the invention is characterised in that the gas turbine portion (20) or the steam turbine portion (30) is extending inside the rotor hub (13).

Title: GAS AND STREAM TURBINE DEVICE

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a turbine device for converting a flow of gas and a flow of steam into a rotational movement in a shaft.

BACKGROUND OF THE INVENTION

Gas turbines are frequently used in different applications for conversion of chemical energy into mechanical energy. This conversion of energy is achieved by generating a flow of gas that is used for rotating a rotor in the gas turbine. The flow of gas is generated by combustion gases from the combustion of for example natural gas or an oil based product. The combustion takes place in a combustion chamber placed upstream of the rotor. Air is continuously supplied to the chamber and in order to improve the efficiency of the turbine, air is preferably supplied to the combustion chamber under pressure generated by a compressor.

In order to improve the efficiency of gas turbines the heat generated in the gas turbine during the combustion is used for generating a flow of steam that, in combination with the flow of combustion gases, could be used to rotate the rotor. The efficiency, the ratio between the amount of supplied energy and the amount of delivered mechanical energy from the gas turbine is thereby improved further.

A gas turbine device designed for using a flow of combustion gases and a flow of steam is disclosed in WO 2008/111905. The disclosed gas turbine device comprises a stator surrounding a rotor placed in the centre of the space within the stator. The stator is provided with stator discs placed along the inside of the stator and extending from the inside of the stator towards the rotor hub. In the spacing between the stator discs, rotor wings extending from the rotor hub are placed. In the space between the inside of the stator and the rotor hub two passages are arranged concentrically and separated from each other. The two passages are separated by sealing elements placed between each stator disc and rotor wing.

The arrangement disclosed above does however suffer from some severe drawbacks. First, the gas turbine rotor is rotating at high speed which makes it very difficult to provide the desired sealing between the stator discs and the rotor wings which is essential to keep the two passages separated from each other. The sealings are furthermore exposed to high temperature that makes it even more complicated, and expensive, to provide sealing that provides the required long time performance. Second, the disclosed gas turbine device is complex which makes it expensive to manufacture.

The present invention provides gas turbine device that solves the problems defined above.

SUMMARY OF THE INVENTION

The present invention, defined by the appended claims, provides a gas turbine device for converting a flow of gas and a flow of steam into a rotational movement in a shaft that reduces the problems described above.

The claimed turbine device for converting a flow of gas and a flow of steam into a rotational movement in a shaft comprises:

- a gas turbine portion,
- a steam turbine portion arranged concentrically with the gas turbine portion, and
- an outer stator surrounding the gas turbine portion and the steam turbine portion,
- a rotor comprising a rotor hub placed in the centre of the stator.

The turbine device is characterised in that the gas turbine portion or the steam turbine portion is extending inside the rotor hub.

The claimed turbine device solves the problems related to previously known turbine devices by letting the gas turbine portion or the steam turbine portion extend within the rotor hub. The rotor hub separates the gas portion and the steam portion whereby the need for complicated and expensive sealings between the rotor wheels and the stator discs is eliminated.

A further advantage with the claimed turbine device is that the hot gas turbine portion and the considerably less hot steam turbine portion are separated by the rotor hub instead of, as in the turbine device disclosed in WO 2008/111905 A1, the sealings placed between the rotor blades and the stator discs. This difference improves the reliability of the turbine device since each of the rotor blades and the sealings in the turbine device disclosed in WO 2008/111905 A1 will be exposed to big temperature differences that cause thermal expansion, and tensions, within the blades and the sealings that could damages the sealings and blades, while each blade in the turbine device according to the invention only is exposed to either the flow of gas or flow of steam.

Furthermore, the turbine device according to the present invention is structurally considerably less complicated which makes it less expensive to manufacture, and reduces the risk for turbine device failure.

In one embodiment of the turbine device, the outer stator comprises stator discs extending from the inside surface of the stator towards the rotor hub substantially transversal to the rotational axis of the rotor. The stator discs are used for directing the flow of gas or steam within the turbine portion in the desired direction and thereby improve the efficiency of the gas turbine device.

