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(54) METHOD FOR COOLING TURBINE STATORS AND COOLING SYSTEM FOR IMPLEMENTING SAID METHOD

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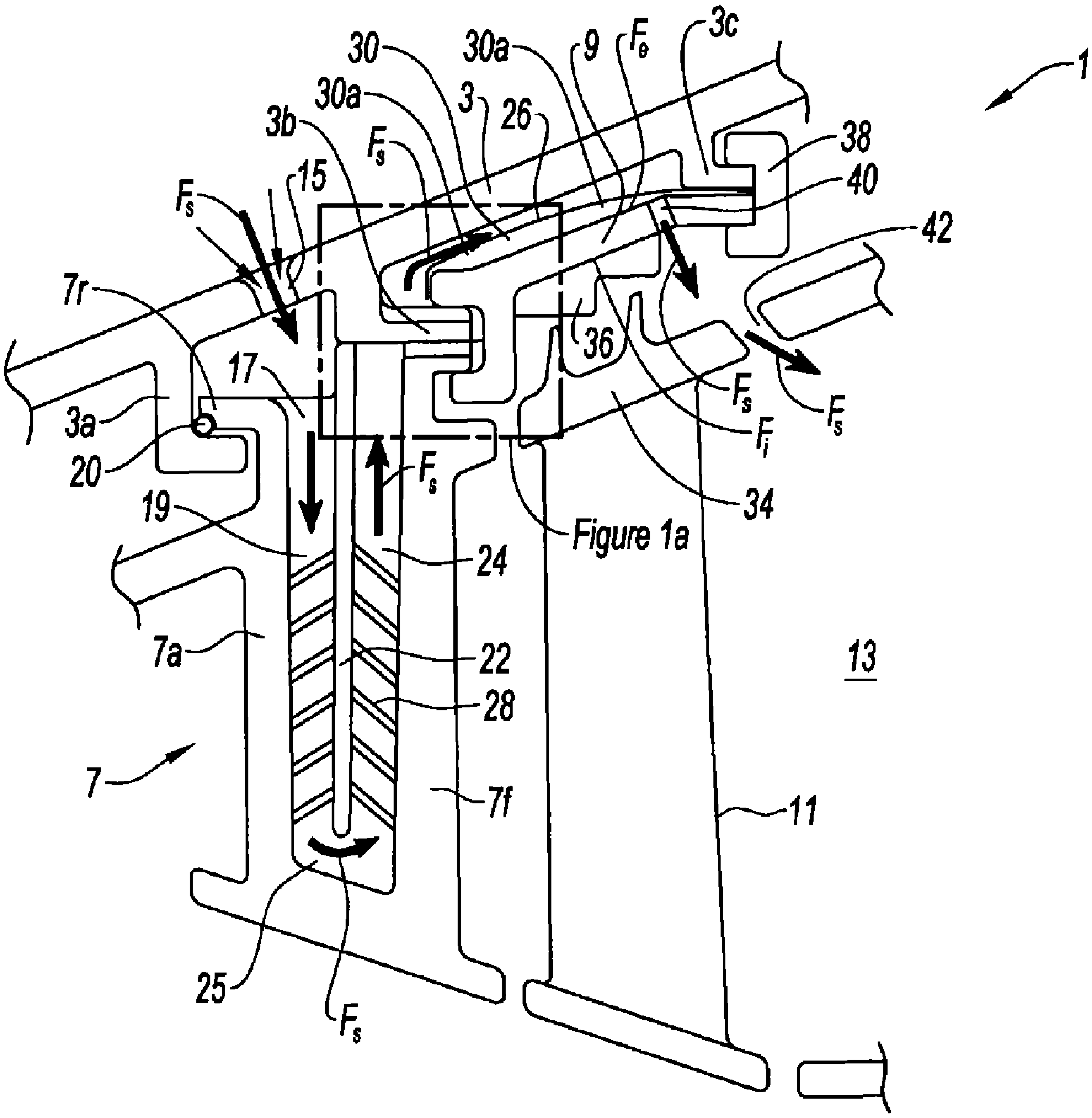
(57) **ABSTRACT**

A method and system for cooling turbine engine turbines, the system includes: at least one pair of parts to be cooled, the pair including a stator upstream from the rotor valve, and a sealing ring mounting a downstream movable blade rotor that is adjacent to the stator; a turbine casing; and an outlet path. The system further includes: at least one opening in the casing facing at least one part to be cooled; and an air circuit producing a forced convection in connection with the parts and at least one downstream outlet in the path so as to draw in and transport an ambient air flow.