In one embodiment of the turbine device, the rotor comprises rotor wheels extending in substantially radial direction from the rotor hub towards the inside of the outer stator. Each rotor wheel comprises a number of inclined rotor blades. When the flow of gas or steam reaches the inclined rotor blades the rotor is turned around its rotational axis.

One embodiment of the turbine device further comprises an inner stator placed in the centre of the rotor hub. The inner stator have an outer diameter smaller than the inside diameter of the rotor hub in order to generate a space for the turbine portion extending inside the rotor hub between the inner stator and the inside surface of the rotor hub. This embodiment provides a turbine device, and a turbine portion extending within the rotor hub, that is effective and reliably.

In one embodiment of the turbine device, the rotor comprises inner rotor wheels extending in substantially radial direction from the inside surface of the rotor hub towards the inner stator. Each rotor wheel comprises a number of inclined rotor blades. When the flow of gas or steam reaches the inclined rotor blades the rotor is turned around its rotational axis. Furthermore, the inner stator comprises inner stator discs extending from the inner stator towards the inside surface of the rotor hub between adjacent inner rotor wheels. The inner stator discs are positioned in the space between two adjacent discs in order to direct the flow in a desired direction to improve the efficiency of the turbine device further.

In one embodiment of the turbine device, the flow of gas or steam is lead into the turbine portion within the rotor hub via a passage in the inner stator. This embodiment provides a reliable turbine device that is possible to manufacture to a reasonable cost.

In one embodiment of the turbine device, the flow of gas or steam exits the turbine portion within the rotor hub via at least one opening in the downstream end of the rotor hub. This embodiment provides a reliable turbine device that is possible to manufacture to a reasonable cost.

In one embodiment of the turbine device, the inner rotor wheels comprises a number of inner rotor blades, and the rotor wheels comprises a number of rotor blades, wherein a passageway is arranged within the rotor blades, the rotor hub and the inner rotor blades so that a fluid flowing in the passageway transfer heat from the gas turbine portion to the steam turbine portion. This embodiment of the invention comprising the passageway for a fluid increases the efficiency of the turbine device further since the ho combustion gases will heat the rotor blades in the gas turbine portion, and consequently also the fluid flowing in the passageway so that the heat is transferred by the fluid to the blades in the steam turbine portion where it will assist in increasing the efficiency of the gas turbine portion further.

In one embodiment of the turbine device, the steam turbine portion is extending within the rotor hub. In order to optimize the efficiency of the turbine device, the steam turbine portion is preferably arranged within the rotor hub since the flow of steam, generated by the heat from the gas generator, is smaller than the flow of combustion gas and the cross sectional area of the turbine portion within the rotor hub is smaller than the cross sectional area of the turbine portion on the opposite side of the rotor hub.

In one embodiment of the turbine device, the inside diameter of the outer stator is increasing downstream the turbine device. This outer stator design improves the efficiency of the gas turbine device.

In one embodiment of the turbine device, the rotor hub has a substantially constant outer diameter.

In one embodiment of the turbine device, the outside diameter of the inner stator is decreasing downstream the turbine device. This inner stator design improves the efficiency of the gas turbine device.

Further aspects and embodiments will present themselves through the following detailed description and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

One embodiments of the claimed invention is illustrated in the appended figures, in which:
Figure 1 illustrates a schematic cross sectional view through the gas turbine device;
Figure 2 illustrates the turbine device in figure 1 with some additional features.

DETAILED DESCRIPTION

The present invention will now be explained in further detail with reference to figure 1 and 2.

The gas turbine device 10 according the present invention could be used in combination with several different arrangements used for generating the desired flow of combustion gas, as well as several different arrangements for generating and deliver the desired flow of steam to the gas turbine device 10.

The arrangement for generating a flow of combustion gas could involve one or more compressors in order to increase the pressure within the combustion chamber before the fuel, such as natural gas or an oil based fuel, is combusted within the combustion chamber and the desired increase of pressure within the combustion chamber is achieved. The generated flow of combustion gas is lead to the turbine device 10 from the combustion chamber.

In the arrangement for generating the flow of combustion gas, considerable amounts of heat is generated during the combustion. This heat is preferably used for vaporisation of a fluid to steam that could be used in the turbine device 10 to increase the efficiency of the turbine device 10.