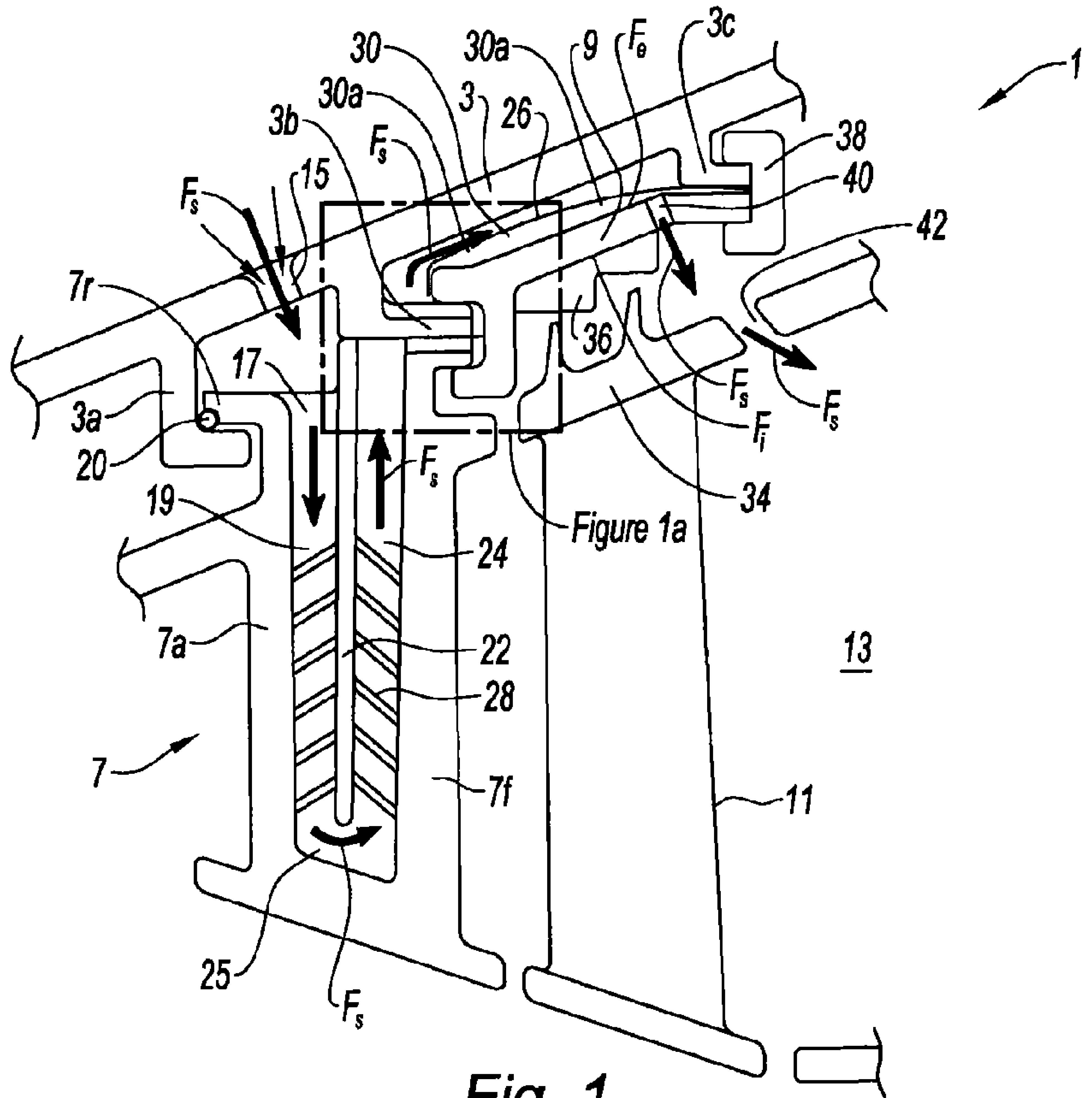


Fig. 1

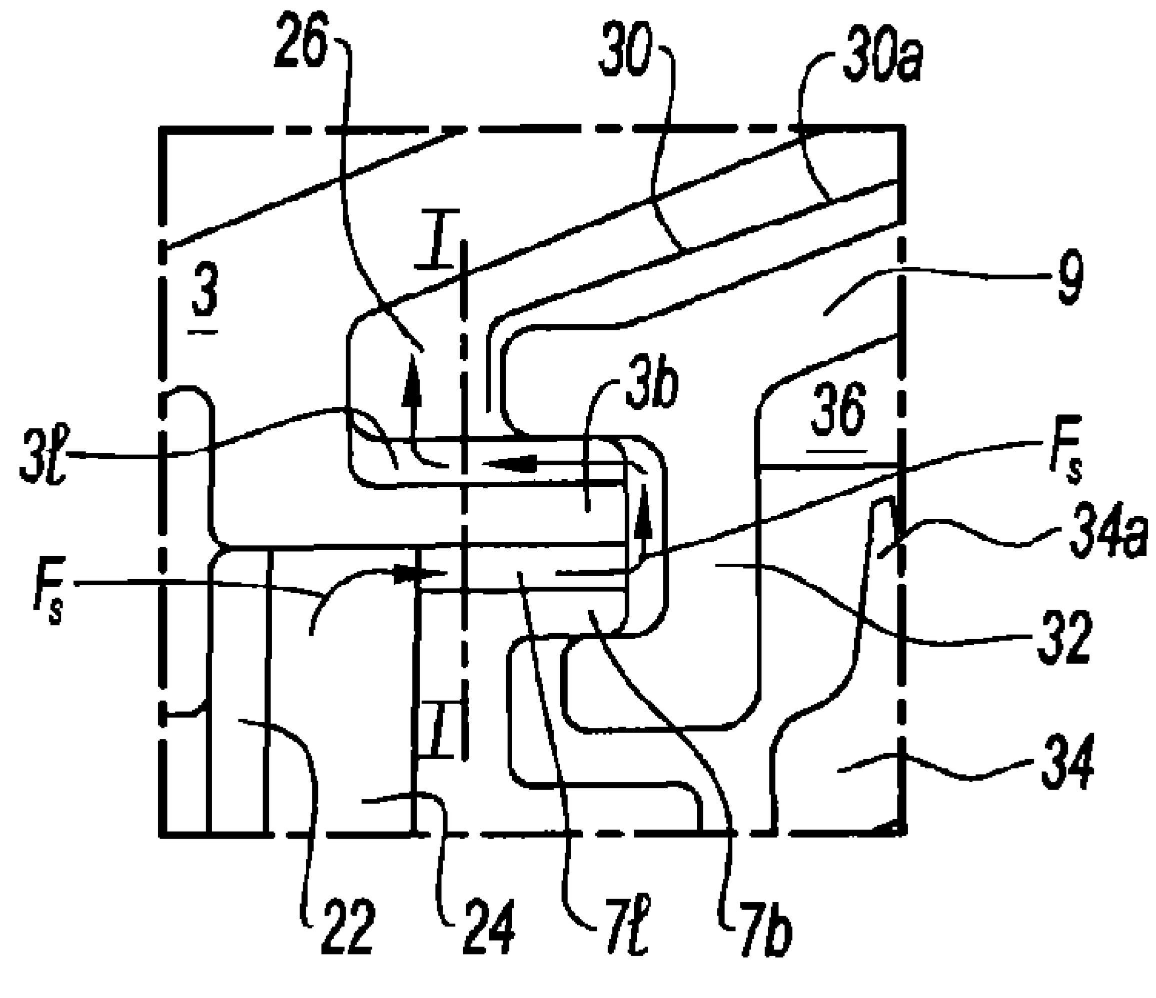


Fig. 1a

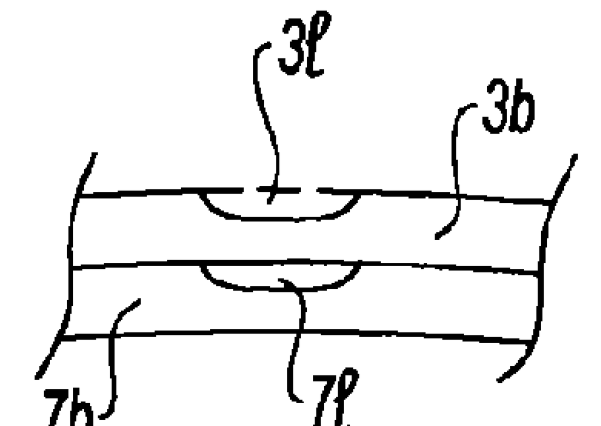


Fig. 1b

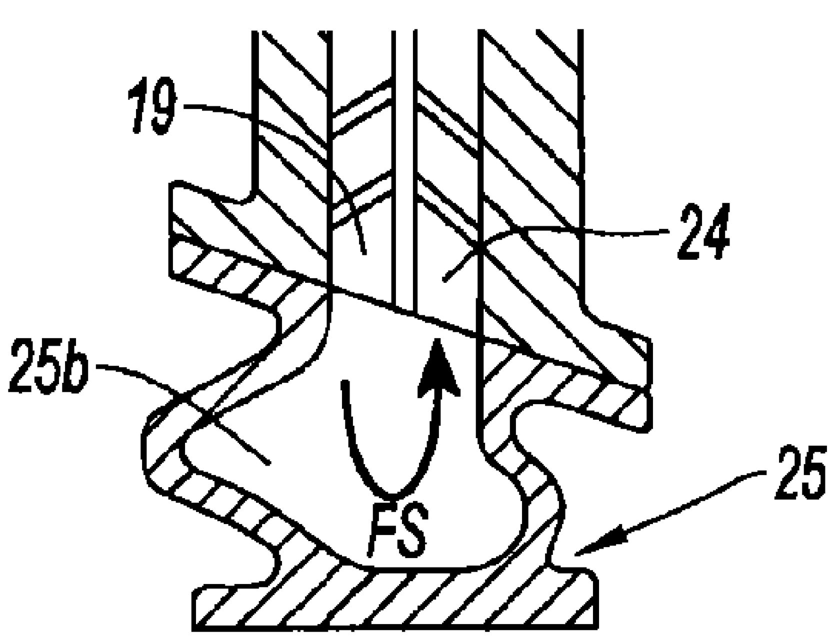
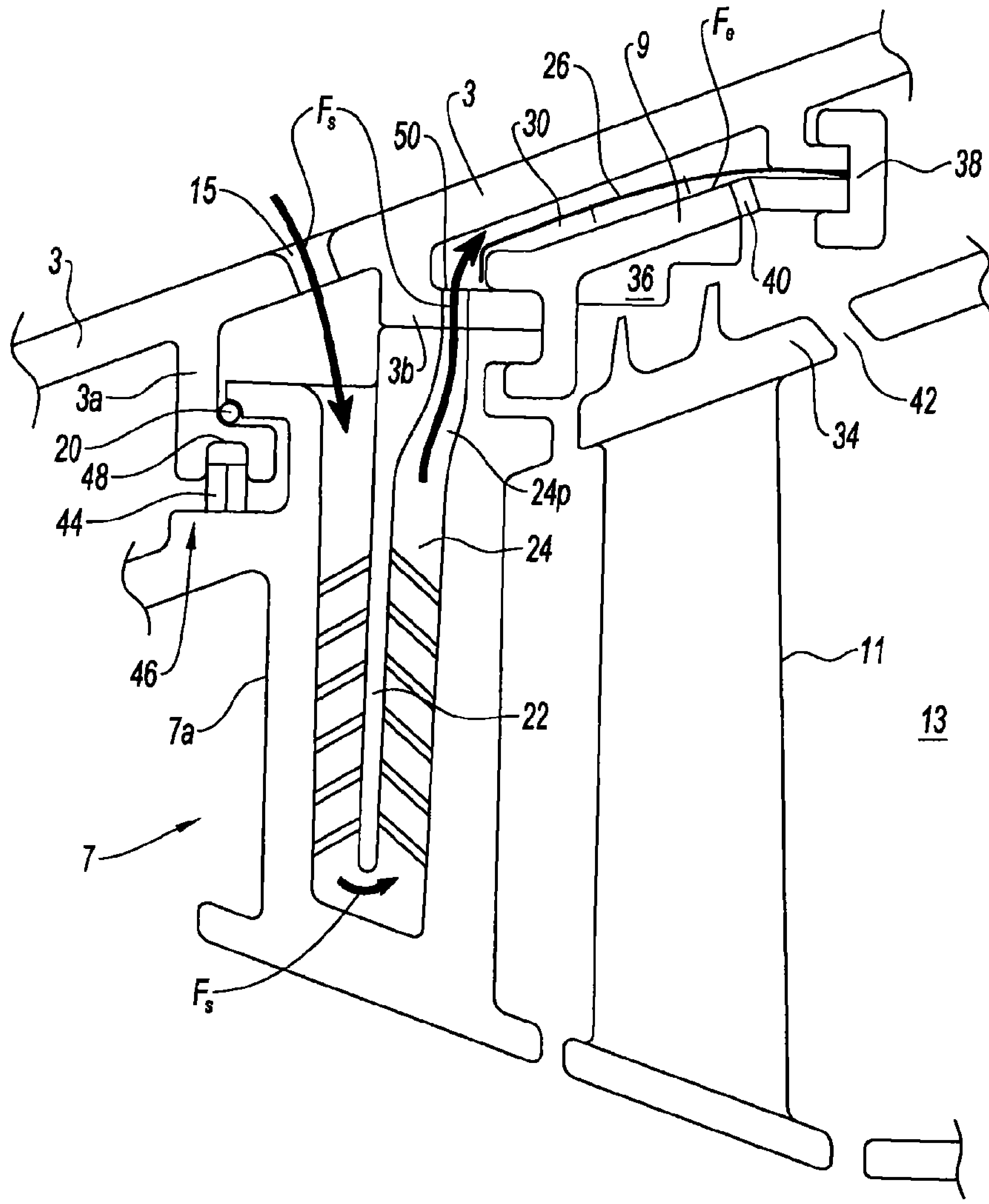