The turbine device 10, illustrated in the figures, comprises an outer stator 11 having a tubular shape. In the centre of the space within the outer stator 11 a rotor 12 is arranged thereby creating a gas flow portion 20 extending within the turbine device 10 between the outer stator 11 and a rotor hub 13 placed in the centre of the rotor 12. The gas flow portion 20 has an inlet 27 for the gas from the gas generator in the upstream end of the turbine device 10 and a gas outlet 16 in the downstream end of the turbine device 10. The inlet 27 and the outlet 16 are arranged around the inside periphery of the outer stator 11. The inlet 27 is connected to the gas flow generator described above. The gas flow generator could be placed in the axial upstream direction of the turbine device 10.

The rotor 12 is able to rotate around a rotational axis coaxial with the longitudinal axis of the outer stator 10. The rotor 12 comprises the substantially cylindrical rotor hub 13 placed in the centre of the rotor 12 and a number of rotor wheels 14 arranged along the cylindrical rotor hub 13 to rotate together with the rotor hub 13. Each rotor wheel 14 comprises a number of inclined rotor blades, that, when exposed to the flow of gas, will turn the rotor 12. The number of blades and the exact shape of each blade could differ depending on the desired turbine features and the specific application for the turbine device 10. The rotor wheels 14 are positioned at a constant axial distance from each other along the cylindrical rotor hub 13. The number of rotor wheels 14 is selected depending on the size of the turbine device 10, and the specific application for the turbine device 10.

In each of the spaces between adjacent rotor wheels 14, a stator disc 15 is positioned. The stator discs 15 are rigidly attached to the outer stator 11 and extend from the inside surface of the outer stator 11 in substantially radial direction towards the rotor hub 13 to fill the space between the adjacent rotor wheels 14. Each stator disc 15 comprises a number of stator wings, not illustrated, that are influencing the flow of gas through the gas turbine portion 20 in order to increase the efficiency of the turbine device 10. The stator wings are preferably as long as possible to fill the space between the adjacent rotor wheels 14, but should preferably not be in contact with the rotor hub 13 to avoid additional friction within the turbine device 10.

In the illustrated embodiment of the turbine device 10, the outer stator 11 inner diameter is changing along the axial direction of the turbine device 10. In the area upstream of the rotor wheels 14, and the stator discs 15, the inner diameter of the outer stator 11 is decreasing downstream to reach its minimum in the area close to the first stator disc 15. The diameter is then increasing downstream the turbine device 10. The radial length of the rotor wheels 14 and the stator discs 15 increase accordingly since the distance between the inside surface of the outer stator 11 and the cylindrical rotor hub 13 is increasing downstream the turbine device 10.

The flow of combustion gas into the turbine device inlet 27 is illustrated by arrows A. The flow of gas is passing through the gas turbine portion 20 and exits the turbine device 10 via the exit opening 16 downstream the turbine device 10. The flow of gas out from the turbine device 10 is illustrated by arrows B.

The rotor 12 is turnably supported in relation to a support structure 17 placed in the centre of the turbine device 10 by bearings 18 placed in the upstream and downstream ends of the rotor 12. In the upstream end of the turbine device 10, and upstream of the rotor hub 13, the support structure 17 has a diameter substantially equal to the outside diameter of the cylindrical rotor hub 13. Close to the upstream end of the rotor hub 13, the diameter of the support structure 17 is reduced considerably and the support structure 17 extends downstream inside the rotor hub 13. The support structure within the rotor hub 13 constitutes an inner stator 19 extending inside the cylindrical rotor hub 13 to the downstream end of the rotor hub 13 to support also the downstream end of the rotor 12 via bearings 18. The bearings could be of different types but should ensure that the rotor is able to rotate as easy as possible in relation to the support structure 17 to avoid additional friction losses.

The outer diameter of the inner stator 19 is smaller than the inside diameter of the cylindrical rotor hub 13 thereby generating a steam turbine portion 30 that extends within the rotor hub 13 concentrically with the gas turbine portion 20 outside the rotor hub 13. The support structure17 is mechanically connected to the outer stator 11 and thereby prevented from turning together with the rotor 12.