Fig. 1c


1
3
3
3a
3b
15
Fs
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30
26
9
Fe
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36
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Fs

Fig. 2

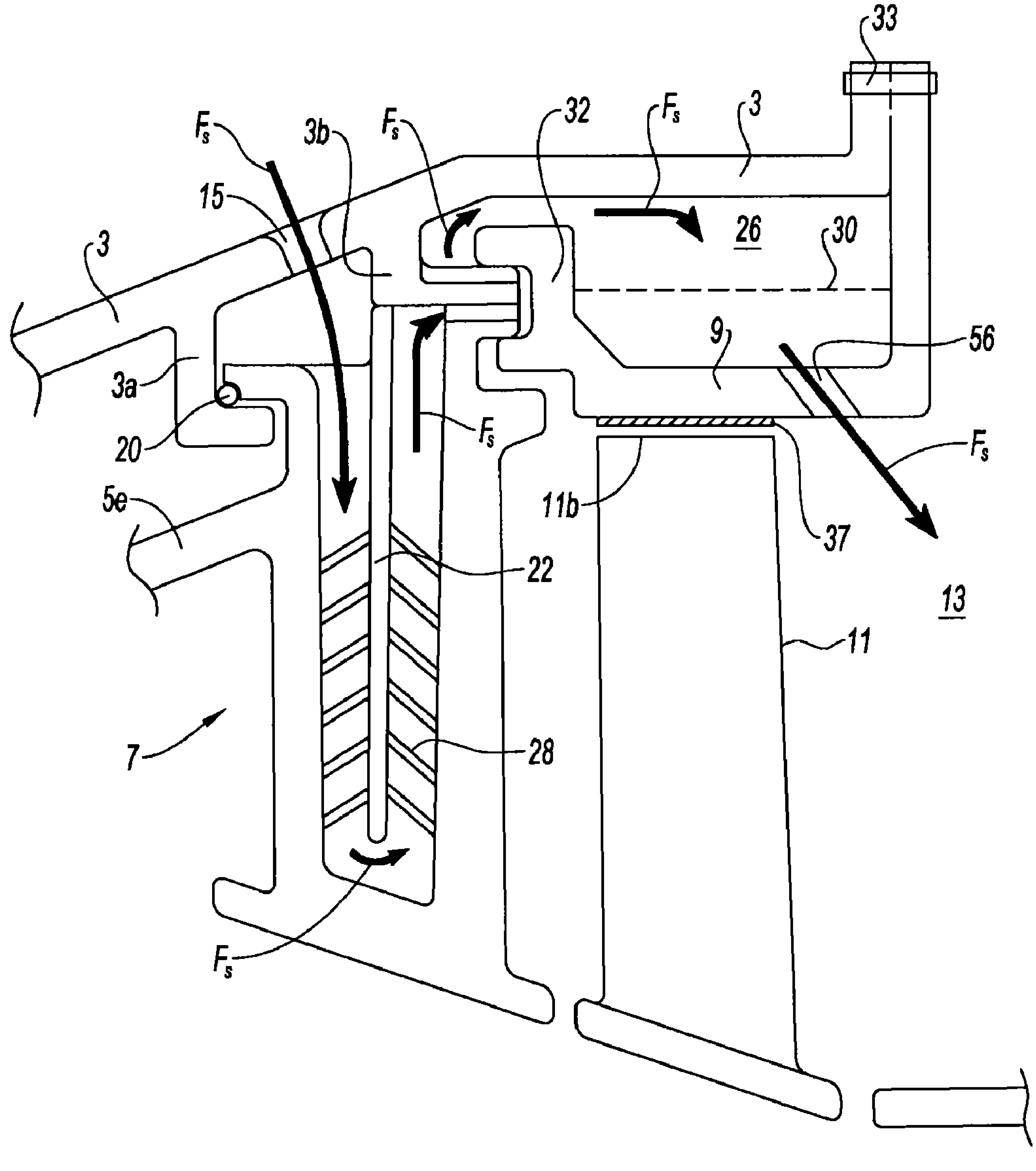

Fig. 3

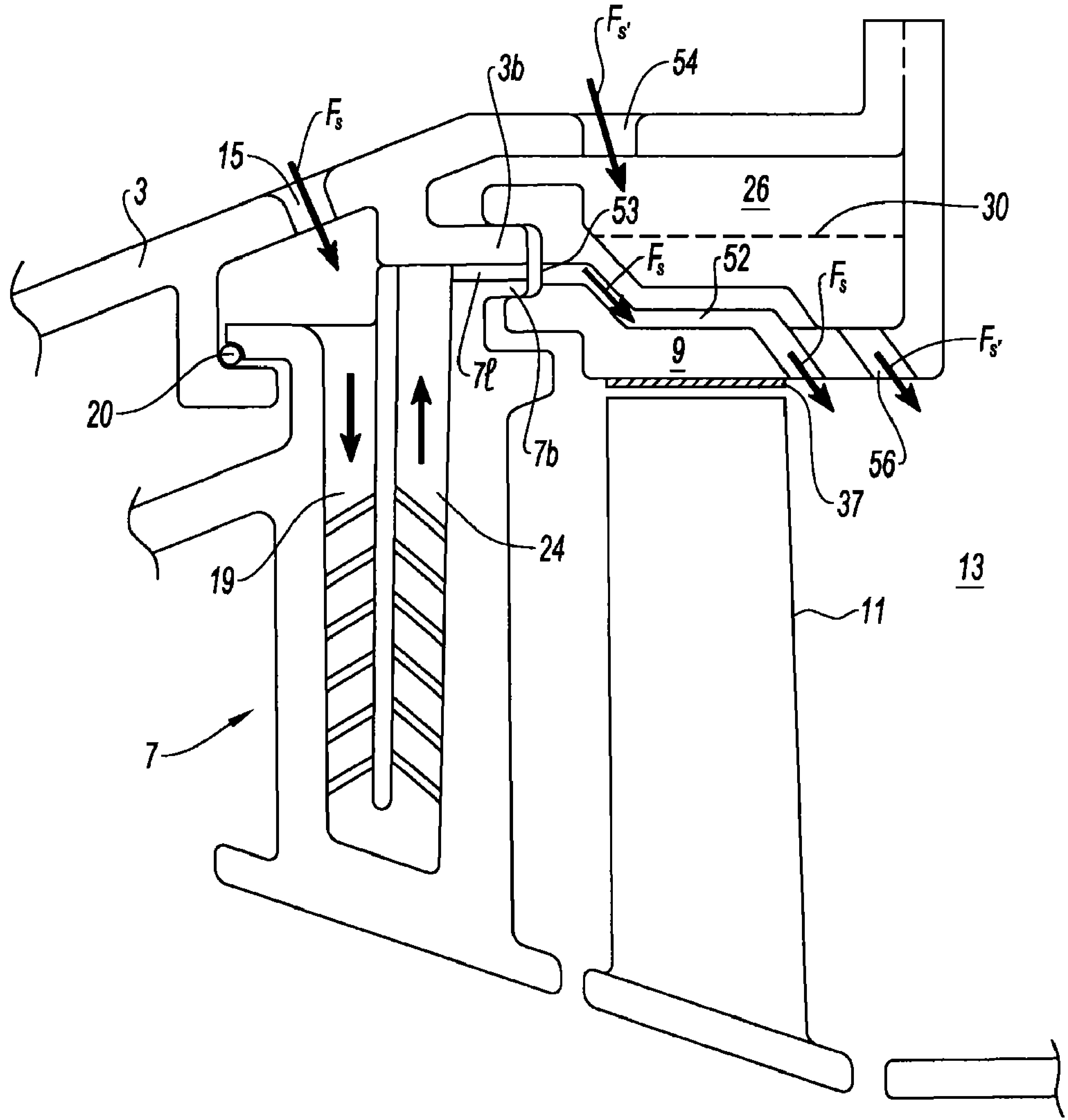

Fig. 4

METHOD FOR COOLING TURBINE STATORS AND COOLING SYSTEM FOR IMPLEMENTING SAID METHOD

[0001] The invention relates to a method for cooling stators, distributors or rings of gas turbines equipping the aircraft propelling turbo-machines, in particular helicopters, as well as a cooling system for implementing the method.

[0002] The thermodynamic cycles of the turbo-machines are higher and higher in temperature, which requires a cooling extended to the stator portions of the turbine: the stationary vanes of the distributor of the turbine, as well as the smooth or sealing ring support (designated hereinunder by ring support) of the movable blades or rotor. The air is then introduced across the vanes of the distributor and then above the rotor ring. The air is then reintroduced in the outlet path.

[0003] Now, the outlet nozzle presents at low speeds a recovering coefficient (Cp) being able to reach negative values, which results in an inversion of the pressure deviation between the atmosphere and the outlet plan of the turbine. Hot air reintroductions can then occur by exhaust and prevent the cooling of the stator.

[0004] Furthermore, the use of cooling air being tapped at the level of the compressor has a performance cost, as it does not any longer contribute to the motive work.

[0005] The invention aims at remedying such disadvantages by proposing an ambient air aspiration at the level of the stator to be cooled.

[0006] More precisely, the invention relates to a method for cooling turbine parts of an engine presenting at the exhaust an architecture with a positive Cp on the whole operating speeds, for which a cooling is desired, consisting in tapping an ambient air flow by aspiration at the level of at least one part to be cooled, followed by a crossing producing a forced convection in connection with said part, and then by a downstream air reintroduction in the outlet path.

[0007] The terms "upstream" and "downstream" refer to the air flow direction in the engine and the terms "internal", respectively "external, refer to localizations "viewed from", respectively "in the direction of" the turbine rotation axis.

[0008] Such method is particularly efficient in the case of configurations of turbines or engines being able to define an outlet depression being sufficient to provide a Cp staying positive on a set of operating speeds. That is the case including for:

- **[0009]** mono-stage turbines operating at the same expansion rate as a bi-stage turbine, which allows an outlet static pressure substantially smaller than with a bi-stage turbine to be obtained;
- **[0010]** engines with axisymmetric nozzles used in particular with a through-shaft architecture.

[0011] According to preferred embodiments:

- **[0012]** cooling being intended for at least one pair of parts comprising an upstream stator and a downstream ring support being adjacent to the stator, such cooling is performed in a serial mode with a successive circulation of a same air flow in both parts, in a parallel mode with circulations being independent of the air flow in each of the parts or in a mixed mode with the successive circulation of a same flow and a circulation being independent in the second part by tapping ambient air at the level of the upstream stator for serial and mixed cooling, and at the level of each part for parallel and mixed cooling;
- **[0013]** the downstream reintroductions in the outlet path are implemented with parallel exhausts;
- **[0014]** the tapped air is also contacted with at least one engine part to be cooled as, for example, the holding lock of the ring support on the arm of the casing.

[0015] The invention also aims at a system for cooling turbines of turbo-machines comprising at least one distributor upstream stator with stationary vanes, a ring support for movable blades, a turbine casing and an outlet path, the system being able to implement the above mentioned method. Such system comprises an opening in the casing facing at least one part to be cooled, a forced air circulation in connection with such part and at least one downstream outlet in the path.

[0016] According to particular embodiments:

- **[0017]** an opening is formed in the casing facing an air circulation inlet in each vane of the distributor to be cooled, such circulation being performed by a radial circuit comprising at least two channels, as well as an air outlet in the outlet path of the turbine;
- **[0018]** an axisymmetric cavity is provided between the two channels so as to homogenize the pressure of the air flow and to implement a better cooling of the stationary vanes;
- **[0019]** the distributor and the sealing ring support of the rotor of a turbine are serially cooled by a communication channel in outlet of a distributor vane, which channel opens into a cavity in radial connection with the external side of the ring support, and then toward the outlet path of the turbine through at least one orifice provided in the ring support;
- **[0020]** the ring support presents at least one upstream hook being able to enclose bladed flanges, being sectored or not, of the casing and the distributor so as to form the communication channel;
- **[0021]** the channel of each vane of the distributor comprises an extension directly opening into the cavity to form the communication channel;
- **[0022]** the cooling being performed in a parallel mode, the radial circuit of the vane of the distributor opens facing a channel inlet arranged in the ring support of the rotor to cross it up to the outlet path, and an orifice is formed in the casing opposite the ring support so as to tap an ambient air flow by drawing in and form a parallel air circulation circuit crossing the cavity and the ring support by an outlet orifice;
- **[0023]** a ring-shaped perforated metal sheet is provided in the cavity of the cooling circuit of the ring support so as to improve the thermal exchange with the air being tapped;
- **[0024]** the cooling is performed in serial and/or parallel mode by a combination of the above mentioned serial or parallel air circulations;
- **[0025]** the air circulation is implemented by blading the structure of the stator vanes and/or the casings participating in such circulation;
- **[0026]** at least one air circuit is equipped with non-return air valves that could be located at the level of the openings arranged in the casing.

[0027] The invention applies in particular to mono-stage turbines, and to the architecture of through-shaft engines, which allows advantageously the use of axisymmetric nozzles presenting particularly favorable CP curves on the whole speeds.

[0028] Other characteristics and advantages of the invention will appear with the reading of the detailed description of exemplary embodiments hereinunder, in reference to the accompanying FIGS. representing respectively:

[0029] FIG. **1**, a partial section view of an exemplary serial cooling circuit of a stator distributor and a sealing ring support of a turbine rotor in a turbo-machine;

[0030] FIGS. **1***a* and **1***b*, an enlargement of the assembly between the distributor and the casing by a hook and a partial section view along I-I of FIG. **1***a* at the level of such assembly;

[0031] FIG. **1***c*, a partial section view of an axisymmetric cavity located between the two cooling channels;

[0032] FIG. **2**, the example of the FIG. **1** with a doubled upstream sealing and an alternative air circulation channel in the distributor;

[0033] FIG. **3**, a partial section view of an exemplary serial cooling circuit of a distributor and a ring support in the rotor with no heel; and

[0034] FIG. **4**, a partial section view of an exemplary parallel cooling circuit of a turbine with movable blades without any heel.