Along the inside surface of the rotor hub 13 a number of inner rotor wheels 22 are arranged to rotate together with the rotor hub. The inner rotor wheels 22 extend from the inside surface of the rotor hub 13 in substantially radial direction towards the inner stator 19. Each inner rotor wheel 22 comprises a number of inclined rotor blades, that when exposed to the flow of steam will assist rotating the rotor 12. The inner rotor wheels 22 are positioned at a substantially constant axial distance from each other along the inside of the cylindrical rotor hub 13. In each of the spaces between the adjacent inner rotor wheels 22 an inner stator disc 23 is placed in a similar way as within the gas turbine portion 20. The inner stator discs 23 are rigidly attached to the inner stator 19 and extend from the surface of the inner stator 19 in substantially radial directions towards the inside surface of the rotor hub 13 to fill the space between adjacent inner rotor wheels 22. Each inner stator disc 23 comprises a number of inner stator wings, not illustrated, that are influencing the flow of steam through the steam turbine portion 30 in order to increase the efficiency of the turbine device 10. The diameter of the inner stator 19 is decreasing towards the downstream end of the turbine device 10. The length of the inner rotor wheels 22 and the inner stator discs 23 increase accordingly since the distance between the inside surface of the rotor hub 13 and the inner stator 19 is increasing downstream the turbine device 10.

The flow of steam from the steam generating arrangement enters the steam turbine portion 30 via passages 24 arranged in the supporting structure 17. The passages 24 end close to the inner surface of the cylindrical rotor hub 13 upstream of the inner rotor wheels 22 and the inner stator discs 23.

The flow of steam into the steam turbine portion 30 is illustrated by arrows C. The flow of steam is passing through the steam turbine portion 30 and exits the turbine device 10 via openings 25 in the downstream end of the rotor hub 13. The flow of steam out from the turbine device 10 is illustrated by arrow D.

In one embodiment of the turbine device, not illustrated in the appended figure, a passageway is arranged within the rotor blades, the rotor hub and the inner rotor blades so that a fluid flowing in the passageway transfer heat from the gas turbine portion 20 to the steam turbine portion 30. This embodiment of the turbine device 10 increases the efficiency of the turbine device further since the hot combustion gases will heat the rotor blades in the gas turbine portion, and consequently also the fluid flowing in the passageway so that the fluid is vaporised and the heat transferred by the fluid to the steam turbine portion 30 where it will assist in increasing the efficiency of the gas turbine portion further. The fluid flowing in the passageways in the rotor blades will also cool the blades in the gas turbine portion which is a further advantage. The vaporised fluid could also be introduced in the main flow of steam in the steam turbine portion 30. The stator blades and the inner stator blades are preferably arranged at the same axial position along the rotor hub 13 in order to facilitate the manufacturing of the passageway within the blades and the rotor hub 13.

Downstream the rotor 12 a directing structure 27 is arranged. In this embodiment of the turbine device the directing structure 27 is substantially cylindrical and has a diameter substantially equal to the rotor hub 13. The directing structure 27 is used for directing the exit gas and exit steam in the desired direction and in other embodiments of the invention the structure could have a completely different shape to direct the hot exit gas and exit steam in a desired direction. The directing structure is rigidly attached to the outer stator 11.

In the downstream end of the rotor 12 the diameter of the rotor hub 13 is reduced to constitute an outgoing shaft 26 for transferring the rotational movement generated by the turbine device 10. The shaft 26 is for example connected to a generator for transforming the rotational movement into electrical energy, or a propeller etc in order to power an aircraft, vehicle, ship or yacht.

The shaft 26 is either connected directly to the arrangement where the rotational movement is used or first lead to a gear in order to makes it possible to adapt the rotational speed and power for a specific application.

In figure 2 en additional shaft 28 has been added. The shaft 28 is structurally rigid connected to the outgoing shaft 26 and extends in the opposite direction from the outgoing shaft 24 upstream the turbine device. The shaft 28, extending upstream the turbine device 10, could be used to drive one or more compressors used in combination with the gas generator that generates the combustion gas flow to the turbine device. In this case the shaft 28 preferably extends all the way to the gas generator that the compressor is directly driven by the shaft 28.

The invention is described above with reference to one embodiment of the invention. Several features of the turbine device could however be modified without departing from the invention. Possible modifications:

- The dimensions and the specific design of the outer stator, the inner stator, the rotor and the outgoing shaft could be changed in order to adapt the device to different applications.
- The number of rotor wheels, inner rotor wheels, outer and inner stator discs could be changed.
- The number and positions of the bearings could be changed as well as the type of bearing could be changed.

While one presently preferred embodiment of the invention have been described herein, it is to be understood that the invention is not so limited but covers and includes any and all modifications and variations that are encompassed by the following claims.

CLAIMS

1. Turbine device (10) for converting a flow of gas and a flow of steam into a rotational movement in a shaft (26), said device comprising:

- a gas turbine portion (20),
- a steam turbine portion (30) arranged concentrically with the gas turbine portion (20), and
- an outer stator (11) surrounding the gas turbine portion (20) and the steam turbine portion (30),
- a rotor (12) comprising a rotor hub (13) placed in the centre of the outer stator (11),

characterised in that the gas turbine portion (20) or the steam turbine portion (30) is extending inside the rotor hub (13).

2. Turbine device (10) according to claim 1, **characterised in** that the outer stator (11) comprises stator discs (15) extending from the inside surface of the outer stator (11) towards the rotor hub (13) substantially transversal to the rotational axis of the rotor (12).

3. Turbine device according to claim 1 or 2, **characterised in** that the rotor (12) comprises rotor wheels (14) extending in substantially radial direction from the rotor hub (13) towards the outer stator (11).

4. Turbine device according to claim 1, 2 or 3, **characterised in** that the turbine device (10) further comprises an inner stator (19) placed in the centre of the rotor hub (13), said inner stator (19) having a outer diameter smaller than the inside diameter of the rotor hub (13) in order to generate a space for the turbine portion (30) extending inside the rotor hub (13) between the inner stator (19) and the inside surface of the rotor hub (13).

5. Turbine device according to claim 4, **characterised in** that the rotor (12) comprises inner rotor wheels (22) extending in radial direction from the inside surface of the rotor hub (13) towards the inner stator (19), said inner sta-

tor (19) comprising inner stator discs (23) extending from the inner stator (19) towards the inside surface of the rotor hub (13) between adjacent inner rotor wheels (22).

6. Turbine device according to claim 4 or 5, **characterised in** that the flow of gas or steam is lead into the space within the rotor hub (13) via one or more passages (24) in the inner stator (19).

7. Turbine device according to claim 4, 5 or 6, **characterised in** that the flow of gas or steam exits the space within the rotor hub (13) via at least one opening (25) in the downstream end of the rotor hub (13).

8. Turbine device according to claim 5, **characterised in** that the inner rotor wheels (22) comprises a number of inner rotor blades, and the rotor wheels (14) comprises a number of rotor blades, wherein at least one passageway is arranged within the rotor blades, the rotor hub (13) and the inner rotor blades so that a fluid flowing in the passageway transfer heat from the gas turbine portion (20) to the steam turbine portion (30).

9. Turbine device according to anyone of the previous claims, **characterised in** that the steam turbine portion (30) is arranged within the rotor hub (13).

10. Turbine device according to anyone of the previous claims, **characterised in** that the inside diameter of the outer stator (11) is increasing downstream the turbine device (10).

11. Turbine device according to anyone of the previous claims, **characterised in** that the rotor hub (13) has a substantially constant outer diameter.

12. Turbine device according to anyone of claims 4 to 8, **characterised in** that the outside diameter of the inner stator (19) is decreasing downstream the turbine device (10).