[0035] The terms "internal" or "external" qualify an element viewed from the side of the rotation axis of the turbine or from the side opposite to such axis. Furthermore, identical reference annotations on the FIGS. refer to identical or equivalent elements.

[0036] Referring to FIG. **1**, the turbine **1** consists specifically in a casing **3**, an air distribution stator or distributor with stationary vanes **7**, a sealing ring support **9** for movable blades **11**, and an outlet path **13** for an access to the nozzles (not represented). The casing **3** fastens the position of the distributor and the ring support by support arms **3***a*, **3***b* and **3***c*. The air under cowl is drawn in under the form of a flow Fs by depression across an intake orifice **15** of the casing **3** and up to the outlet path **13** thru the distributor **7** and the ring support **9**.

[0037] The orifice **15** is arranged facing an air inlet opening **17** provided on one end of a first radial circulation channel **19** inside the distributor **7**. The upstream sealing of the distributor **7** on the casing **3** is provided by a gasket **20** between the first upstream arm **3***a* of the casing **3** and an upstream rim **7***r* of the distributor **7**.

[0038] A central radial wall **22** separates the first channel **19** from a second circulation channel **24**, the channels being also bordered by the leading **7***a* and trailing **7***f* edges of the vanes of the distributor **7**. Both channels communicate through a cavity **25** allowing the flow Fs to circulate from the first to the second channel in opposite directions. In an alternative solution, shown on FIG. **1***c*, a part **25***a* is fastened by any known means (screw, welding) to the end of the vane **7** so as to provide the transition between the channels **19** and **24**. The inside of this part is machined so as to form an axisymmetric cavity **25***b* located between the two channels **19** and **24** for homogenizing the pressure of the air flow Fs and thereby obtaining a better cooling of the stationary vanes **7**. Such insert configuration also favors the manufacture of the vane **7**, since the internal radial end thereof is opened. Air flow perturbations **28**, of the so-called "trombone" type, are provided inside the channels so as to increase the thermal transfers.

[0039] At the radial end of the second channel **24**, the flow Fs enters and circulates, causing a forced convection in a cavity **26** located between the casing **3** and the external side Fe of the ring support **9**. A radially external ring-shaped sheet **30** is made integral, at the level of the ends thereof, with the stationary ring support **9**. As more particularly illustrated on FIGS. **1***a* and **1***b*, the connection between the channel **24** and the cavity **26** is made by bladings **7***l* and **3***l* formed in the arms **7***b* and **3***b*, respectively, of the distributor **7** and the casing **3**. Such flanges are held in a hook **32** forming the upstream end of the ring support **9**. Perforations **30***a* are arranged in the ring-shaped sheet so as to form a ring-shaped impact jet **30** with increased air speed so as to facilitate the thermal transfer between the ring support **9** and the cavity **26**. The ring-shaped sheet is made integral, at the upstream end thereof, with a radial side of the hook **32**.

[0040] In the illustrated example, the movable blades **11** are equipped with heels **34** on their external ends, facing an abradable honeycomb material **36**. Such abradable material is made integral with the internal side Fi of the ring support **9**. The downstream end of the ring support **9**, with which the downstream end of the ring-shaped sheet **30** is made integral, and the downstream flange **3***c* of the casing **3** are held tightened by a lock **38**. Such material allows the clearances to be limited between the movable blades **11** and the sealing ring support **9** upon expansion of the blades, in particular at high speeds: the lips **34***a* of the heel **34** can then enter the material **36** with no degradation so as to provide the sealing between the rotor and the ring.

[0041] The flow Fs goes up by depression, still providing a forced convection, toward the downstream end of the ring support, and then is drawn in by an opening **40** arranged on the ring support **9**. Advantageously, the thermal transfer can be improved by forced convection on a rough surface formed on the ring-shaped sheet **30**. The flow exhausts then in the path **13** through passages **42** downstream from the movable blades **11**.

[0042] Alternatively, on the one side, the upstream sealing gasket **20** of the stationary vane **7** may be a lip joint in "w" and, on the other side, the ring support may be present under a continuous annular form or in the form of annular sectors (sectoring).

[0043] In an alternative, such as represented on FIG. **2**, the upstream sealing of the distributor **7** is doubled: a place for a second gasket **44** is arranged by the presence of a shoulder **46**, being formed on a protuberance of the leading edge **7***a*, facing a groove **48** arranged in the upstream flange **3***a* of the casing **3**.

[0044] Moreover, FIG. **2** shows an alternative for the flow passage of the second cooling channel **24** of the distributor **7** toward the cavity **26**. Such passage is obtained by an extension **24***p* of the channel **24**. Such extension is going, while bending and tapering in the illustrated example, directly to open into the cavity **26** through an opening **50** formed in the flange **3***b* of the casing **3**.

[0045] According to another alternative, being illustrated on FIG. **3**, the movable blades do not have any heel. The ring support **9** stays at a sufficient distance from the edge **11***b* of the blade **11** so as to prevent any contact upon thermal expansions of the movable blades **11**. Moreover, an abradable material layer **37** may be projected on the ring support so as to provide the sealing at the top of the blades. Such configuration has this advantage to be able to have a cavity **26** of a larger volume and, thus, of a larger quantity of air flow Fs, allowing for a better thermal transfer with the external side Fe of the ring support, before exhausting through the opening **26** toward the outlet path **13**. A perforated ring-shaped sheet **30** can also be provided within such cavity, for example by welding at mid-height. Moreover, the mounting of the ring support **9** is simplified by being held on the casing **3** with the help of a flange **33**.