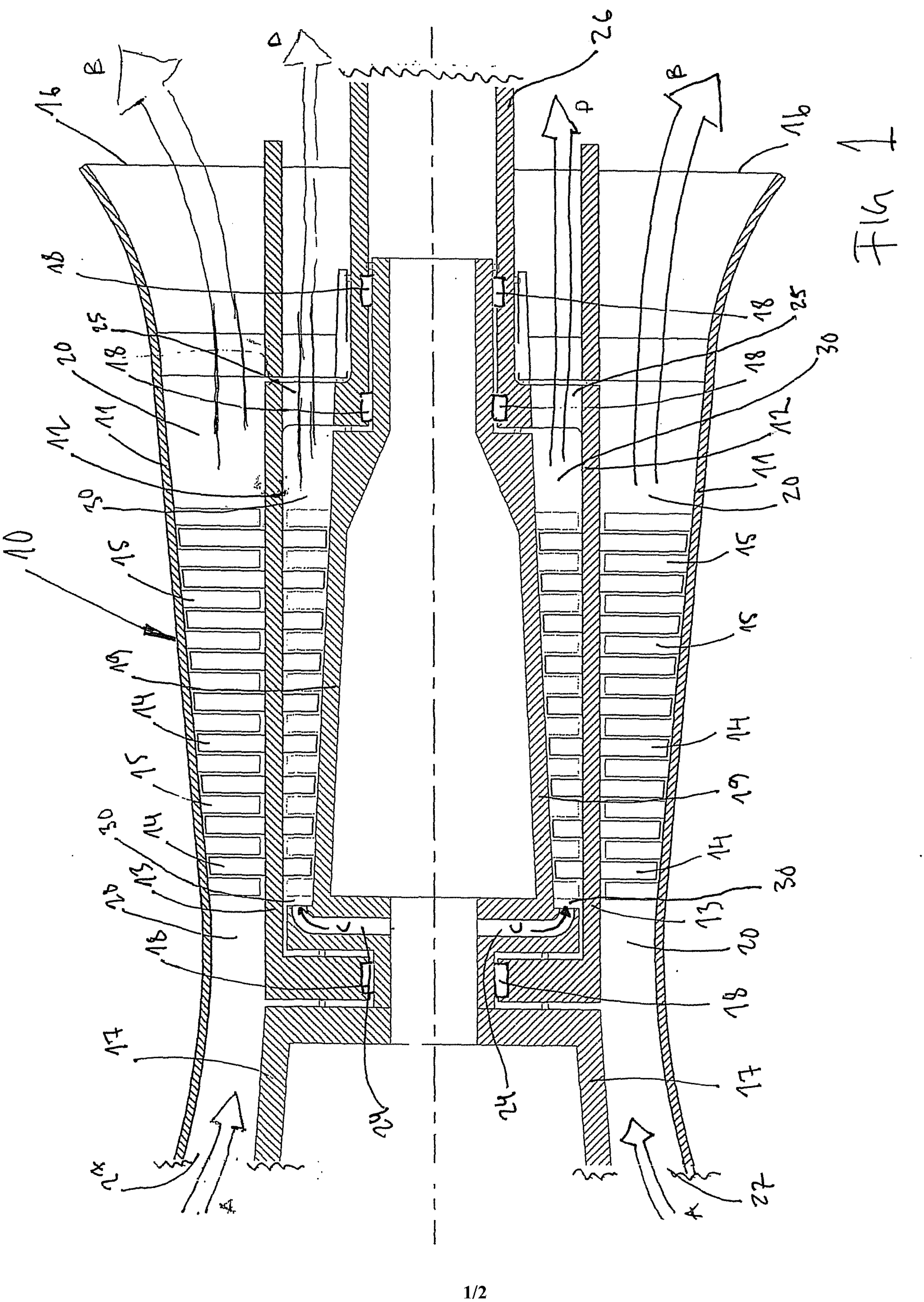

FIG 1
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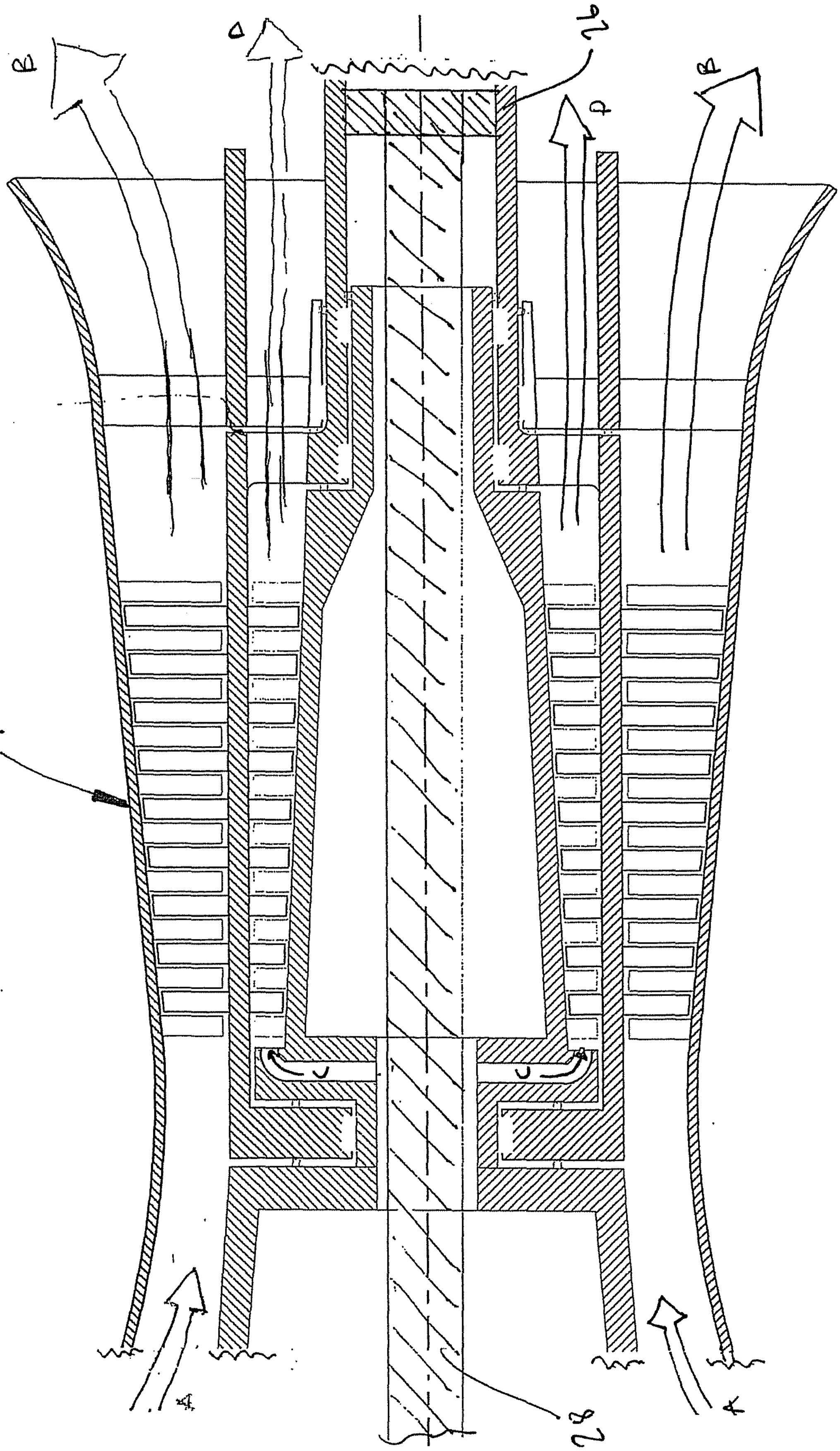

Fig 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2009/050234

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01D1/02 F02C3/073 F01K23/16 F01K23/10

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 F02C F01K

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 333 309 A (CORONEL PAUL D) 8 June 1982 (1982-06-08) page 14, lines 1-48 figures 1,11 -----	1
A	WO 2008/111905 A (ERIKSSON DEV AND INNOVATION AB [SE]; ERIKSSON TORBJOERN [SE]) 18 September 2008 (2008-09-18) cited in the application page 4, last paragraph page 6, last paragraph page 14, paragraph 2 page 15, paragraph 1 figures 3a-3c,4 -----	1

☐ 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 document but published on or after the international filing date

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"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	Date of mailing of the international search report
3 December 2009	17/12/2009

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/SE2009/050234

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 4333309	A	08-06-1982	NONE		
WO 2008111905	A	18-09-2008	SE	0700586 A	11-03-2008