[0046] FIG. **4** illustrates an exemplary cooling system in a parallel mode according to the invention from a configuration of movable blades **11** with no heel. Such cooling system comprises two air flow circulation circuits Fs and Fs' being independent. The first circuit relates to the cooling of the distributor **7** from the aspiration through the opening **15** of the carter **3** and the air flow circulation Fs in the channels **19** and **24**, as described in reference to FIGS. **1** and **2** up to the first blading **7***l* formed in the arm **7***b* of the distributor **7**. No blading is formed herein in the flange **3***b* of the casing **3**. A direct outlet channel **52** is formed in the ring support **9** opposite the blading **7***l* and opens into the outlet path **13**. At the outlet of the blading **7***l*, the air of the flow Fs then enters the inlet **53** of the channel **52** to go out in the path **13**.

[0047] The second air circuit is implemented from a second orifice **54** formed in the casing **3** at the level of the ring support **9**. By depression, the air flow Fs' crosses the cavity **26** and goes out through a second opening **56** made in the ring support **9**, in parallel with the outlet of the channel **52**. Those circuits thus contribute to the cooling of the ring support **9**.

[0048] The invention is not limited to the exemplary embodiments described and represented. Thus, the air circulations in connection with the stator and with the sealing ring support can be totally independent by providing an outlet from the radial channel **24** of the vanes **7** in the stator directly in the path **13**. Furthermore, it is possible to provide a number of radial channels higher than two in the vanes of the distributor, several openings in the casing at the level of each stator, distributor or ring support, or still arrangements of the distributor or the ring support on the casing by any convenient means known from the man of the art (crimping, hooping, welding, etc.). Furthermore, the number of distributors and rotors is not limited to one, but corresponds to any turbine targeted by the present invention.

1-10. (canceled)

11. A method for cooling turbine parts of an engine presenting at exhaust an architecture with a positive Cp on whole operating speeds, for which a cooling is desired, provided for at least one pair of parts including an upstream stator and a sealing ring support of downstream movable blades adjacent to the stator, the method comprising:

tapping an ambient air flow by aspiration at a level of at least one part to be cooled;

then a crossing producing a forced convection in connection with the part; and

then a downstream air reintroduction in an outlet path,

wherein cooling is performed in a serial mode with a successive circulation of same air flow in both parts, in a parallel mode with circulations being independent of the air flow in each of the both parts, or in a mixed mode with successive circulation of a same flow in the both parts, and independent circulation of a second flow in the second part by tapping ambient air at a level of the upstream stator for serial and mixed cooling, and of each part for parallel and mixed cooling.

12. The cooling method according to claim **11**, wherein the downstream reintroduction in the outlet path is implemented with parallel exhausts.

13. A system for cooling turbines of turbo-machines for implementation of the method according to claim **11**, comprising:

at least one pair of parts to be cooled of a distributor upstream stator with stationary vanes and a sealing ring support of a rotor with downstream movable blades adjacent to the stator, a turbine casing and an outlet path, at least one opening in the casing facing at least one part to be cooled, a forced air circulation in connection with the one part and at least one downstream outlet in the path, wherein the cooling of the distributor and the sealing ring support of the turbine rotor is serially performed; and

a communication channel in an outlet of a vane of the distributor opening into a cavity in radial connection with an external side of the ring support, and then toward the outlet path of the turbine through at least one orifice provided in the ring support.

14. The cooling system according to claim **13**, wherein an opening is formed in the casing facing an air circulation inlet in each vane of the distributor to be cooled, circulation being performed by a radial circuit comprising at least two channels, and an air outlet in the outlet path of the turbine.

15. The cooling system according to claim **14**, wherein an axisymmetric cavity is provided between the two channels so as to homogenize pressure of the flow and to implement a better cooling of the stationary vanes.

16. The cooling system according to claim **15**, wherein the ring support includes at least one upstream hook configured to enclose bladed flanges of the casing and the distributor vane so as to form the communication channel.

17. The cooling system according to claim **16**, wherein the circulation channel of each vane of the stator comprises an extension directly opening into the cavity to form the communication channel.

18. The cooling system according to claim **13**, wherein a ring-shaped perforated metal sheet is provided in the cavity of the cooling circuit of the ring.

19. A system for cooling turbines of turbo-machines to implement the method according to claim **11**, comprising:

at least one pair of parts to be cooled of a distributor upstream stator with stationary vanes and a sealing ring support of a rotor with downstream movable blades adjacent to the stator, a turbine casing and an outlet path, at least one opening in the casing facing at least one part to be cooled, a forced air circulation in connection with the one part and at least one downstream outlet in the path,

wherein the cooling is performed in a parallel mode, the radial circuit of the vane of the distributor opening opposite a channel inlet arranged in the ring support of the rotor so as to cross it up to the outlet path, and an orifice being formed in the casing facing the ring support to tap an ambient air flow by aspiration and form a parallel air circulation circuit crossing the cavity and the ring support through an outlet orifice.

20. A system for cooling turbines of turbo-machines to implement the method according to claim **11**, comprising:

at least one pair of parts to be cooled of a distributor upstream stator with stationary vanes and a sealing ring support of a rotor with downstream movable blades adjacent to the stator, a turbine casing and an outlet path, at least one opening in the casing facing at least one part to be cooled, a forced air circulation in connection with the one part and at least one downstream outlet in the path,

wherein the cooling is performed in a mixed mode through a successive circulation of a same flow in both parts for a cooling in a serial mode, and through a flow circulation being independent in the second part for a cooling in a parallel mode.

* * * * *